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World Heritage Centre

UNESCO Category 2 Centre
World Natural Heritage Management and Training for Asia and the Pacific Region

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

DigitalGlobe

Event Report

Training Program on Application of Very High Resolution Satellite Data in Natural Heritage Management in Asia-Pacific region 11-14 July, 2017 at Wildlife Institute of India, Dehradun

Jointly organized by

UNESCO Category 2 Centre on
Natural World Heritage Management and Training (NWHMT) for
Asia-Pacific Region at Wildlife Institute of India, Dehradun and Digital Globe

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CONCEPT NOTE

UNESCO World Heritage Convention encourages effective conservation of Natural and Cultural Heritage sites having Outstanding Universal Value for the humankind and posterity. These sites are one of the best testimonies for irreplaceable cultural heritage such as traditional architecture, landscape planning, human history; and natural heritage such as natural landscapes, on-going geological and ecological processes, and habitat to threatened biodiversity. According to UNESCO WHC website, a total of 1052 properties are listed on the prestigious UNESCO WH list (as on 01.01.2017) which consists of 814 cultural, 203 natural and 35 mixed sites. Asia-Pacific region, consisting of more than 50 State Parties, has 247 sites including 173 cultural, 62 natural and 12 mixed sites. India, one of the state parties in the Asia-pacific region is home to 27 cultural, 7 natural and 1 mixed heritage sites.

However, with the inscription of sites on the UNESCO WH list, a robust management regime is requisite to be in place. UNESCO WHC has developed a reporting and monitoring mechanism for the state parties and site managers to work towards effective site management and protection of OUVs. This mechanism includes three types of monitoring protocols viz. State of Conservation report (SOC), Periodic Reporting and Reactive Monitoring (in case of sites in danger). While SOC is about various protection measures put in place at a particular WH sites, Periodic Reporting is prepared on a regional scale and provides updated information about the sites to record possible changes in the state of conservation over a pre-established cycle of six years.

Having such monitoring mechanism in place, all the WH sites have been regularly monitored using various ecological, biological, socio-cultural and technical measures to protect the OUVs. Among many other ways of management and monitoring, application of Earth Observation techniques is an effective and efficient way of monitoring the trend and status of the sites. Nowadays, due to launch of satellites having high resolution sensors together with a greater range in spectral bands, EO techniques are excellent tool for management and conservation. The EO techniques include assessment of state of conservation of a particular site remotely using advanced satellite imageries. Very high resolution satellite and/or aerial remote sensing data are being used to map and monitor the heritage sites. Terrestrial Laser Scanning (TLS) and 3-D visualization techniques also have wide scope of application in creating database for cultural heritage sites.

Given this background, UNESCO Category 2 Centre (C2C) on World Natural Heritage Management and Training for Asia and the Pacific Region (http://wii.gov.in/unesco_category2_centre), Wildlife Institute of India (WII), responsible for protection and management of natural and mixed heritage sites in the Asia-

Pacific region conducted a three day course program titled 'Application of Very High Resolution Satellite Data in Natural Heritage Management in Asia Pacific region' at Wildlife Institute of India, Dehradun.

OBJECTIVES:

The overall objectives of the course were to give critical understanding of high resolution satellite imagery in the field of Heritage management.

1. To impart the knowledge of use of High Resolution Satellite Data to World Heritage site managers, practitioners, academicians, students etc.
2. To give in depth knowledge of application of high resolution data in mapping, monitoring and modelling of World Heritage sites.
3. Exposure to Photogrammetric techniques using high resolution satellite data.

TARGET AUDIENCE:

UNESCO WH site managers, WH practitioners, Government organisations and NGOs from different Asian countries. A total of 25 participants were expected to participate whereas the training programme saw an enthusiastic batch of more than 40 participants.

LEARNING OUTCOMES:

The course gave an insight into various applications of high resolution satellite images in heritage sites management using advanced remote sensing techniques, both in theory and in practice. After the course, the participants were able to develop an understanding of the use of data for various applications like disasters, climate change, land use land cover change, forest cover change, river morphology etc.

VENUE: WILDLIFE INSTITUTE OF INDIA

DAY 1 – 11TH JULY, 2017

Inaugural Session

The participants registered for the workshop. A beautiful registration kit (bag, copy, pen, pen drive and programme schedule) was provided to each participant for the workshop. More than 40 participants including the dignitaries registered for the workshop out of which 6 participants were from foreign countries.

The workshop commenced with a beautiful Sanskrit shloka on the importance of *vidya* or knowledge. Ms. Persis Farooqy (UNESCO C2C, WII) welcomed the participants and invited all dignitaries to the dais. The dignitaries were Dr. Y.V. Jhala (Scientist G, WII), Dr. V.B. Mathur (Director, WII), Mr. S. Nelamangala (Senior Director, Digital Globe), Mr. V.S. Oberoi (Former Secretary, MoHRD, GoI) and Dr. Abhineet Jain (Regional Director, Digital Globe, Singapore). All the dignitaries were then welcomed by Ms. Prarthi Shah and Ms. Shaoni (Project Intern, UNESCO C2C WII).The distinguished dignitaries were invited for the lamp lighting ceremony initiated by Dr. Sonali Ghosh, IFS (Scientist F, UNESCO C2C WII) with a soulful rendition in the background by Ms Prarthi Shah.

Dr. Sonali Ghosh, IFS (Scientist F, UNESCO C2C WII) welcomed and introduced the distinguished guests to the audience with a special mention of their remarkable achievements/ backgrounds. She proceeded to give the course overview and requested all the participants to make the most of the programme by learning as much as possible from both demo and practical sessions. This was followed by felicitation of the honourable guests with beautiful mementos. Dr. Sonali Ghosh then invited Dr. V.B. Mathur (Director, WII) for his opening remarks at the Training Programme on Application of Very High Resolution Satellite Data in Natural Heritage Sites Management.

Dr. V.B. Mathur (Director, WII) in his opening remarks welcomed all the dignitaries and all the participants especially those from the different countries of South Asia. He thanked Digital Globe on behalf of the SAARC participants. He noted that the year 1999 saw the turning point in the resolution of remote sensing imagery with the launch of IKONOS. He spoke of the importance of very high resolution imagery and highlighted the latest technologies available for the management of World Heritage Sites. He indicated that in general, very high resolution imageries are less preferred due to their high cost but the possibility of drawing in commercial companies exists and should be considered. Dr. Mathur ended his opening remarks assuring the participants a great learning experience through the ample practical

examples incorporated in the training programme and encouraging them to apply the same in their own field research and interests.

Mr. Shankar Nelamangala (Senior Director, Civil Government Segment, Digital Globe) in his address journeyed through the advancements in the field of Remote Sensing. He talked about the development trends of satellite imagery from very low resolution to very high resolution up to 30 cm resolution with the ever-developing technologies and applications in various aspects. Sir introduced all to the evolution of World View3 and its eight bands, the additions of short wave infra-red (SWIR) and its advantages. He showed an imagery of Taj Mahal with the tourists and proclaimed that it is the only satellite that can "see" human beings. His presentation was comprehensive with some striking slides of satellite imageries. He demonstrated the application of VHRI, mapping plantation activities forest density mapping, change detection, monitoring of illegal logging, red sandal wood in Andhra Pradesh. He also showed how with the stereo capability, a 3D model of Jaipur city was prepared for the Rajasthan Police. Mr. Shankar endorsed that Digital Globe not only provides products but delivers solutions too. He then went ahead to speak of the ready to use products like Vricon which provide a Base Map with Vivid Archive Data (from IKONOS Geo Eye and World View-Images of the world from 2000). He also mentioned the Geospatial big data platform GBDX that has a demo centre in Bengaluru, where you do not need to pay for the data. Mr. Shankar ended his talk with a message that we should have keen interest to learn something. He quoted from the Gita, that wherever Krishna and Arjuna are together, victory is assured- where he compared knowledge and concentration with Krishna and Arjuna respectively.

As the chief guest of the inaugural session, Mr. V.S. Oberoi (Former Permanent Representative of India at UNESCO & Former Secretary, MoHRD, GoI) delivered a beautiful and informative talk. He mainly talked about World Heritage Sites and emphasized the application of developed technologies for their monitoring and management. He mentioned that heritage sites are our legacy of culture and it is our responsibility to manage them in a good manner for our future generations. Mr. Oberoi sensitized the audience about the value of heritage. He noted that there is a lacunae in the educational systems when it comes to heritage studies. There is a need to include more multidisciplinary studies. Another important observation that he conveyed was that heritage conservation always saw more success with community involvement.

Technology is a major tool in the management of the heritage sites. With technology, comes more data, more information, more detail and this essentially brings in greater clarity. Addressing the park managers, he also mentioned that when this clarity is used with passion and commitment, it becomes

the perfect tool for conservation and management of heritage sites. Referring to the young researchers, Mr. Oberoi marvelled on the importance of original research and analysis and free interaction between experts, practitioners, students and researchers.

Dr. Sonali Ghosh, IFS (Scientist F, UNESCO C2C WII) gave the Vote of Thanks and appreciated the way dignitaries had smoothly initiated the participants into the programme and how with the overview of technology by Mr Shankar and heritage by Mr Oberoi, the participants were ready for the blend of two. Dr. Sonali also mentioned that Wildlife Institute of India has always been a knowledge centre and the participants should take cue from that and whole heartedly learn and share as much as possible.

The Vote of thanks was followed by a group photo outside the auditorium and a tea break.

The next session had a round up introduction and ice breaking session. All the participants told their background, area of interest and shared one secret from their lives, which ended up as the most interesting activity of the introduction session.

SESSION ONE

Overview on World Natural Heritage and Monitoring using Earth Observation

After the introduction session, Dr. Sonali Ghosh, IFS (Scientist F, UNESCO C2C WII) spoke on the topic Natural World Heritage and Monitoring using Earth Observation. In her presentation, Dr Sonali introduced and described the World Heritage Convention and the concept of Outstanding Universal Value of World Heritage Sites. Out of a total 1073 WHS worldwide, 36 WHS are in India including the newly inscribed Ahmedabad city, which is the first city in India to be declared as a World Heritage Site by UNESCO. Dr. Sonali elaborated with multiple examples, on how the heritage sites of India are mainly classified into natural heritage site, cultural heritage site or mixed properties e.g. Kanchendzonga National Park of Sikkim based on 10 criteria for the nomination of a site as a World Heritage Site. She detailed the process of nomination and mentioned the challenges for the nomination and management of a WHS like involvement of local communities, earthquake, landslide, flood etc. She emphasized how having a site inscribed as a World Heritage Site is a nailing factor offering stability for sustainable conservation of natural resources and culture. She also pointed out how in the case of disasters or other threats, having world recognition helps to bring in more help or put the right pressure on government and non-government organizations to take action. Dr Sonali, in the last part of her presentation highlighted how Earth Observation Technology plays a key role in Heritage Site Conservation especially in terms of Disaster Risk Reduction by mapping, creating 3D replica models of the sites and by

monitoring the sites for possible threats. Better management is also facilitated through the use of technology. Overall Dr Sonali's talk set the focus right for the audience to view Heritage Sites Management and the cutting edge offered by Earth Observation.

