

Presentation

on

### **Geospatial Technology in Forestry**

for



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by

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### Outline

- Importance of Forestry
- **Economic Benefits of Forestry**
- Forest Conservator's Pain Areas
- Remote Sensing & Digital Image Processingbased Solutions
- Geographic Information System (GIS)
  Technology-based Solutions
- Solution: Nallamala Forest, Andhra Pradesh, India
  - Remotely Sensed Digital Image Processing
  - Information Capturing & Attribute Management
  - Geospatial Analysis
  - Desktop Automation
  - Collaboration, Integration & Web-enablement

### **Importance of Forestry**

- Regulates Slope Stability & Soil Erosion
- Controls Hydrology & Reduces Downstream Flooding
- Supplies Water for Power Generation & Irrigation
- Acts as Windbreaks & Shelterbelts
- Increases Soil Fertility
- Network of Deep Tree Roots act as Natural Water Filters
- Sustains Biodiversity
- Stabilizes Climate & Weather
- Sequesters Carbon & Sources Oxygen







- Forest Produces
  (Lumber, Timber, Plywood, Sawn Wood, Fuel Wood, Matchwood, Wood Fiber, Tendu Leaves - Diospyros sp., Sal Seeds
   Shorea sp., Bamboo, Cane, Rattan, Resins, Gums, Grass, Fodder, Herbs, Medicinal Plants, Tannins & other Nonwood Forest Products)
- Employment for Marginal Farmers & Landless Laborers
- Recreation & Ecotourism
- Protection of Watersheds for Downstream Agriculture





### Forest Conservator's Pain Areas

- Depending on Laborious Ground-based Forest Surveys
- Monitoring Health & Quality of Forests
- Assessment of Change in Forest Cover
- Identification of Sustainable Locations for Forest Regeneration
- Transportation Routing of Forest Produces through feasible Corridors
- Forest Surveillance & Encroachment Monitoring
- **Solution** Controlling of Wildfire & Regulating Soil Erosion
- Assessment of Environmental Impact of nearby Industrial Development
- Understanding of Surface Drainage Pattern beneath Forests
- Estimation of Trees Outside Forests & Identification of Suitable Sites for Social Forestry





### **Remote Sensing & Digital Image Processing-based Solutions**

- Sampling of Larger Areas, Rapid
  Acquisition & Speedy Assessment
- Consistent Monitoring & Spatiotemporal Change Detection
- Both Qualitative & Quantitative Estimation
- Monitoring of Annual Growth, Degradation & Depletion
- Measurement of Crown Diameter & Canopy Height
- Estimation of Forest Age & Volume of Woody Biomass
- Health, Vigor & Stress Monitoring
- Automated Workflows



HRSI Interferometsy Temporal Biophysical Properties Follar Chemistry Volume of Woody Biomass Automated Workflows Protection of Watershed Canopy Density Infestation of Pests Forest Health Afforestation & Stocking

Resolutions Measurement of Crown Diameter & Closure Canopy Height through Light Detection & Ranging (LIDAR) **Annual Growth Electromagnetic Spectrum & Reflectance** Spatial Forest Degradation & Monitoring of Depletion Hyperspectral Technology Damage caused by Diseases **RADAR Rapid Acquisition & Assessment** Differentiation of Tree Species Forest Cover **Consistent Monitoring Spatiotemporal Change Detection** Floristic Composition & Species Inventory Environmental Monitoring Forest Classification Aerial Photographs Sampling of Larger Areas Cutting & Regeneration Estimation of Forest Age Vigor & Stress Qualitative & Quantitative Estimation Timber Volume Prescribed Burning & Wildfire MicrowaveSensing Active & Possive Sensors Videography Nutrient & Moisture Deficiencies Social & Commercial Forestry Polarimetry Spectral



### Geographic Information System (GIS) Technology-based Solutions

- Desktop & Mobile-based Data Capturing
- Querying, Statistical Analysis, Charting
  & Thematic Mapping
- Delineation of Forest Corridors for Routing of Harvest
- Finding Suitable Sites for Forest
  Rehabilitation
- Demarcating Ecologically Sensitive
  Zones around Protected Areas
- Monitoring of Pollution & Encroachments
- Identification of Wildfire-prone Areas
- Biodiversity Characterization & Wildlife Habitat Assessment
- Exploration of Spatial Patterns & Trends









### **Rolta's Software**



### Area of Interest: Nallamala Forest, Andhra Pradesh, India





IRS AWiFS (October 2010, Resolution: 56 m, NIR-R-G)

### Remotely Sensed Digital Image Processing: Automatic Selection of Ground Control Points (GCPs) for Geometric Correction



