2024

Geotagging and Geospatial Solutions for Forest management

FOREST DEPARTMENT, HARYANA

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Message

As the head of the Haryana Forest Department, I am proud to present this comprehensive document detailing the significant strides we have taken in forest management. Our department's initiatives, including the digitization of forest boundaries, geotagging of plantations, and the development of a sophisticated geospatial portal, exemplify our dedication to sustainable forestry practices. These efforts not only improve operational efficiency but also ensure that we maintain ecological balance and biodiversity.

The adoption of geospatial technologies has transformed our approach to forest management, enabling us to monitor forest health, assess biodiversity, and plan conservation strategies with greater accuracy. The ability to visualize forest data on interactive GIS platforms has enhanced our capacity to make informed decisions and implement effective interventions. This has been particularly beneficial in areas such as fire management, where real-time data allows for prompt action to mitigate the impact of forest fires.

This report encapsulates our journey and the innovative steps we have taken towards a greener future. It serves as a comprehensive guide to the various applications of geospatial solutions in forestry, demonstrating how these technologies have been instrumental in our efforts to protect and conserve Haryana's forest resources. I extend my gratitude to all the dedicated personnel who have contributed to these achievements, and I look forward to continuing our work towards sustainable forest management.

Pankaj Goel IFS,
PCCF (HoFF)

Editor's Page

In recent years, the Haryana Forest Department has made remarkable strides in adopting advanced geospatial technologies to enhance forest management. The potential of these technologies in revolutionizing forestry practices cannot be overstated. Geospatial solutions such as GIS and remote sensing provide critical insights into forest health, biodiversity conservation, and resource management. By leveraging these tools, we can achieve accurate mapping, effective monitoring, and timely interventions, ensuring sustainable forest management.

The integration of geospatial technology into our forestry operations allows us to monitor vast forest areas, assess the impact of various interventions, and make data-driven decisions. This technological advancement has enabled us to combat challenges such as deforestation, forest fires, and habitat degradation more effectively. The use of high-resolution satellite imagery and GIS mapping has provided us with unprecedented precision in managing forest resources, ensuring that our conservation efforts are both efficient and impactful.

Moreover, the emergence of breakthroughs in more frequent and high-quality remote sensing data availability, combined with the capacity of cloud computing and the power of AI to interpret data in real time, is opening up new frontiers in natural resource management. These advancements allow for close, real-time monitoring, providing invaluable inputs to address issues promptly and appropriately.

This report highlights our commitment to integrating innovative technologies into forestry, paving the way for transparent and accountable forest governance. It showcases the various applications of geospatial solutions in forestry, from forest inventory and biodiversity conservation to fire risk assessment and watershed management. The detailed documentation shows our endeavour to preserve Haryana's rich natural heritage through modern, science-based approaches.

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Geotagging and Geospatial Solutions for Forest Management

1. Introduction

The Haryana Forest Department has pioneered the use of geospatial technologies to enhance the efficiency and effectiveness of its forestry interventions. The department has digitized forest boundaries and forest assets, and hosted them on a web-based geospatial platform, integrating the latest satellite imagery for comprehensive visualization and monitoring. This innovative approach is supported by a mobile-based system for the spatial data collection of forestry interventions, such as geotagging annual plantation boundaries and individual plants. This document details the available technologies and their implications for forest management.

2. Digitization of Forest Areas by the Haryana Forest Department

To harness advanced GIS and Remote Sensing technologies in forestry, the Haryana Forest Department undertook the crucial task of digitizing forest boundaries. This process is essential for accurate mapping and analysis, forming the foundation for numerous forestry management and conservation initiatives. Additionally, the digitization of forest boundaries is required by the State government in compliance with various court orders and directions from the Ministry of Environment, Forest and Climate Change (MoEFCC).