Introduction to Digital Globe Products and Services

Dr. Abhineet Jain (Regional Director, Digital Globe, Singapore) took over from Dr Sonali Ghosh and provided the audience with an "Introduction to Digital Globe Products and Services". He mentioned about the technologies available for the management of Natural Heritage Sites especially the Very High Resolution imagery datasets and tools and services developed by Digital Globe, an American Company. Speaking about the developments and advancements in Space Science, he mentioned that around 5000 satellites were launched in the last 5 years. Dr Jain highlighted the sensor advancements in the technology from Worldview 2 and 3 to Worldview 4 and informed that the World View 4 is the latest satellite of Digital Globe that provides resolution up to 30 cm. The highly sophisticated sensor functions as telescope to highly increase the spatial resolution to provide a natural colour image of the world. It takes around 90 minutes to complete one round around the earth and each day it covers 15 orbits. After 22 days, the satellite again follows the same orbit to take the high resolution images. With a constellation of 5 satellites, a revisit of 1 day is achieved. Covering approximately 3 million sq. km. a day, the entire Earth's landmass is covered within six months time. In the World View 4, two new tools have been added viz., scout and world view legion. He also proved the efficiency of the eight spectral bands by picking examples of different types of case studies like Bathymetric studies, Species Mapping, Habitat mapping etc, both from India and across the globe which benefitted from the spectral quality of the very high resolution images used. Dr Jain informed that now Digital Globe is part of MDA, a Canadian Company, which owns Radarsat, which means now they have a greater archive of multiple products including night time imagery. He also tried to remove the mental block about high resolution datasets beings expensive by pointing out with examples of how cities like Delhi and Bangalore used VHSI to track illegal settlements and fine builders that encroached lakes and other water bodies; proving that though the initial investments are high, the returns to the government are much higher.

SESSION TWO

Exploring the Discovery Tool of Digital Globe Archive and Traditional Processes of Acquiring VHRS Imagery

The afternoon session comprised of a detailed explanation of the spectral properties of vegetation and other components of earth observation like water, urban areas, bare soil etc. and how the very high resolution images can be used for vegetative studies like monitoring the health of vegetation, species mapping, tree crown detection and delineation especially for counting trees outside forest or urban green cover mapping, with different case studies. Dr. Abineet Jain also demonstrated the efficiency of SWIR band and its ability to see through smoke and highlight fire with excellent images taken of an active volcano. Another example of mapping of Sumatran Forest Fire to estimate the loss was also shown. Dr. Jain moved on to explain how the management of data has undergone a shift from earlier "vaulting" the data to now moving everything onto the cloud for everyone to view and yet pay only as per use. Through creative animations, he demonstrated the coverage achieved with Digital Globe's constellation of satellites in a month, three months and six months' time (complete coverage of earth's landmass) and then let the trainees get a grasp of the tremendous amount of data collected on a daily basis, about 2 terra bytes per day, reaching up to peta bytes with the years of imagery archived. Dr. Jain then went ahead to postulate the advantages of moving on to cloud and the advanced computational capabilities that it provides. Many tools specifically for building extractions, infrastructure mapping etc. have been developed that automate these processes thereby saving a huge amount of time and effort for the users. Moreover the user gets normalized images that have been pre-processed to do sensor specific haze corrections. So, they also save the effort of running complex algorithms through atmospheric correction models. Dr. Jain also pointed out that now the customer gets to browse data freely, computing services are provided and the user only needs to subscribe for the data that they use. He also acknowledged that Digital Globe goes open source to support humanitarian causes like in the case of Nepal Earthquake and the missing Malaysia Airlines.

Exploring the Discovery Tool of Digital Globe Archive and Traditional Processes of Acquiring VHRS Imagery

The next session was the Group Practicals, wherein different groups were formed and distributed a very high resolution image of an area with the Manas River, on the boundary of Manas National Park. The trainees were encouraged to explore the clarity and detail of the image up to pixel level owing to its resolution. They also visualized the image under different band combinations and tried to co-relate it to

the spectral properties of different objects and identify which element stood out under which set of band combination. The session was then followed by sharing of insights learnt from the practical.

SESSION THREE

Exploring Digital Globe's online Cloud Platform Access

The group broke for a quick tea after which Mr. Andrew Steel took over from Dr. Jain and accustomed the audience to browse through 'Image Finder' to locate and download imagery from the Digital Globe Archive. Using VHRI of an area outside Manas National Park, he demonstrated how very high resolution imagery could help calculate how much area has been lost in a river course change and quantify micro level changes, which could not be thought of earlier. Mr. Steel also demonstrated many case studies of biomass estimation and crown delineation for estimation of trees outside forest. The next practical that Mr. Andrew demonstrated was the mapping of flooding in Thailand using unsupervised classification. This was followed by a doubt clearing session followed by brainstorming and discussion of possible applications, advantages and limitations, if any (for linear and curvilinear features), of VHRI. The effectiveness and efficiency achieved through advancement in sensor and satellite technology followed by automation through development of better algorithms, real time processing through cloud services and integration of newer datasets like Lidar and Radarsat were discussed. With this, the program for the first day came to an end.

In the late evening, a course dinner was organized for the guests and participants at River Stone Cottage. A little off the city, the place was beautiful with a stream flowing by, soft lightings and good music. Everybody enjoyed the evening and the delicious dinner.

Plate 1: Pictures showing the first day activities (11TH July 2017)

Figure 2- Ms. Persis Farooqy delivering the welcome address

Figure 1- Chief Guest Mr. Vinay Sheel Oberoi formally inaugurates the event with the lighting of the lamp

Figure 3- Dr. Sonali Ghosh delivering the course overview and formally introducing the guests for the event

Figure 4- The auditorium all set with the participants seated

Figure 5- Director WII, Dr. V.B.Mathur delivers his opening remarks

Figure 6- Address by Mr. Shankar Nelamangala

Figure 7- Address by Chief Guest Mr. Vinay Sheel Oberoi

Figure 8- Director, WII, V.B. Mathur gifts a memento to the Chief Guest

Figure 9- Dr. Sonali Ghosh delivers the Vote of Thanks

Figure 10- An ice- breaking session with all the participants and the guests

Figure 11- Dr. Abhineet Jain demonstrating Digital Globe archives

Figure 12- Participants during the demonstrations of Digital Globe

DAY 2 – 12TH JULY 2017

SESSION FOUR

Introduction to Global Datasets

The morning saw heavy downpour and all the outstation guests got an experience of the Dehradun rains. It took some time for everyone to assemble. Miss Kamana gave a brief about the previous day's program. The first speaker of the day was Dr Gautam Talukdar and he gave a very informative lecture on the Global Datasets. He cautioned that each dataset has its own uniqueness with its own spatio-temporal and spectral properties and no dataset can completely replace the other and that each serves their own purpose. However, according to each project's requirement, it would be a good idea to make use of the freely available datasets shared by many different organizational sites. He shared many a links from a plethora of web sites and portals, availing a range of datasets right from shape files, terrain and satellite imagery to complex data models to interesting statistics and educative videos. Most importantly, Sir educated the trainees on the nuances of open source licensing. Dr. Talukdar ended with a note to remember that if something was not on Google, it would generally be assumed that it probably didn't exist.

Disaster Risk Reduction and Response in WHS, 3D Elevation Datasets, First Look Emergency Tasking Services, Tomnod and Geospatial Big Data Platform

The next session was by Dr. Abhineet Jain about the use of VHRI in disaster risk reduction, response and rehabilitation. Dr. Jain mentioned that they are associated with the UN Charter and whenever a red alert was given, they joined in to contribute for the humanitarian cause. He explained how people can be prepared for an emergency with ready base maps of population distribution and housing, navigational analysis, logistic planning, helicopter landing zones, shortest possible evacuation routes etc. and a 3D terrain model from Digital Globe's Stereo data. Dr. Jain then spoke about crowd sourcing and how, in the event of Nepal's earthquake, with the help of volunteers, aftereffects could be identified and marked through pre and post high resolution imageries. With the help of that, a map could be prepared within hours depicting the destruction, broken roads, temporary settlements etc. that could be used by the rescue and rehab team for emergency crisis management. He also highlighted the role of Digital Globe in search of missing Malaysian flight MH 370.

SESSION FIVE

Characterizing Ecosystem Services in Keoladeo National Park (World Heritage Site) - exploring high resolution satellite remote sensing data and other tools

Dr. P.K Joshi, Professor, School of Environmental Sciences, JNU, took up the next session. He gave a very comprehensive presentation covering the basics of remote sensing- right from the different types and levels of resolution and colour composting to the general classification of imagery and the applications of each. He spoke on the advantages achieved through very high satellite imagery in terms of detailing, particularly for urban studies and demonstrated a few interesting case studies where VHRSI had been utilized for analysis like Rooftop classification and moving object's speed detection. Dr. Joshi then went ahead to explain the Characterization of Ecosystem Services in Keoladeo National Park and how the results improved for very high resolution imageries as opposed to high resolution. He then discussed the changes identified in light of the actual ground reality. Then were many doubts and questions posed particularly from the various site managers who found special interest in the study, all of which were addressed by Dr. Joshi.

The next session was taken over by Dr. Uttara Pandey from IORA Ecological Solutions. She began with an introduction to her company and the four packages, IFORM, ITWIN (Tree Wealth in Non Forest), IFIRM, and IMAP, developed for forestry needs using very high resolution datasets. IFORM included Forest Stock Map, Forest Type Map, Forest Canopy Density Map and Forest Biomass & Carbon Map. She showed different case studies where great results were achieved by employing VHRI. One of the studies was the 'Invasive Species Mapping in South Sikkim' where five floral invasive species were identified and mapped using WorldView Data. There was another study of 'Estimating Tree Outside Forest for Assam Forest Department'. Also, 'Plantation Activity Montoring' was done for Chandrapur District of Maharashtra. Dr. Pandey was very convincing about the need of VHRI in forest applications especially in regions of high degradation where a low resolution satellite doesn't 'pick' each tree and she assured that with improved algorithms, the vegetative studies done with VHRI had given very good results. Both Dr. Joshi and Dr. Pandey thanked Digital Globe for their data support and cooperation in their respective research studies.