Remotely Sensed Digital Image Processing: Atmospheric Correction





Landsat TM (November 1992, Resolution: 28.5 m, NIR-R-G) Image after Atmospheric Correction





**Remotely Sensed Digital Image Processing:** Automatic Change Detection based on Spectral Reflectance



Landsat ETM+ (February 2001, Resolution: 28.5 m, NIR-R-G) IRS LISS-III (October - November 2009, Resolution: 23.5 m, NIR-R-G) Automatically Detected Changes

Remotely Sensed Digital Image Processing: Classes based on Canopy Density



Moderately Dense Forest (MDF)
 Non-forest Area (N)
 Open Forest (OF)
 Very Dense Forest (VDF)
 Waterbody (W)

**Remotely Sensed Digital Image Processing: Unsupervised** Classification

IRS LISS-III (October - November 2009, Resolution: 23.5 m, NIR-R-G)

**Classified Image** 

Moderately Dense Forest (MDF) Non-forest Areas (N) Open Forest (OF) Scrub (S) Very Dense Forest (VDF)







Remotely Sensed Digital Image Processing: Supervised Classification



Landsat ETM+ (February 2001, Resolution: 28.5 m, NIR-R-G)



Training Bitmaps for Classification VDF Training Bitmaps for Classification MDF Training Bitmaps for Classification OF Training Bitmaps for Classification S Training Bitmaps for Classification N Training Bitmaps for Classification W



- Moderately Dense Forest (MDF)
  Non-forest Areas (N)
  Open Forest (OF)
  Scrub (S)
  Very Dense Forest (VDF)
- Waterbodies (W)



Degraded Forest
 Good Forest

Remotely Sensed Digital Image Processing: Supervised Classification



IRS LISS-III (October - November 2009, Resolution: 23.5 m, NIR-R-G)





Barren Land / Non-forest Areas
 Green Areas
 Waterbodies



- Moderately Dense Forest (MDF)
- Non-forest Areas (N)
- Open Forest (OF)
- Scrub (S)
- Very Dense Forest (VDF)
- Waterbodies (W)

- - Training Bitmaps for Classification VDF Training Bitmaps for Classification MDF Training Bitmaps for Classification OF Training Bitmaps for Classification S Training Bitmaps for Classification N Training Bitmaps for Classification W







Remotely Sensed Digital Image Processing: Spatio-temporal Change Assessment



Landsat ETM+ (February 2001, Resolution: 28.5 m, NIR-R-G)



IRS LISS-III (October - November 2009, Resolution: 23.5 m, NIR-R-G)



Degraded Forest
 Good Forest



Degraded Forest
 Good Forest



- Degraded Forest to Good Forest
  Good Forest to Degraded Forest
- Good Forest to Waterbodies
- No Change
- Waterbodies to Good Forest

**Remotely Sensed Digital Image Processing:** Neural Network-based & Rule-based Classifications



**IRS LISS-III** (October - November 2009, Resolution: 23.5 m, NIR-R-G)





0 Degree - 10 Degrees 10 Degrees - 20 Degrees 20 Degrees - 35 Degrees > 35 Degrees



Lithosols





Slope > 10° & Soil Type is Lithosols Slope ≤ 10° & Land Cover is Non-forest



Agricultural Land Dense Forest





Remotely Sensed Digital Image Processing: Computation of Vegetation Indices





Normalized Difference Vegetation Index (NDVI)

Barren Rocks (0 to 0.1) Dense Forest Canopy (>0.3 to 0.6) Shrubs & Grasslands (>0.2 to 0.3) Soil (>0.1 to 0.2) Waterbody (-1 to <0)



Soil-adjusted Vegetation Index (SAVI)

Barren Rocks (0 to 0.1)
 Dense Forest Canopy (>0.3 to 1)
 Shrubs & Grasslands (>0.2 to 0.3)
 Soil (>0.1 to 0.2)
 Waterbody (-1 to <0)</li>





Normalized Difference Water Index (NDWI)

Green Vegetation (>-0.1 to <0.4)</p>



Leaf Area Index (LAI)

Bare Ground (0 to 0.1)
 Dense Forest (>4 to 10)

Landsat ETM+ (February 2001, Resolution: 28.5 m, NIR-R-G)

## ROLTA

### **Forestry Management Solution**

Data Capturing & Attribute Management: Charting & GeoTagging of Photographs



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**Forestry Management Solution** 

Data Capturing & Attribute Management: Unlawful Encroachment



IRS LISS-III (October - November 2009, Resolution: 23.5 m, NIR-R-G)



Assigned Area
 Encroached Area

**Boundary of Forest** 

Data Capturing & Attribute Management: Compensatory Afforestation



IRS LISS-III (October – November 2009, Resolution: 23.5 m, NIR-R-G)