The Supreme Court of India and MoEFCC, in various orders and directions, have emphasized that forest mapping should be completed by State Forest Departments. In the landmark T.N. Godavarman Thirumulpad vs. Union of India & Ors case, numerous orders focused on forest conservation, including the importance of identifying and mapping forest areas. Similarly, in the Lafarge Umiam Mining Pvt. Ltd. vs. Union of India case, the Court emphasized the need for precise identification and mapping of forest areas for effective conservation and management. Furthermore, the MoEFCC Notification dated 26.04.2001 provided guidelines for the identification and demarcation of forests using modern mapping techniques. It is evident from these orders and directions that the preparation of geo-referenced maps of forest areas to enhance forest conservation and management is a crucial activity to be completed. This activity includes the digitization of forest boundaries and making these layers accessible through a GIS portal.

2.1 Digitization Efforts

The Haryana Forest Department recognized the need for precise and accurate mapping of forest areas to leverage modern GIS and remote sensing technologies effectively. This led to the initiation of a comprehensive digitization project aimed at creating detailed and accurate digital maps of forest boundaries.

2.1.1 Block Forest Boundaries

Initiated in 2015, the Haryana Space Applications Centre (HARSAC) was associated with the task of digitizing block forest boundaries. This project successfully digitized 647 block forests, and these boundaries are now hosted on the department's geospatial portal. This digitization provides a clear and precise framework for forest management and planning.

2.1.2 Strip Forest Boundaries

In 2018, HARSAC extended its efforts to include strip forests, which comprise more than 40% of Haryana's forest area. The digitization of strip forests has been instrumental in identifying areas suitable for afforestation and in determining forest areas being affected for new projects seeking diversion under the Forest Conservation Act, 1980. This comprehensive mapping supports the planning and execution of conservation and development projects.

2.1.3 Morni Hills

The digitization of the 14-bhoj area in Morni Hills is being handled separately by the Survey of India (SoI) and revenue officials in collaboration with the Forest Department. To date, 150 out of 172 villages within the 14-bhoj area have been digitized using a best-fit methodology. This approach aligns the 3D features of the hilly Shiwalik landscape from cadastral maps dating back to 1917 with LiDAR data, supported by the geo-location assessment of local revenue patwaris. A significant challenge encountered during this process is the absence of ground control points, largely due to the considerable time lapse since the last revenue settlement in 1917. The village-wise Khasra maps that have been prepared have been handed over to the Revenue Department for ground verification to ensure that the digital maps are accurate and up-to-date.

Figure 1: LiDAR mapping of 14 Bhoj, Morni

2.1.4 Cadastral Level Accuracy

Digitization was performed at the cadastral level using digitized revenue maps, achieving sub-meter accuracy. This meticulous process involved digitizing land parcel details from the mussavis at the village level, which is crucial for keeping the accuracy intact. It allows forest managers to identify land details in cases of encroachment from adjoining areas, enabling verification from the Revenue Department and subsequent eviction of encroachments. This high level of accuracy ensures that all forest boundaries are clearly defined and legally sound.

2.2 Implications of Digitization

The digitization of forest boundaries by the Haryana Forest Department has significant implications for forest management and conservation:

1. **Enhanced Accuracy and Precision:** The use of cadastral level maps and georeferencing them with the aid of ground control points (GCPs) on high-resolution orthorectified World View-II satellite imagery has resulted in sub-meter accuracy which ensures that forest boundaries are accurately represented, reducing conflicts and aiding in precise planning and management.

2. **Improved Forest Management:** With detailed and accurate digital maps, forest managers can make informed decisions about afforestation, conservation, and development projects. This supports sustainable forest management practices.

3. **Support for Legal and Regulatory Compliance:** The accurate mapping of forest boundaries assists in compliance with the Forest Conservation Act, 1980, and other regulations. It also aids in the identification and eviction of encroachments, protecting forest lands.

4. **Integration with Advanced Technologies:** The digitized boundaries are integrated into the department's geospatial portal, allowing for advanced GIS analyses and remote sensing applications. This integration enhances the department's ability to monitor and manage forest resources effectively.

5. **Facilitation of Ground Verification:** The detailed georeferenced cadastral maps provided to the Revenue Department for ground verification ensure that the digital maps are validated and can be used for legal and administrative purposes.

The digitization of forest boundaries represents a significant advancement in forest management. By leveraging advanced GIS and remote sensing technologies, the department has laid a robust foundation for precise mapping, effective management, and sustainable conservation of forest resources in Haryana.