SESSION SIX

Group Practical (Invasive species mapping and image classification exercise)

After lunch, the trainees assembled in the lab for a practical session jointly conducted by Dr. Joshi and then taken over by Dr. Uttara. Following Dr. Joshi's demonstration, and the handouts, the trainees were able to perform supervised classification on a WorldView image. The image was visualized under different bands for better contrast between the objects in the image. Each participant from a group selected signatures for a particular class (like water, vegetation etc.) and the images were finally classified. Dr. Joshi guided how the signature should be pure yet a little non-homogenous enough to represent the class.

Dr. Uttara Pandey, on special request from the participants demonstrated how to perform Fractional cover downscaling, conversion from DN values to radiance and reflectance and Canopy density from Fractional Cover. She also shared the nuances to be remembered while classifying, or choosing signatures and while using algorithms.

Mr Shailesh Shankar continued the session by speaking about newer algorithms utilizing object based classification and decision tree classifier, which provided faster results. He mentioned that SAAV technologies, whose aerial photographs were acquired by Apple, took 100% overlap images to create high resolution 3D images and now Digital Globe and SAAV Tech have come together and jointly used animations to create World Digital Elevation Models. He introduced VRICON, which provides Digital Elevation Models up to 30 cm, 3 m, 5 m and 10m accuracy, obtained from monoscopic images, which can generate Surface as well as Terrain Models and can generate point clouds.

Plate 2: Pictures showing the second day activities (12th July 2017)

Figure 1- Dr. Gautam Talukdar at his lecture on Global Datasets

Figure 2- Dr. P.K. Joshi on the basics of remote sensing

Figure 3- Brief given by Dr. Abhineet Jain before the practical

Figure 4- Dr. Uttara Pandey during her demonstration

Figure 5- Mr. Shailesh Shankar and Dr. Abhineet Jain during the practical demonstrations

Figure 6- Dr. Sonali Ghosh during the practical demonstrations

Figure 7- Discussions before the practical

Figure 8- Participants during the practical

Figure 9- Teamwork during practicals

Figure 10- Dr. Andrew Steele during the demonstrations of Digital Globe

Figure 11- Dr. Andrew Steele helping the participants with the practical

Figure 12- Participants busy in their practical work

DAY 3- 13TH JULY, 2017

Tracking *tricarinates*: A Nature Walk

After the previous day of heavy rains, the morning was pleasant. Dr. Suresh Kumar assisted by Miss Anuja, a researcher on turtles, were guiding the Nature walk. Dr. Gautam, Dr. Abineet and Dr. Joshi had all joined the walk. Miss Anuja showed the turtle to everyone and explained how to identify the male and female species and how they were moisture loving but terrestrial and how, in fact, they could drown in water. Dr Suresh told the story of the *Tricarinate Hill Turtle*- how it got its name, how they were brought to the campus and have been studied since then, how they have been marked, and how Dr. Suresh and researchers gained insights on their various habits with ample anecdotes. Dr Gautam and Dr. Sonali also added a few points about the campus and the earlier days. It was a very interesting session followed by breakfast.

Dr. Suresh gave a very interesting presentation on the Amur Falcon. It was a very fascinating story of research and Dr. Suresh, a very good narrator, spun the entire research as a beautiful story. Amur Falcon is one of the smallest raptors that is long distant, a trans equatorial migrant that breeds near the river Amur in Mangolia and migrates in the winters to South Africa, and happens to stop at Nagaland. Unfortunately, in 2012, the mass killing of almost 150 thousand drew attention towards these birds. To address this growing concern, WII intervened. The birds were tagged with solar powered geotags and their migratory paths were traced as they flew across the globe. Their halts were investigated and correlated with the termite emergence and monsoonal winds that increase their speed and reduce their time of flight. With the development of a sense of ownership and belongingness for the Amur Falcon, the involvement of the Church and the sharing of the technology with the local people where even they could view real time, online, their birds on flight, the community driven conservation program was very successful. It was only due to the community's involvement that the birds could be captured and after geotagging, they were named after the villages and released. This had a huge impact on the villagers and it was one of the rare events when within a short span of a year, there was an attitude shift and the communities which were earlier responsible for the mass killing ended up becoming protectors of the birds. It was a wonderful narrative.

SESSION SEVEN

Application of Very High Resolution Imagery in Forest Management

After a quick tea break, everyone assembled for one of the most awaited presentations by Dr. Saibal Dasgupta, Director General, Forest Survey of India. Mr. Dasgupta gave an overview on remote sensing and GIS application in Forestry in India. He started with a quote from Dr Rajendra Prasad about how forests are one of the more useful resource providers and yet how little is known about them. He noted that we have a rich history of about 150 years of scientific forestry and thirty years of remote sensing data.

Dr. Dasgupta then proceeded to give a detailed overview on Forest Survey of India and how the biannual reports are produced. He also responded to many queries in this regard.

He moved on to explain how geoinformatics was used in Forest Survey for forest cover mapping, monitoring, fire mapping, inventory, preparation of forest management plans, assessment of tree outside forest, plantations under CAMPA. Dr. Dasgupta aptly depicted the improvements in forest mapping with the advancements in spatio- spectro-tempero qualities of remote sensing technology in his case studies. He also spoke about the information facilitating portals like E-Greenwatch and Decision Supporting System that helped administrators take informed decision on forestland diversion based on different parameters, up to 21 layers of accessory information. Dr. Dasgupta proceeded to display the application of VHR data in accurate land cover classification, pattern analysis, quantification of carbon, plantation management, asset monitoring and even ground truthing for forest cover mapping, working plan preparation, watershed management plan, fire and burnt area assessment, environment impact assessment. He also mentioned the use of SAR data for biomass estimation. There were many queries raised, such as, 'Why riverine vegetation and grasslands were not included as a forest type class?' to which Dr. Saibal responded by accepting the gap. He also announced that making the forest data available freely for the public through a National Forest Monitoring System, was part of their future plan.

Big Data and Image Analytics on the Cloud

Mr. Shailesh Shankar took over from Dr. Dasgupta to talk about 'Big Data' and 'Image Analytics on the Cloud'. He mentioned that with advancing web technologies people are facilitated with the power of the Cloud. The entire coverage of the earth in Very high resolution is available for everyone to view. Not only is there the concept of 'elastic compute' wherein one doesn't need to worry about the computing

as advanced algorithms are already available, but the analysis too can be done on the cloud. Mr. Shankar quoted case studies from Australia where in GBDX was used to delineate swimming pools, housing material, height of buildings, and a list of other attributes of the features were collected completely through remote sensing. Another case study was of assessing the change of mangroves in Gorai due to illegal construction activities. Digital Globe also captured river dredging in Baitarini River. Mr Shailesh spoke about the algorithms developed for feature extraction and classification. He spoke about tip and cue method to train machine to do land use, land cover classification stating a case study of built up changes of entire Delhi done entirely based on machine learning. He also displayed a case study where in American Company used the GBDX services to count cars outside departmental stores. Mr. Shailesh encouraged everyone to use GBDX, read GBDX Stories and avail the QGIS extension. He ended with a brief on the vast variety of imageries from LANDSAT, RADARSAT, Sentinel etc. A question was raised about how GBDX was different from Google Earth Engine providing similar data completely free of cost, to which Mr. Shankar warned the audience that Google data was free only for individual users within the app. According to their policies one could not extract information from the imagery. Moreover, Google Earth Engine was working only on an experimental basis wherein GBDX followed industry standards and provided datasets, ENVI engine, algorithms and was developed as an open source.

SESSION EIGHT

Travel to IIRS

The afternoon session was at the Indian Institute of Remote Sensing. It was a good opportunity for all the participants to visit the prestigious institution. After a thorough security check, some welcome tea and snacks, the participants were finally seated in the auditorium named after Aryabhatta. The session comprised of two lectures- one by Dr. Poonam Seth Tiwari and the other by Dr. Raghavendra of Photogrammetry and Remote Sensing Department. Dr. Poonam spoke on the 'Use of Close Range Photogrammetry in 3D Modelling'. The Trivim App indigenously developed at IIRS was introduced to the audience. Madam very patiently, solved the technical doubts related to parallax error by explaining the basic concepts. The next lecture by Dr. Raghavendra on the "Use of Terrestrial Laser Scanner" was equally interesting. He explained the working of TLS with simple and easy-to-understand set of slides, showed examples of where it had been used and shed light on its computation. He went ahead to clear the doubts and ended with emphasizing on the overall efficiency of both TLS and CRP technology and hoe to overcome the limitations when used together as both complement each other. By 5:30 pm the team had started back from the IIRS campus.

Plate 3: Pictures showing the third day activities (13th July 2017)

Figure 1: Resource Persons and participants on Nature Trail walk.

Figure 2: Dr. Suresh Kumar, Scientist, Wildlife Institute of India interacting during the session

Figure 3: Dr. Saibal Dasgupta, Director General, Forest Survey of India presenting during the session

Figure 4: Mr. Shailesh Shankar from Digital Globe

Figure 5: Participants during their visit to Forest Research Institute, Dehradun

Figure 6: Participants on their visit to Indian Institute of Remote Sensing

DAY 4- 14TH JULY, 2017

SESSION NINE

Demo on Unmanned Aerial Vehicle (UAV)/ Drone Technology in Forestry/ Wildlife Applications

The fourth day started with a Demo on Unmanned Aerial Vehicle (UAV) by Mr. Srinivas and team from Bubblefly Technologies, Delhi. As the sky was clear, it was decided that the Drone would be demonstrated to the participants. Everybody assembled outside the auditorium. Mr. Srinivas introduced the machine and its parts and specifications to the audience and mentioned that the stability of the camera is the most important for a good recording. Mr. Srinivas manoeuvred the UAV and the audience watched mesmerized as the blades of the UAV started spinning and it slowly and steadily rose mid air and took flight. Mr Srinivas invited everyone to look at the hand held device, which streamed the live capture of the drone's camera. The camera displayed the view of the features it captured in thermal band. The participants could see themselves as small bright yellow dots, a moving car and the campus building on the device. The trainees were full of questions for the drone experts and they cleared their doubts one by one such as the cost ranging from 7- 8 lakhs including 4 lakh for the thermal camera, the calibrations to be done every two months, the camera generally having a backup of two and a half hours, FLIR camera imported from US, flying time ranging from 25 minutes to 45 minutes, its ability to shoot at night etc.