Landsat ETM+ (February 2001, Resolution: 28.5 m, NIR-R-G)





### Data Capturing & Attribute Management: Social Forestry





Agroforestry
 Community (Rural) Forestry
 Extension Forestry
 Farm Forestry

# ROLTA

### **Forestry Management Solution**

Geospatial Analysis: Thematic Mapping



Moderately Dense Forest (Sq. Km, 2011)





**Geospatial Analysis:** Hotspots to demarcate Wildfire-prone Areas





Density of Fire Incidents (100 m, 25 Km) IRS AWiFS (October 2010, Resolution: 56 m, NIR-R-G) High Density

Low Density





### **Geospatial Analysis: Spatial Interpolation of Meteorological Data**



IRS AWiFS (October 2010, Resolution: 56 m, NIR-R-G)



Spline Interpolation of Rainfall (0.5 Flatness, 30m)





Geospatial Analysis: Pollution Monitoring







### **Geospatial Analysis: Proximity to Forest Corridors for Transportation of Harvest**



Forest Corridors
 2 Km Buffer Area
 5 Km Buffer Area

IRS AWiFS (October 2010, Resolution: 56 m, NIR-R-G)





### Geospatial Analysis: Computation of Slope from Digital Elevation Model (DEM) to detect Vulnerable Areas of Soil Erosion



IRS AWiFS (October 2010, Resolution: 56 m, NIR-R-G)



Digital Elevation Model (DEM) (ASTER, Resolution: 30 m)





Contours derived from ASTER DEM (Interval: 50 m)



Vulnerable Areas Slope computed from ASTER DEM

- 1 Degree 10 Degrees
  11 Degrees 20 Degrees
  21 Degrees 30 Degrees
  31 Degrees 40 Degrees
  41 Degrees 50 Degrees
  51 Degrees 60 Degrees
  61 Degrees 70 Degrees
  71 Degrees 80 Degrees
- 81 Degrees 90 Degrees

**Geospatial Analysis:** 

### Identification of Suitable Sites for Forest Regeneration through Growing Stocks

**Riverbanks** Streams Waterbodies Chromic Luvisols Lithosols Pelic Vertisols **IRS AWiFS** 0 Degree - 10 Degrees 10 Degrees - 20 Degrees (October 2010, 20 Degrees - 35 Degrees Resolution: 56 m, > 35 Degrees NIR-R-G) **Overlay Analysis for** identification of Suitable **Sites for Growing Stock** \* Will not fall on Riverbanks, **Streams & Waterbodies** Roads **\*** Have to be situated on Proximity to Roads (10 Km) Lithosols, where Slope of the Terrain is between 10° - 20 ° 🔺 Town 🔺 Village \* Will be located within 10 Kms Proximity to Settlements (10 Km) from Roads & Settlements

Suitable Areas for Growing Stock.

### **Geospatial Analysis: Mapping of Eco-sensitive Zones (ESZs) around Protected Areas**



A Priority-1 Town for Rehabilitation
 Priority-1 Village for Rehabilitation
 A Priority-2 Town for Rehabilitation
 Priority-2 Village for Rehabilitation
 Eco-sensitive Zone (ESZ)
 Nagarjunsagar-Srisailam Tiger Reserve
 Core Area

IRS AWiFS (October 2010, Resolution: 56 m, NIR-R-G)



### Geospatial Analysis: Biodiversity Characterization



<u>Disturbance Index</u>: Interspersion (35%) + Juxtaposition (25%) + Fragmentation (15%) + Biotic Disturbance (15%) + Porosity (10%)



Geospatial Analysis: Biodiversity Characterization



<u>Biological Richness</u>: Species Richness (35%) + Disturbance Index (25%) + Total Importance Value (15%) + Terrain Complexity (15%) + Ecosystem Uniqueness (10%)



### Geospatial Analysis: Viewshed Analysis for establishment of Watchtower & Identifying Panoramic Viewing Sites for Ecotourism Development



Landsat TM (November 1992, Resolution: 28.5 m, NIR-R-G)



Shaded Relief

United Watchtower

Visible Areas from more than one Watchtower

**Desktop Automation:** 

### Delineation of Catchment Boundaries & Drainage Network under Forest-covered Areas





Landsat TM (November 1992, Resolution: 28.5 m, NIR-R-G)



Digital Elevation Model (DEM) (ASTER, Resolution: 30 m)









### **Collaboration & Integration in Forestry Management Solution**





### Web-enablement of Forestry Management Solution











"Reforesting the earth is possible, given a human touch" – Sandra Postel & Lori Heise