3. Benefits of Forest Boundary Digitization

Digitizing forest boundaries has provided numerous advantages that significantly enhance forest management practices. Below are some benefits in the context of the Haryana Forest Department:

1. **A First Step in GIS-Based Forest Analysis:** Digitization of forest boundaries is the foundational step for integrating GIS technology into forest management. It enables the creation of spatial databases comprising administrative, environmental and classified forest type, and forest density layers that can be used for various analytical purposes, aiding in better decision-making and planning.

2. **Visually Seeing Distribution of Forest Area in the Division:** Digitized boundaries on the geospatial portal allow for the visual representation of forest areas within a division. This visualization helps in understanding the spatial distribution of forests, identifying contiguous forest patches, and planning interventions more effectively.

3. **Forest Demarcation and Fixing Missing Pillars:** Accurate digitization assists in the clear demarcation of forest boundaries, making it easier to identify and rectify missing or displaced boundary pillars. This ensures legal clarity and helps in preventing encroachments.

4. **Forest Change Analysis:** By comparing historical and current imageries over digitized boundaries, forest managers can analyze changes over time. This includes deforestation, afforestation, and natural regeneration, providing insights into forest dynamics and trends.

5. **Forest Encroachment Assessment:** Digitized boundaries are crucial for detecting and assessing encroachments. By overlaying boundaries with recent satellite or drone images, forest managers can identify unauthorized activities and take timely corrective actions.

6. **Forest Density Mapping:** Digitization enables the creation of forest density maps, which are essential for understanding the health and composition of forest stands. These maps help in identifying areas that need conservation or reforestation efforts. The Forest department, besides the forest cover analysis done by the Forest Survey of India (FSI) on a biennial basis using 24-meter resolution LISS-III data, has endeavoured to create forest cover maps in partnership with HARSAC using high-resolution data sets of Cartosat-2 and LISS-IV, giving an effective resolution of 2.5 meters for better insight into forest density distribution of forest areas.

7. **Blank Area Identification for Plantation:** Accurate boundary maps help in identifying blank areas within forests that are suitable for new plantations. This aids in planning and implementing reforestation programs effectively.

8. **Natural and Artificial Regeneration Assessment:** Digitized boundaries facilitate the monitoring of natural and artificial regeneration within the forest area. Forest managers can track the success of plantation projects and natural regrowth, ensuring sustainable forest management.

9. **Forest Biomass and Carbon Assessment:** GIS-based boundary data is vital for estimating forest biomass and carbon stock. This information is crucial for climate change mitigation strategies and for participating in carbon credit programs.

10. **Status of Inaccessible Areas:** Digitized boundaries help in assessing the status of remote and difficult forest areas due to steep topography. By using satellite imagery and drones, forest managers can monitor these areas without physically entering them, ensuring their protection and conservation.

11. **Proof of Plantation Area:** Having digitized boundaries serves as verifiable proof of plantation areas. This is important for reporting purposes, compliance with legal requirements, and securing funding for forestry projects.

12. **Writing Working Plan:** Digitized forest boundaries provide accurate data that is essential for writing comprehensive working plans for forest divisions. These plans guide sustainable forest management practices over a specified period.

13. **Developing Prospective Projects like Green India Mission (GIM):** GIS data is crucial for developing and implementing large-scale forestry projects like the Green India Mission for identification of landscapes and targeted intervention. Accurate boundary maps help in planning interventions, monitoring progress, and achieving project goals.

14. **Biophysical and Socio-Economic Assessment of Forest Villages:** Digitized boundaries support biophysical and socio-economic assessments of forest villages. This information is vital for integrating community needs into forest management plans and ensuring sustainable livelihoods.

15. **Decision Support Tool:** GIS-based forest boundary data acts as a powerful decision support tool. It enables forest managers to analyze various scenarios through modelling, predict outcomes, and make informed decisions.

16. **Forest Conservation Act (FCA) Cases:** Accurate boundary maps are essential for processing FCA cases. They help in assessing the impact of proposed activities on forest land and ensuring compliance with legal requirements.

17. **Wildlife Management:** Digitized forest boundaries aid in wildlife management by identifying critical habitats, migration corridors, and human-wildlife conflict zones. This helps in implementing effective conservation strategies.