Mr Srinivas demonstrated the thermal drone videos captures in Manas National Park to show how thermal band can be used to look under the canopy cover and how the sensor can 'see' animals such as wild buffalos. He also shared an anecdote of how they used the thermal sensor to check the present location of Black Panther. Mr Srinivas spoke about the innovations that they were working upon to enhance the service capabilities of drones for forestry applications like algorithms to improve species identification- now elephants could be easily distinguished and counted. Also, a special feature to distinguish between guards and poachers was being developed. They were also in the process of developing SLAM Simultaneous Location and Mapping and Path Planning Algorithms that wouldn't need a GPS but would instead use a localized map with calibrated locations.

Mr Srinivas covered various applications for which the drones were extensively used, for example- aerial surveillance, anti-poaching, waterbodies location, tree felling report generation, tree counts with lidar, timber loss estimation, species distribution and forest fire capture using heat seeking drones. Mentioning other non-forest applications, he spoke about the water proof, cold resistant, super silent

drones produced for military applications and 3D mapping of Nagpur Municipality to produce 25 layers of data including man holes and wells using oblique imagery in India for the first time. He also gave insights of how drones could be used for crowd management or crop loss estimation especially in light of the recent insurance policy for farmers launched by the Prime Minister. Mr Srinivas concluded by saying that Bubblefly Technologies developed tailor made UAVs to suit the requirements of customers and ensured operational success by providing at least a 15-day training to calibrate, handle and maneuver the UAVs.

World Heritage Site Monitoring and Reporting

Dr. Sonali Ghosh, IFS (Scientist F, UNESCO C2C WII) gave a presentation on possible WHS for nomination from different countries and the criteria those are matching with the 10 criteria of nomination of WHS at UNESCO. She mentioned that all the natural heritage sites are a best of In-Situ conservation and each party has to prepare a State of Conservation Report (SOC) to submit to UNESCO. Establishment of Management and Monitoring Committee, justification of Outstanding Universal Values and the involvement of local communities are some prerequisites of the nomination of a site as a WHS. She also pointed out that there were some sites that could be nominated as WHS under both cultural and natural criteria. She mentioned that in Sri Lanka there were 6 possible cultural sites and 2 possible natural sites at present. In Bhutan, the most famous Royal Manas National Park and the Sakteng WLS are following the criteria number III, VI, VII and X of nomination for the WHS. She also described about Taman Negara, Archeological Heritage of Lenggong Valley of Malaysia; Kathmandu Valley, Chitwan and Sagarmatha of Nepal; Pyu Ancient Cities and Hakabo Razi of Myanmar, Sundarban, Bagarghat: a historic mosque site, Ruins of Buddhist Vihara at Paharpur of Bangladesh etc.

Dr. Ghosh specially mentioned about the Manas Natural World Heritage Site of Assam, India. She described the history of Manas from its nomination as WHS in 1985, its inclusion in the List of Danger from 1989-2011 and its subsequent successful withdrawal from the List of Danger as a major Natural WHS of India. Efforts by the local political parties, communities, site management authorities and other conservation stakeholders, Rhino introduction, management of park sites and involvement of local communities are some major efforts that pushed the site from danger to safe place for In-Situ conservation. Adding to this Dr. Ghosh also mentioned about the sustained ownership and sense of pride which made anyone understand the values of sites and their management. She ended her

presentation with mentioning that World Heritage Biodiversity Programme for India was a good initiative of Indian Government to protect India's World Heritage Sites.

For the participants who could not make it up in the morning, the demonstration on drone flying was repeated and the audience thoroughly enjoyed the second round too. The participants then joined in for tea.

Commercial Space Based High Resolution Imagery Trends

Dr. Abhineet Jain gave a short talk on Commercial Space Based High Resolution Imagery Trends. He mentioned that there were 4 elements of success for resource management viz., Resolution, Accuracy, Speed and Analytics. These leveraged the scale of machines and human accuracy in analysis. Dr, Jain also added that they were looking forward for creating a common group or platform, sharing of knowledge and experience, collaboration with researchers, site managers, institutions and NGOs. In the end, he mentioned that such a collaboration would definitely help everyone address the current issues for the field of conservation and management. This was followed by feedback session by the participants.

Presentation by course participants, feedback, collaborations with C2C and Digital Globe

Dr. Sonali Ghosh initiated the feedback session by the participants. Here, the participants were requested to give their background, area of research interest and possible collaboration with UNESCO C2C and Digital Globe. Among the feedback from the participants, most of them wanted to collaborate with UNESCO C2C requesting their expertise in the nomination process of a possible WH nomination. The researcher participants requested Digital Globe to help in their research work by providing VHR data for assessment, Orchard mapping and 3D modelling in their research works. The participants who expressed their interest in collaboration with UNESCO C2C and Digital Globe were Mr. Kripashankar, Ms. Shreya, Mr. Fauzul, Mr. Jiju, Mr. Amit, Dr. Droupti, Mr. S. K. Srivastava (IFS), Mr. Patil, Mr. Nuwan, Mr. Asish and Ms. Niti Singh.

High Resolution Remote Sensing: Changing the paradigm shifts in information extraction and decision-making

Dr. P. S. Roy (Senior Scientist, Centre for Earth & Space Sciences, University of Hyderabad, India) delivered a talk on the "High Resolution Remote Sensing: Changing the paradigm shifts in information extraction and decision-making. To address the issues of conservation, management and monitoring high resolution data set had a major role. He explained the changes in forest from independence to

recent times and the role of very high resolution satellite data in detecting such changes. With the development of technologies, most of the issues could be addressed with the open source data. He showed many interesting slides to show a variety of applications. Dr. Roy mentioned the use of Sentinel Satellites and spoke about the upcoming technologies.

Valedictory

Dr Sonali Gosh invited Dr. Mathur, Dr. P.S. Roy Dr. Abhineet Jain to the stage. As a "new tradition in the old institution" Dr. Roy was welcomed with a book by Dr. Mathur. Dr Abineet Jain noted that this programme was a great learning of the specific needs and that a variety of applications were covere-taking cue from which, better planning can be done for future endeavours. Dr Mathur speculated that this was the first of a kind of workshop by C2C and a lot of innovations were incorporated. The participants included various Park Managers and Site Managers at different stages of learning with respect to remote sensing and GIS. It was a great opportunity to imbibe technology. Wildlife Institute of India had always been an institution for capacity building and networking. We had 40 people and 4 days and limited resources but very good outcome.

Dr Mathur, commenting on the application of technology, said that South Pacific was open to technology but that one should also be aware of the dangers too, especially while converting research and development to application. He noted that today, from a manager's point of view, there was less time for research and development and they needed immediate solutions. Technology solved this but he also warned that one should not oversell the technology. For example, Animal human conflict was a common problem faced by all National Parks. One could use technology and radio collar animals where the animal itself would give a virtual alert in the guard's mobile. Six collars had been used by Chhattisgarh Forest Department recently. But, one should overcome the tendency to waste too much time with technology without a need. One should also be careful about balancing technology and automation with man power and make use of human potential too.

Dr Roy shared his long association with WII and tagged it as a pro-active institution. As a conclusion, he commented that Technologies were there but the usage of technology should be based on ones needs. He also emphasized on conservation and mentioned a study conducted the previous year, which identified 20 to 25 species in the Northern Western Ghats as indicators of climate change, which meant that ecosystems were responding to climate change. Dr Roy advised that such research should be up taken up that were relevant to the society and nature.

Md. Sajidur Rahman from Bangladesh thanked the C2C team for being such wonderful hosts and requested that such initiatives be continued in future too. He was greatly impressed by the information about the vast availability of cost effective processed data.

Another researcher came forward to share his learnings and took great pride in being able to interact with stalwarts from the remote sensing field who had always been his inspiration and indirect teachers. He was particularly interested in urban landscape studies with high resolution imagery.

Dr Sharat Goyal felt that there should have been more time for the speakers to deliver and demonstrate without having to rush through it.

Dr Sanjay from the Tamil Nadu Forest Department congratulated the speakers for educating such a mixed crowd at different learning stages and from different backgrounds. He opined that a case study documenting the whole process of nominating and getting a site inscribed and the management plans etc. would have given the managers more clarity and enhanced the chances of better results. His second suggestion was that for monitoring the existing sites, the parameters to be monitored should be picked and the standards and methods for monitoring each parameter should be discussed upon.

Mementos were gifted to Dr. Roy, Mr. Steele, Mr. Srinivas and team and Dr. Gautam Talukdar.

Plate 4: Pictures showing the fourth day activities (14th July 2017)

Figure 1: Participants during Demo on Unmanned Aerial Vehicle (UAV)/ Drone Technology in Forestry/ Wildlife Applications

Figure 2: Experts from Bubblefly Technology interacting with participants during the demonstration

Figure 3: Mr. Srinivas and Mr. Ajay presenting during the session

Figure 4: Dr. Abhineet Jain taking the session on Commercial Space Based High Resolution Imagery Trends

Figure 5: Dr. P. S. Roy, Senior Scientist, Centre for Earth & Space Sciences, University of Hyderabad, India during his talk.

Figure 6: Dr. V.B. Mathur felicitating Dr. P.S. Roy during the valedictory session.

ANNEXURE -I

TRAINING PROGRAMME ON APPLICATION OF VERY HIGH RESOLUTION SATELLITE DATA IN NATURAL HERITAGE SITES MANAGEMENT

11-14 JULY, 2017

Venue: Wildlife Institute of India, Dehradun

Program Schedule

TUESDAY, 11TH JULY, 2017		
0900– 0930 hrs	**Registration(Auditorium)**	
INAUGURAL SESSION		
0930-0935 hrs	Welcome and Lighting of Lamp	
0934-0945 hrs	Course Overview and Felicitations: Dr. Sonali Ghosh, Scientist F, WII-C2C	
0945-0955 hrs	Opening Remarks: Dr. V.B. Mathur, Director, WII	
0955-1010 hrs	Address by Mr. Shankar Nelamangala, Senior Director, Civil Government Segment, Digital Globe	
1010-1025 hrs	Address by Chief Guest, Mr. Vinay Sheel Oberoi, Former Permanent Representative of India at UNESCO & Former Secretary, Ministry of Human Resource Development, Government of India.	
1025-1030 hrs	Vote of Thanks	
1030-1100 hrs	**GROUP PHOTOGRAPH AND TEA (AUDITORIUM)**	
	Subject/ Topic	**Resource Person**
1100-1130 hrs	Overview on World Natural Heritage and Monitoring using Earth Observation	Dr. Sonali Ghosh, Scientist F, WII-C2C
1130-1300 hrs	Introduction to Digital Globe Products and Services	Dr. Abhineet Jain, Regional Director, Digital Globe, Singapore
1300-1400 hrs	**LUNCH BREAK**	
1400- 1430 hrs	Exploring the Discovery Tool of Digital Globe Archive and Traditional Processes	Mr. Andrew Steele, Manager, Sales Engineering, Digital Globe

	of Acquiring VHRS Imagery	
1430- 1530 hrs	Basic Image Processing and Spectral Exploration of Worldview 2/3 images in ERDAS	Mr. Andrew Steele and C2C Team
1530-1545 hrs	**TEA BREAK**	
1545-1700 hrs	Exploring Digital Globe's online Cloud Platform Access	Mr. Andrew Steele and C2C Team
1700- 1730 hrs	Group Practical contd. and wrap up	Mr. Andrew Steele and C2C Team
2000- 2200 hrs	Course Dinner at Riverstone Cottage *(Participants to leave WII Campus at 1830 hrs)*	

WEDNESDAY, 12th JULY, 2017		
0930-1015 hrs	Introduction to Global Datasets	Dr. Gautam Talukdar, Scientist E, WII
1015-1025 hrs	Documentary Screening (World Heritage)	
1025-1115 hrs	Disaster Risk Reduction And Response in WHS, 3D Elevation Datasets, First Look Emergency Tasking Services, Tomnod and Geospatial Big Data Platform	Dr. Abhineet Jain
1115-1130 hrs	**TEA BREAK**	
1200-1300 hrs	Characterizing Ecosystem Services in Keoladeo National Park (World Heritage Site)- exploring high resolution satellite remote sensing data and other tools	Dr. P.K. Joshi, Professor, School of Environmental Sciences, Jawaharlal Nehru University(JNU), Delhi
1300-1400 hrs	**LUNCH**	
1400-1530 hrs	Group Practical (Invasive species mapping and image classification exercise)	Dr. P.K. Joshi
1530-1545 hrs	**TEA BREAK**	
1545-1730 hrs	Continuation of Practical	Mr. Shailesh Shankar and C2C Team

THURSDAY, 13th JULY, 2017		
0630-0715 hrs	Tracking *tricarinates*: A Nature Walk	Dr. Suresh Kumar, Scientist E, WII
0800-1030 hrs	Field Trip (for ground truthing)	Digital Globe & C2C
1030-1045 hrs	Documentary Screening (Cultural Landscapes)	

1045-1100 hrs	**TEA BREAK**	
1100-1230 hrs	Application of Very High Resolution Imagery in Forest Management	Mr. Saibal Dasgupta, IFS, Director General, Forest Survey of India, Dehradun
1230-1330 hrs	**LUNCH BREAK**	
1330-1415 hrs	Travel to IIRS	
1415-1730 hrs	Use of Terrestrial Laser Scanner (TLS)/ Close Range Photogrammetry in Natural Heritage Sites	

FRIDAY, 14TH JULY, 2017		
0830-0930 hrs	Demo on Unmanned Aerial Vehicle (UAV)/ Drone Technology in Forestry/ Wildlife Applications	Mr. Saurav Deb Roy, Co- founder & Business Head, Bubblefly, Delhi
0930-1000 hrs	World Heritage Site Monitoring and Reporting	Dr. Sonali Ghosh, Scientist F, WII-C2C
1000-1200 hrs	Presentation by course participants, feedback, collaborations with C2C and Digital Globe	
1200-1300 hrs	Keynote address	Dr. P.S. Roy, Senior Scientist, Centre for Earth & Space Science, University of Hyderabad, India.
1300-1400 hrs	**LUNCH BREAK**	
1400-1500 hrs	Valedictory	
1500 hrs onwards	Departure of Participants	

Link to all PPTs and Photographs:

https://drive.google.com/open?id=0B_Ep0UWVwOdgMGtta2hSdDFHNHM

ANNEXURE- II

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ANNEXURE- III

PROFILE OF SPEAKERS

Vinod B. Mathur,

Director, Wildlife Institute of India & UNESCO C2C

Dr. Vinod B. Mathur joined the Indian Forest Service (IFS) in 1985. He obtained his doctorate degree in wildlife ecology from the University of Oxford, United Kingdom in 1991. He is the Regiional Vice-Chair of the IUCN-World Commission on Protected Areas (WCPA-South Asia) and member of the International Association of Impact Assessment (IAIA). He is currently serving as member of Ministry of Environment & Forests (MoEF), Government of India Committees on World Heritage Conservation, Biosphere Reserves, Management Effectiveness Evaluation and Environment Appraisal of Coal and Thermal Projects. He has now spent more than 34 years in WII, actively contributing to its wide range of training, research and academic programmes in the field of biodiversity conservation and research-policy interface. He has extensive experience as an international trainer and his special interest include biodiversity conservation, environmental and strategic impact assessment, biodiversity informatics and natural heritage conservation. He has been actively contributing on research-policy interface issues and is the member of United Nations-Intergovernmental Panel on Biodiversity and Ecosystem Services (UN-IPBES) Multidisciplinary Expert Panel (MEP). He has been part of the official Indian delegation for CBD and UNESCO World Heritage Convention Meetings since 2006 and has in-depth knowledge about the working of these conventions.

Vinay Sheel Oberoi

Shri Vinay Sheel Oberoi is a 1979 batch retired IAS Officer of the Assam Meghalaya Cadre. He was Secretary, Department of Higher Education in the Ministry of Human Resource Development, Government of India at New Delhi. He has served in various departments of his cadre as well as on Central Deputation and assignments abroad. Shri Oberoi was Permanent Representative of India to UNESCO, Paris from 2010 to 2014. During his stay in Paris, he spearheaded the task of successfully bringing in transformational changes in the working of the UNESCO World Heritage Convention.

Abhineet Jain,

Director - Business Development for Asia Pacific Region, Digital Globe

Dr. Abhineet Jain is Director - Business Development for Asia Pacific region of Digital Globe. Dr. Abhineet has been in the Remote Sensing and Photogrammetry Industry for the last 24 years, having done his Masters in Botany and Post Graduate research in the field of climate change from Indian Institute of Remote Sensing (IIRS), Dehradun, Department of Space, Government of India. In the last 15 years, Dr. Abhineet has served various roles in the industry as Industry Manager, channel Manager, Aerial Survey specialist (Products and Services) and head of Sales and business development with Intergraph and other prominent companies. Environment & Forestry and Disaster Management are among his favourite areas where he has been promoting the use of Remote Sensing.

Sonali Ghosh

Dr. Sonali Ghosh has more than 17 years of work experience in the field of forest and wildlife conservation. The initiation began when she completed her master's in wildlife science from Wildlife Institute of India in 1997. Subsequently she worked as a research fellow with WWF-India and Indian Institute of Remote Sensing and joined the Indian Forest Service (IFS) in Assam-Meghalaya cadre in year 2000. During her service tenure in Assam, she has mostly worked as a Protected Area manager. The sites include Kaziranga and Manas World Heritage sites wherein she gained experience from implementing various projects related to park management and community development. She has also been part of the drafting team for the Management Plan for Assam State zoo, Chakrashila Wildlife Sanctuary, Tiger Conservation Plan for Manas Tiger Reserve and preliminary Working Plans for Kachugaon and Haltugaon Forest Divisions. In 2014, she completed her PhD from Aberystwyth University, Wales UK in the field of Physical Geography wherein she used Remote Sensing and GIS tools to analyse habitat suitability for Tigers (*Pantheria tigris*) in the Indo-Bhutan Manas Landscape. She joined the UNESCO-C2C in December 2014 and have since been entrusted with the primary task of capacity building and strengthening the network of Natural and mixed World Heritage Sites in Asia-Pacific region.

Shankar Nelamangla,

Senior Director, Government Programs, Digital Globe India

Mr. N.S. Shankaranarayana (Shankar) is Senior Director, Government Programs, DigitalGlobe, working with Digital India Land Record Projects, E-Governance and Watershed Programs. Shankar has more than 30 years experience in International Satellite Remote Sensing/3-D GIS/ Visual Information Technology solutions business. As Director, IRS Program at Space Imaging/ Lockheed Martin, USA, he has established more than 20 ground stations from IRS-satellites data distribution network along with IKONOS satellite program. He was working as Vice President, International Programs at The Sanborn Map Company, took lead role in 3-D GIS mapping programs in DSSDI Delhi and Middle East. He was former ISRO Scientist and founder Business Development Manager, Antrix Corporation. He has a degree in Electronics and Instrumentation engineering from Indian Institute of Science Bangalore.

Andrew Steele,

Manager, Sales Engineering, Digital Globe

Mr. Andrew Steele holds the position of Sales Engineer with Digital Globe Singapore. He has more than 10 years of experience in geospatial industry. He has interest in analysis of big data, artificial network, GIS modeling, 3D GIS modeling for various applications in the field of disaster management, forestry, urban planning, and water resources.

Gautam Talukdar

Scientist, Wildlife Institute of India

Dr. Gautam Talukdar obtained his Ph.D. from the Indian Institute of Remote Sensing (IIRS), Dehradun. He has been in the field of Geoinformatics for more than ten years and has experience with several reputed institutes such as the Forest Survey of India (FSI) and the Centre for Development of Advanced Computing (CDAC). He has worked in several national and international level projects, such as landscape dynamics and its impact on ecosystem composition, biodiversity characterization at the landscape level and the Natural Resources Census (NRCENSUS). His research interests include advances in remote sensing, geospatial modelling for issues relevant to sustainable

development, data interoperability and climate change. He is also involved in teaching geoinformatics for wildlife management.

Pawan Kumar Joshi

Professor, School of Environmental Sciences, JNU

Dr. Pawan is trained as an environmentalist with specialization in satellite remote sensing and GIS. Prior to joining SES-JNU, he was Professor & Head Department of Natural Resources, TERI University, New Delhi. Before that he spent around a decade with the Indian Space Research Organisation (ISRO) posted at Indian Institute of Remote Sensing (IIRS), Dehradun. During this, he was also adjunct faculty to the Centre for Space Science and Technology Education in Asia and the pacific (CSSTEAP), an UN affiliated institution. He was visiting faculty to University of Helsinki, Finland (Spring 2009), Yale School of Forestry and Environmental Studies (YSF&ES), USA (Spring 2011) and University of Freiburg, Germany (October 2011-14). His research focuses on applications of RS&GIS for environmental studies including landscape characterization and climate change. He has immensely contributed to ISRO, NASA, DST, MOEFCC funded projects. His research contributions have been recognized by the Indian National Science Academy (INSA) and the National Academy of Sciences India (NASI) through the award of their highly prestigious Young Scientist Medal (2006) and Young Scientist Platinum Jubilee Award (2009) respectively and many others of similar kind. Recently he was awarded P. R. Pisharoty Memorial Award (Indian National Remote Sensing Award) (2014) for contribution in RS & GIS. He has consistently published in peer-reviewed journals, written monographs/books.