18. **Eco-Sensitive Zone (ESZ):** GIS data helps in delineating Eco-Sensitive Zones around protected areas. This ensures that developmental activities in these zones are regulated to minimize ecological impact.

19. **Assessment of Loss Due to Mining Activities:** Digitized boundaries are used to assess the impact of mining activities on forests. This includes calculating the area affected, estimating the loss of vegetation, and planning rehabilitation measures.

20. **Navigation to Forest Area and Plantation:** Digitized maps facilitate navigation within forest areas. Field staff can use these maps to locate specific sites, plan patrol routes, and ensure efficient forest management.

21. **Identification of Khasra Numbers:** Digitized forest boundaries help in identifying Khasra numbers, which are essential for legal documentation and land management. This ensures clarity in land ownership and use.

22. **Ecology and Habitat Management:** GIS-based boundary data is crucial for managing forest ecology and habitats. It helps in monitoring biodiversity, planning habitat restoration, and ensuring ecological balance.

23. **Fire Management:** Accurate boundary maps are essential for fire management and to know fire alerts within forest areas. They help in identifying fire-prone areas, planning firebreaks, and coordinating firefighting efforts.

24. **Forest Protection:** Digitized boundaries support forest protection efforts by providing accurate data for patrolling, monitoring illegal activities, and ensuring the enforcement of forest laws.

25. **Watershed Management:** GIS data is vital for watershed management. It helps in identifying critical watersheds, planning soil and moisture conservation measures, and ensuring the sustainable use of water resources.

In summary, the digitization of forest boundaries has provided a multitude of benefits that enhance the effectiveness, efficiency, and sustainability of forest management practices in Haryana. By using GIS technology, the Haryana Forest Department can strengthen the protection and conservation of its forest resources while supporting community livelihoods and environmental health.