Suresh Kumar

Scientist, Wildlife Institute of India

He has been involved in field research on threatened and lesser known fauna since 1998. His research interests understand the distribution of species and their habitat requirements, assessing their status and developing conservation strategies. He carried out research on galliformes in north and north-east India and discovered a new subspecies of Sclater's monal pheasant from Arunachal Pradesh. Later, he carried out a study on a new species of monkey – the Arunachal macaque – from western Arunachal Pradesh. And, since 2005, he has been researching using satellite telemetry the movement and migration of the olive Ridley sea turtle along the east coast of India.

Saibal Dasgupta,

Director General, Forest Survey of India, Dehradun

Shri Saibal Dasgupta joined the Indian Forest Service (IFS) in 1984 and allotted Madhya Pradesh Cadre. He has more than 33 years of experience in the field of forest management. His area of specialization is Remote Sensing, GIS, Human Resource Development and Project formulation. From 2006, he is holding the post of Director General, Forest Survey of India. He has published more than 4 books and 40 research papers. He is Member of IUCN, IUFRO, various committees of MOEFCC.

Uttara Pandey,

Senior Manager – RS & GIS

Dr. Uttara Pandey holds a Doctorate in Forestry (Forest Environment Management) from the Forest Research Institute, Dehradun. Dr. Pandey possesses expertise in Remote Sensing Data Efficiency and Remote Sensing Data Proficiency with specialization in IRS Cartosat-1, LISS-III & LISS-IV, MODIS, ASTER, Landsat and Envisat ASAR, ERS ½ & TerraSAR-X. Dr. Pandey is associated with the USAID funded Forest-PLUS Program, a technical assistance program funded by USAID India for the development of REDD+ projects in various landscapes in India. Prior to joining IORA, she was associated with IIT Mumbai as a Project Manager, looking after the entire project planning and implementation process, project documentation, ensuring error-free deliverables and successful project implementation. She served as a GIS Manager with the Uttar Pradesh Forest Department and was associated with the Uttar Pradesh Participatory Forest Management & Poverty Alleviation Project, which involved the implementation of Joint Forest Management activities in 20 forest divisions, spread over 14 districts. Dr. Pandey has also trained Indian Forest Services (IFS) and State Forest Services (SFS) probationers and taught Postgraduate Diploma and M.Tech students at the Indian Institute of Remote Sensing, Dehradun.

Yadvendradev V. Jhala,

Scientist G; Department of Animal Ecology and Conservation Biology, WII

Wildlife has been his passion since his early childhood. He studied zoology for bachelor's and master's degrees from the University of Bombay. For his Ph.D. research at Virginia Polytechnic Institute and State University, he used optimization to manage the conflicting habitat needs

of two endangered species that interacted as prey (blackbuck) and predator (wolf). In 1991, he obtained a postdoctoral fellowship at the Smithsonian Institution and studied reproductive energetics using doubly labelled water. Later, he taught courses in wildlife conservation and management for the Smithsonian Institution in China, Tanzania, Malaysia, India and the U.S.A. He joined the Wildlife Institute of India in 1993 and have since pursued an active research programme on Indian carnivores. He have supervised research projects on the Indian wolf, striped hyaena, golden jackal, Indian fox, Asiatic lion and tiger using VHF, GPS, satellite and recapture telemetry. He supervises the Conservation Genetics Laboratory at WII. He teaches Biometry and Population Ecology for the master's course in wildlife science and Applied Population Ecology for the diploma programme in wildlife management. He continues to be a research associate of the Smithsonian Institution and a member of the IUCN SSC Specialist Group for Wolves and Canids.

Partha Sarathi Roy

NASI Senior Scientist Platinum Jubilee Fellow Center for Earth & Space Sciences, University of Hyderabad

Dr. Roy is world renowned scientist in the field of Geospatial technology with more than 40 years of experience. He has been Visiting Scientist in University of Illinois, Urbana, US. Fellow of National Academy of Science, India (FNASc) and Fellow of National Academy of Agricultural Sciences (FNAAS). Fellow of Indian Society of Remote Sensing, B P Pal National Environmental Fellow. Chair Professor at University of Hyderabad (UoH), (2012-15). Presently NASI Senior Scientist Platinum Jubilee Fellow at UoH, Hyderabad. He has more than 450 publications in peer-reviewed journals, written monographs and books. He has also been associated with ISRO for more than 35 Years as Scientist.

Srinivasan Kanni Udaiyar,

Research Head, Aerial Robotics, Bubblefly technologies Pvt Ltd

Shri Srinivasan Kanni udaiyar is R&D head at Bubblefly Technologies private limited with more than 4 years of experience in UAV technologies. Prior joining Bubblefly Technologies he is associated with Google and Averecon technology. He has a bachelor's degree in computer engineering from Anna University Chennai.

ANNEXURE- IV

Group Practical

International Training course on Application of Very High Resolution Satellite Data in Natural Heritage Management in South Asia (11-14 July, 2017)

Background: These exercises are prepared for the participants at the Wildlife Institute of India (WII), Dehradun. The objective is to provide hands-on training on visualising and exploring the very high resolution multispectral satellite data. After completing these exercises the participants will be confident to open and visualise the satellite data and understand the spectral response pattern/profile of different features as captured by the very high resolution satellite data in 7 bands. The participants will also assess pixel based classification (by giving training data) to understand the spectral variability and capability of very high resolution satellite data to map the individual tree species and stands. The exercise uses a subset of WorldView-3 (8 bands, 1 m) data of Keoladeo National Park (KNP), which was procured by Spatial Analysis and Informatics Laboratory (SAIL), School of Environmental Sciences, Jawaharlal Nehru University (JNU), New Delhi. The data is being used only for this training purpose.

Disclaimer: The exercises designed here do not limit the scope of Digital Image Processing and functions available in the Erdas Imagine. The faculty/author has used icons and details provided in Erdas Imagine only for the purpose of training/education and not commercial usage. Any resemblance to existing documents is mere coincidence.

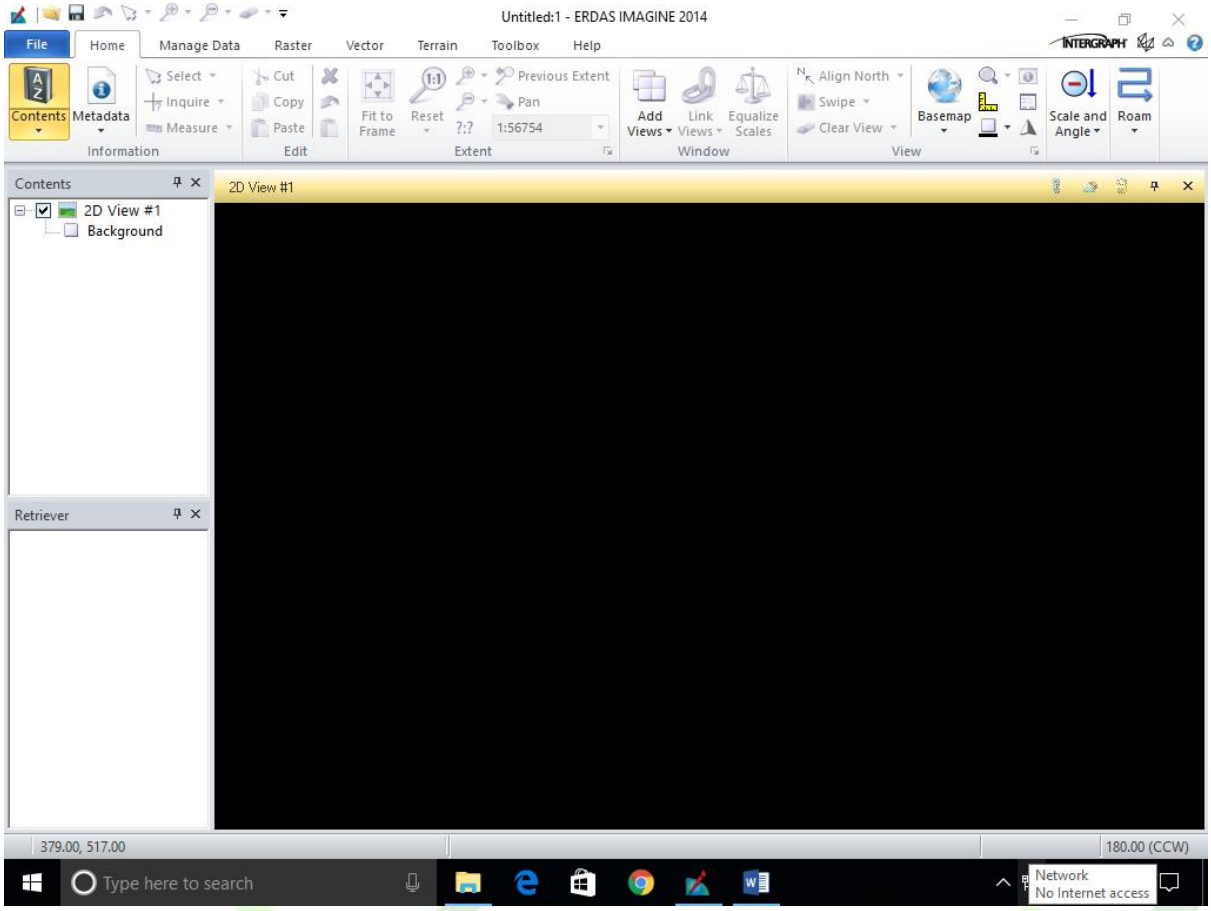
Note:

I. The participants and organisers are free to use these hand-outs for multiple purposes. However, the data being given is limited to use in this training course only.

II. Each instruction has some keywords mentioned within "< >", these are exactly the terms being used in Erdas Imagine. The participant should try locating these on the software. In case of difficulty or absence of assistantship, same could be located using <Search Command> within <Help>.

III. Text mention against „NB‟ denotes alternate options. It also provides details for better understanding of the readers.

On invoking Erdas Imagine 2014 you will be able to see the following display on the monitor.



There might be slight variations based on the version of Erdas Imagine installed on your machine. It should not affect your working for this exercise.

Exercise 1: ***A quick review of creating True Colour Composite (TCC) and False Colour Composite (FCC)***

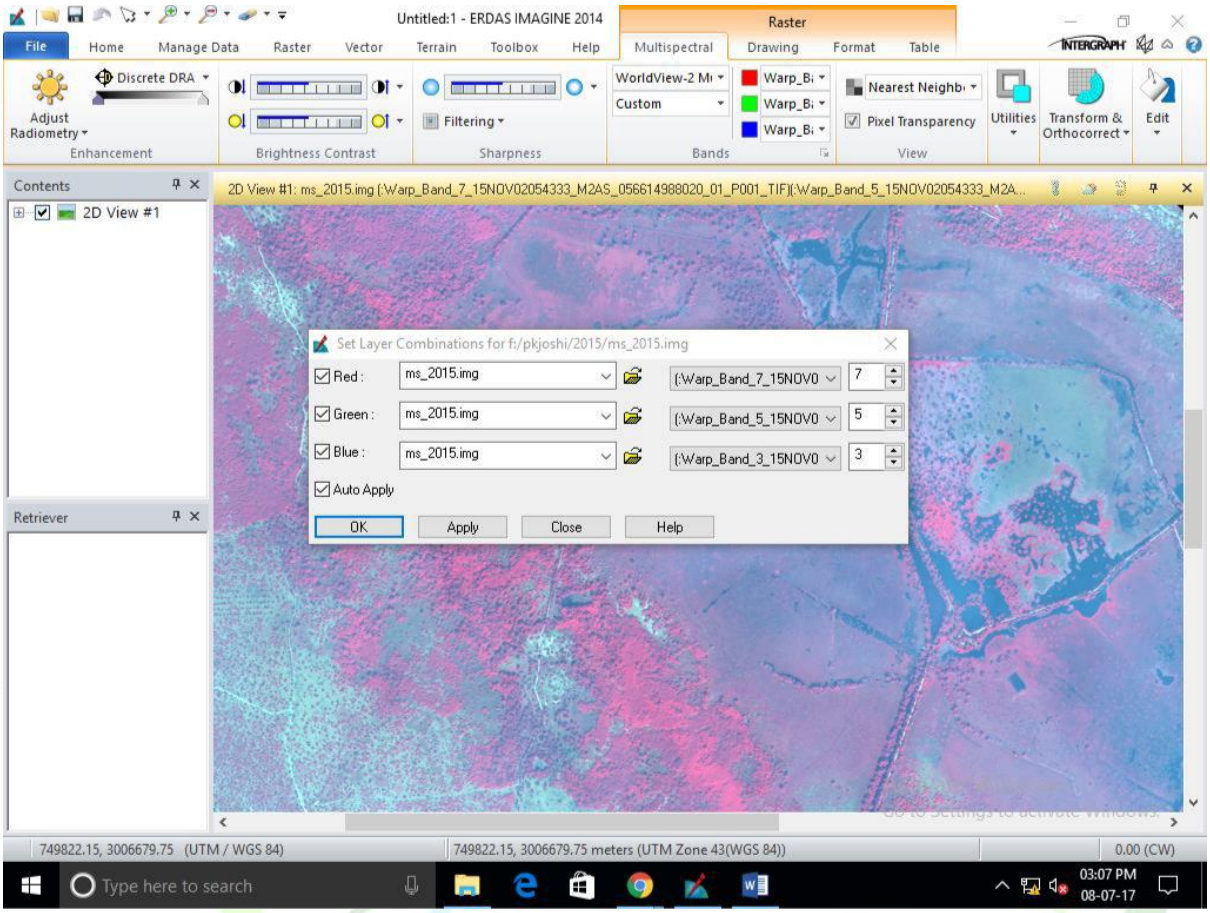
Right click on the <2D View #1> (within Contents) for <Open Raster> to select the satellite data to open. Go to d:\PKJ\image.img

NB: You can do the same using file open icon on the top panel.

Click the icon <Fit to Frame> to display the complete image on the viewer.

NB: You can do the same by right click and select <Fit to Frame>. Click the option <Multispectral> given on the top of the panel. Click on <Bands>, this will invoke Set Layer Combination for (file name). This is used to change the band combination so as to view the image in desired colour combination.

You may check off <Auto Apply> and change the band display by altering the numbers on the right-hand-side of the menu. These numbers represent the respective wavelength.



NB: To know the respective band width you should know the Spectral Resolution of the satellite data you are using. For example, you are using Multispectral WorlView-3 dataset and following are the specifications:

Coastal	400 – 450 nm	Red	630– 690 nm
Blue	450 – 510 nm	Red Edge	705– 754 nm
Green	510 – 580 nm	NIR-IR1	770– 895 nm
Yellow	585 – 625 nm	NIT-IR2	860– 1040 nm

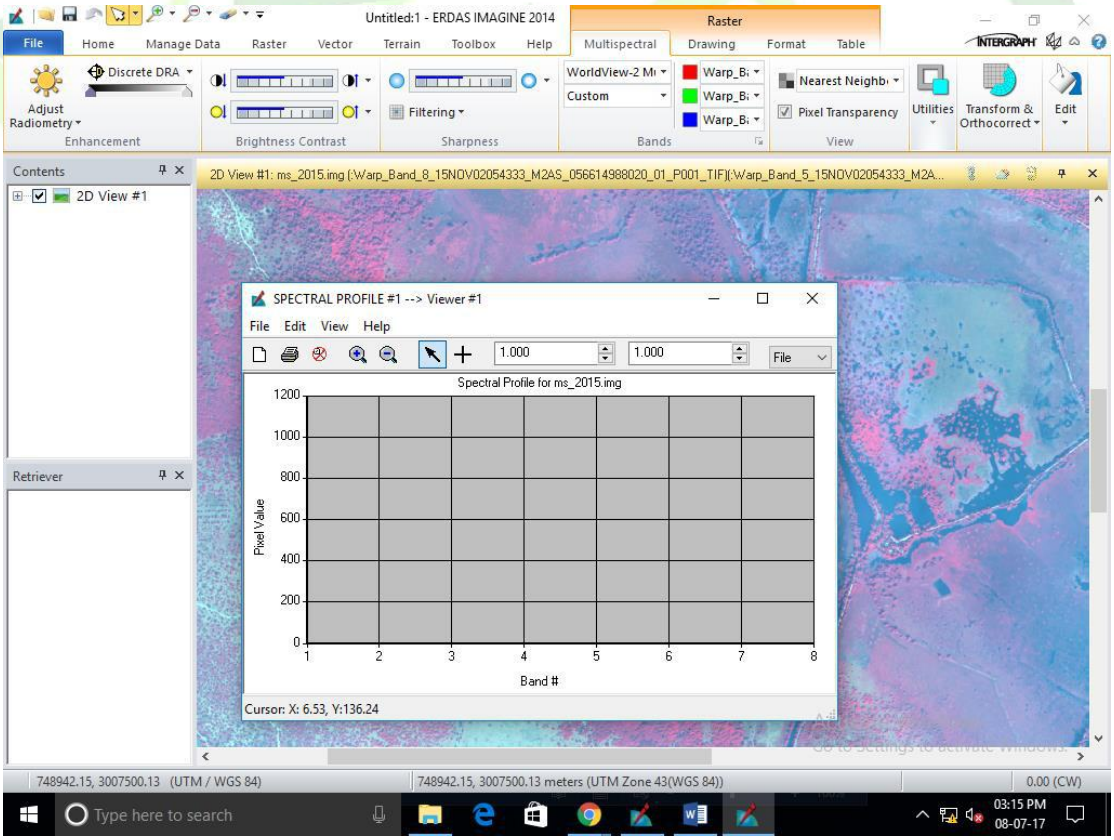
To create a True Colour Composite (TCC) select 5 : 3: 2 (on Red, Green, Blue image plane) as the combination. Click apply to see the satellite data in TCC. This is the combination in which actually the ground would look when you are flying over this. There may be slight variations depending on the condition of the atmosphere on the day of flight and data capture.

Click the option <Multispectral> given on the top of the panel and then <Bands> to change the lay combination. To create a standard False Colour

Composite (FCC), select 7 : 5 : 3 (on Red, Green, Blue image plane). Click apply to see the satellite data in FCC.

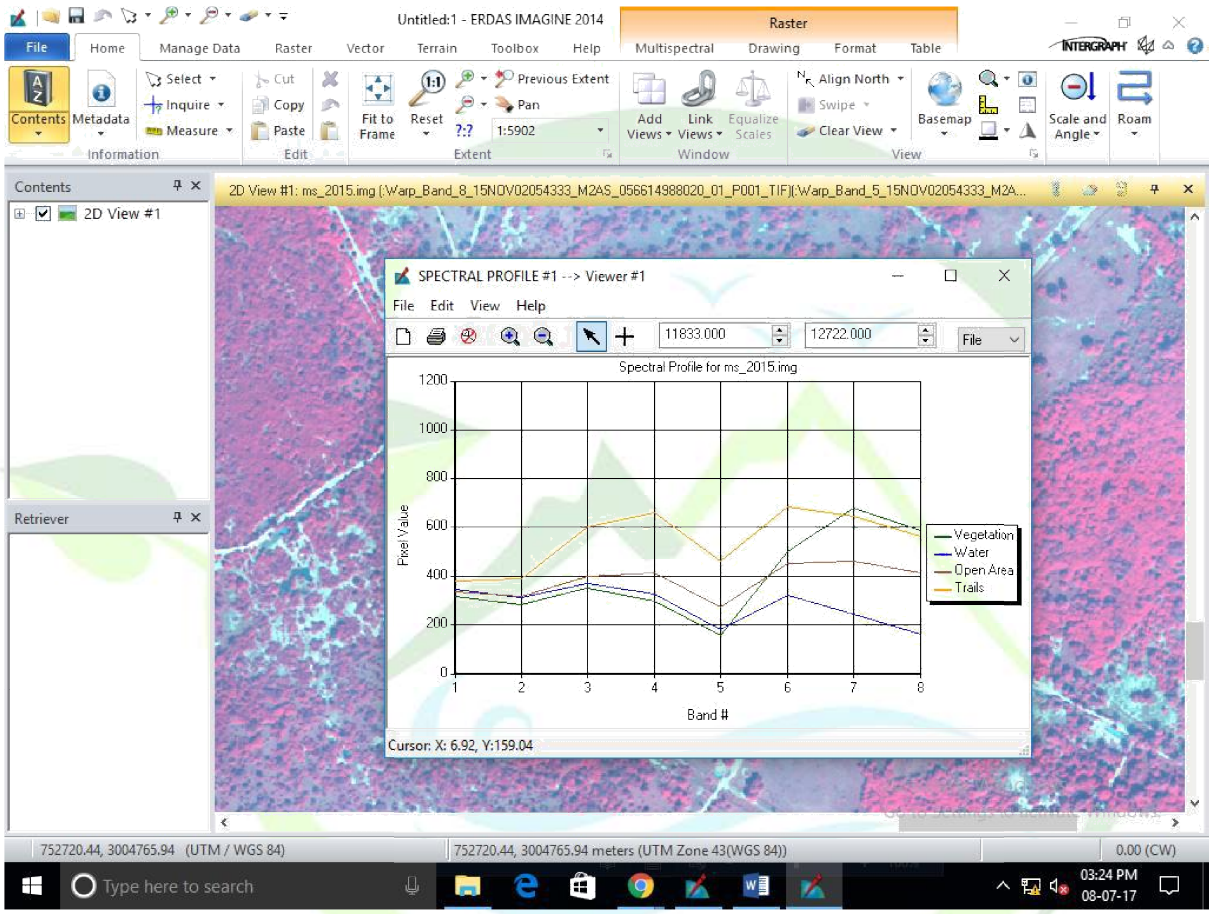
NB: You might like to see 8: 5: 3 (on Red, Green, Blue image plane) which will again be standard FCC. However, if you select any other combination you will be able to see different types of FCC (please remember these are FCCs, not standard FCC). One may select any of the band combinations so as for see visualise the data. Some of the features might appear very contrasting in a specific combination, thus there is no rule of thumb. But most the time remote sensing community prefers standard FCC to visualise the data as it gives the maximum information. The TCC is used for the common purpose usage as it is the closest to the reality.

Exercise 2: ***A quick review of creating spectral profiles for different earth surface features using the given satellite data***



Click the option <Multispectral> given on the top of the panel. Click on <Utilities> and select <Spectral Profile>. This will invoke a menu Spectral Profile.

NB: Spectral Profile is the spectral signature of the feature of interest in the given spectral resolution of satellite data. By generating this one is able to see the pattern of variation in the spectral response/values of selected features across the spectral bands of the satellite data.



NB: These could be very close to the spectral signature we have studied in the theory. You have numerous options to customise these plots.

Exercise 3: ***Pixel based supervised classification for target detection and preparation of vegetation type/land use land cover map.***

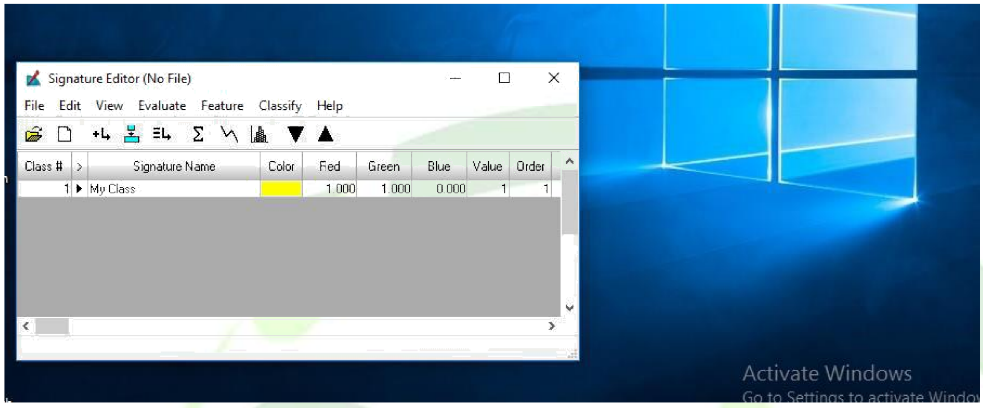
NB: Satellite image classification is the process of sorting pixels into a finite number of individual classes, or categories of data based on their data pixel values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to that criterion. Supervised classification is more closely controlled by interpreter/analyst than unsupervised classification. In this process, you

select pixels (training sets using AOI) that represent patterns you recognize or that you can identify with help from other sources (including field knowledge).

Go to Viewer. Open your image “Execise_2015” as standard FCC.

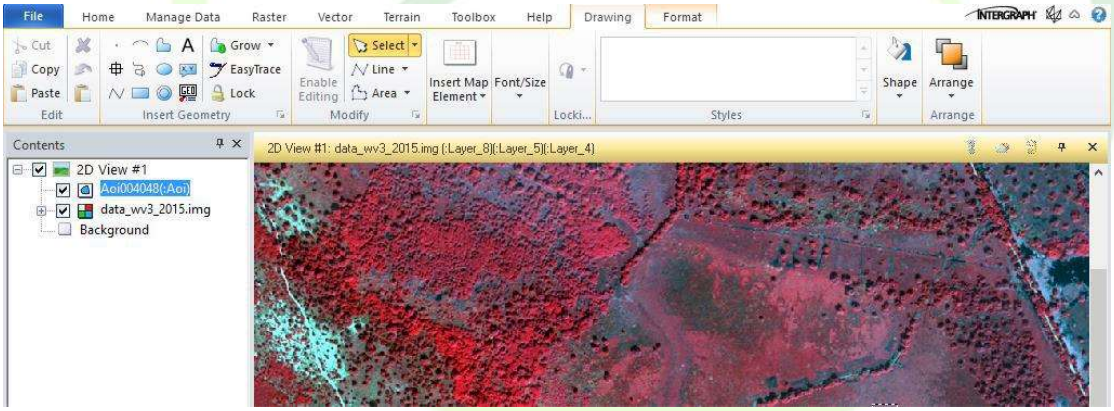
To create training set, Click <Raster>, <Classification>, <Supervised> and select <Signature Editor>.

A pop-up <Signature Editor> will appear. You can save it in your working directory.



Identify a known location and zoom-it-in to locate the pixels to be used for the training set.

Click <Drawing> and go to <Insert Geometry>. Using the polygon tool create training set (AOI) on the image.



NB: AOI is a polygon created as dotted lines around the area of interest and a bounding box surrounding the polygon (indicating that it is currently selected– click on this if the box is not appearing).

Go to the <Signature Editor>, on the menu bar click <Edit> and select <Add> (a signature will be added to the Signature Editor file).

In case your training set or AOI on the viewer is not selected, a message “Error getting AOI from Viewer. Use AOI Tools in Viewer to create AOIs for Signature Editor” will pop-up.

In the Signature Editor, click inside the Signature Name column for the signature you just added. Change the name to “the class you are trying to map” then press Return on the keyboard.

Hold (left or right click) in the Colour column next to Signature Name and select a colour.

Zoom in on one of the similar set pixels on some other locations in the Viewer.

Draw a polygon (as you did in previous steps). Name it as done (note that you can‟t give the same name, though the class is same for you).

The Signature Alarm utility highlights the pixels in the Viewer that belong to, or are estimated to belong to a class according to the parallelepiped decision rule. An alarm can be performed with one or more signatures. If you do not have any signatures selected, then the active signature, which is next to the >, is used.

In the Signature Editor, select the first training set by clicking in the > column for that signature.

In the Signature Editor menu bar, select <View> and then <Image Alarm>.

NB: The Signature Alarm dialog pops-up. Click Edit Parallelepiped Limits in the Signature Alarm dialog to view the limits for the parallelepiped. In the Limits dialog, click Set to define the parallelepiped limits. The Set Parallelepiped Limits dialog opens. The Signature Alarm utility allows you to define the parallelepiped limits by either (i) minimum and maximum for each layer in the signature, or (ii) a specified number of standard deviations from the mean of the signature. If you wish, you can set new parallelepiped limits and click OK in the Set Parallelepiped Limits dialog OR simply accept the default limits by clicking OK in the Set Parallelepiped Limits dialog. Click Close in the Limits dialog.

In the Signature Alarm dialog, click <OK>.

The alarmed pixels display in the Viewer. You can use the toggle function <Utility> and <Flicker> in the Viewer to see how the pixels are classified by the alarm.

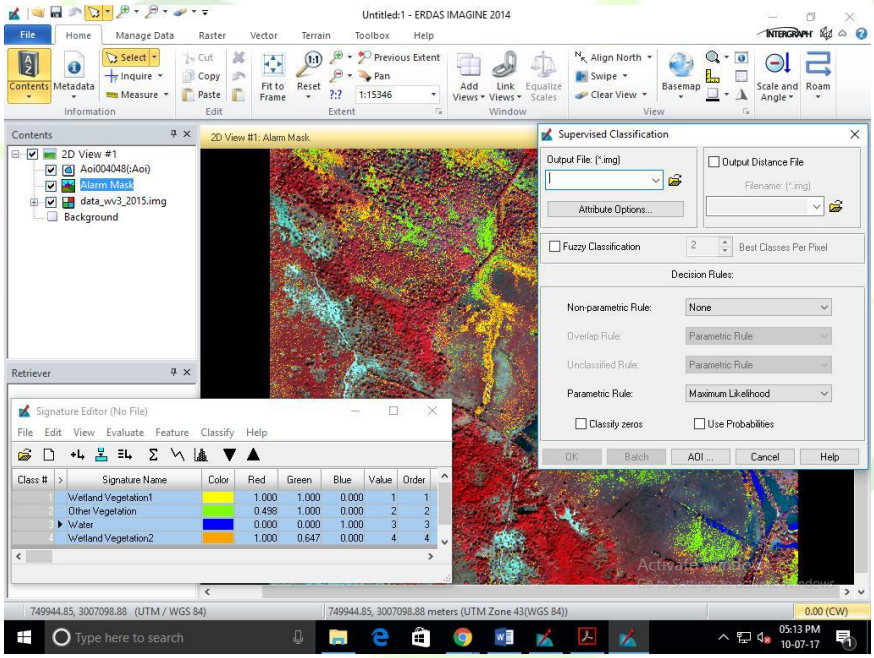
In the Signature Alarm dialog, click Close.
In the Contents, select Right Click <Alarm Mask; you can <Save Layer> or <Remote Layer>.
You can see for more than one class and look for the overlaps if any.
NB: Some of the training sets (AOI files) are given in your working directory for practice. Try to call or Open those on your viewer as <Open AOI Layer>, select each of them and visualise the image alarm.

Classification

Many a time users save the Alarm Mask as the individual classes. This is specifically done when one is interested in target mapping.

For entire image classification (vegetation type/land use land cover), in the Signature Editor, select all of the signatures so that they are all used in the classification process (if none of the signatures are selected, then they are all used by default).

In the Signature Editor menu bar, select <Classify> and <Supervised> to perform a supervised classification. The Supervised Classification dialog box pops-up.



Under the Output File, type in (super_data.img). Fill the details in Non-Parametric Rule and Parametric Rule. Click OK and see the results of classification.