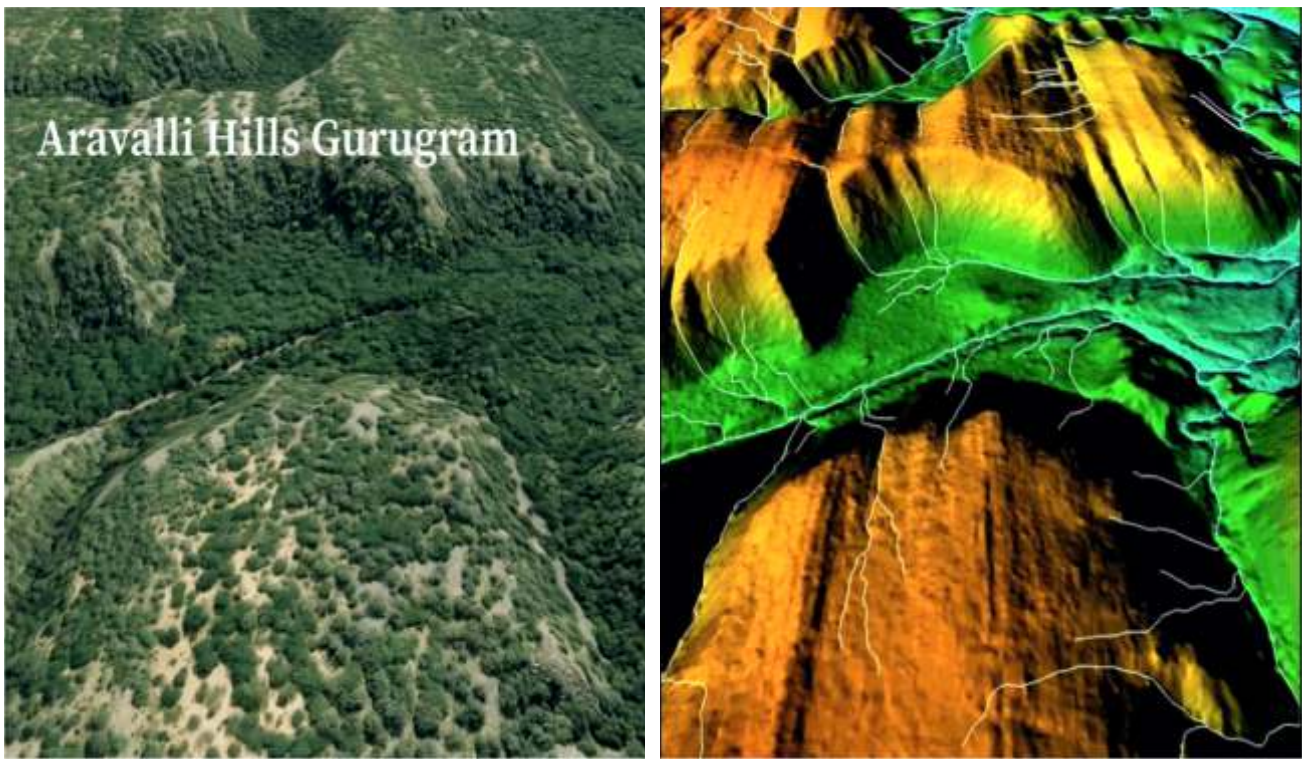

Figure 2 : Bare Earth modelling of Damdama, Gurugram catchment from DEM

4. Geospatial Solutions and Web-Based Platforms

Modern geospatial servers have revolutionized forest management by providing a powerful platform for storing, managing, and analyzing spatial data. These servers are integral to advanced Geographic Information System (GIS) applications, offering numerous benefits that enhance the efficiency and effectiveness of forest management practices.

4.1 Key Features and Capabilities

1. **Data Storage and Management:**
    - **Centralized Repository:** Geospatial servers serve as a centralized repository for all spatial data, including maps, satellite imageries, and geospatial datasets. This centralization ensures that data is easily accessible and well-organized.
    - **Scalability:** These servers are designed to handle large volumes of data, making them scalable to accommodate growing datasets as more spatial information is collected and integrated.
2. **Data Integration and Interoperability:**
    - **Multiple Data Sources:** Geospatial servers can integrate data from various sources such as satellite images, aerial photographs, GPS data, and field surveys. By using Web Map Service (WMS) data hosted on other servers can be integrated into the departmental server. This interoperability allows for comprehensive data analysis and visualization.
    - **Standardized Formats:** They support standardized data formats (e.g., GeoJSON, KML, Shapefiles), ensuring compatibility and ease of data sharing across different platforms and systems.
3. **Advanced Data Analysis:**
    - **Spatial Queries:** Users can perform complex spatial queries to analyze patterns and relationships within the data. Spatial queries allow data visualization on maps based on filtered datasets. This capability is crucial for tasks such as identifying areas of deforestation, mapping wildlife habitats, and assessing forest health.
    - **Geospatial Modelling:** Geospatial servers support advanced modelling techniques, including predictive modelling and simulations. These models help in forecasting changes in forest cover, evaluating the impact of conservation efforts, and planning future interventions.
4. **Real-Time Data Processing:**
    - **Live Data Feeds:** Modern geospatial servers can process real-time data feeds from sensors and GPS devices. This real-time processing is essential for monitoring forest conditions, tracking wildlife movements, and responding promptly to environmental threats like wildfires.

- **Dynamic Updates:** The servers allow for dynamic updates of spatial data, ensuring that the most current information is always available for decision-making.

5. **User Accessibility and Collaboration:**

   - **Web-Based Interfaces:** Geospatial servers often come with web-based interfaces that allow users to access data and perform analyses from any location with internet connectivity. This accessibility promotes collaboration among forest managers, researchers, and policymakers.
   - **Role-Based Access Control:** They provide role-based access control, ensuring that sensitive data is protected and only accessible to authorized users.

6. **Visualization and Reporting:**

   - **Interactive Maps:** Users can create interactive maps and dashboards that provide intuitive visualizations of spatial data. These visual tools are invaluable for communicating complex information to stakeholders.
   - **Custom Reports:** The servers can generate custom reports based on specific queries and analyses, supporting data-driven decision-making.

4.2 Applications in Forest Management

1. **Forest Monitoring:**

   - **Deforestation Tracking:** Geospatial servers help in tracking deforestation activities by analyzing satellite imagery over time. This monitoring is crucial for enforcing conservation laws and preventing illegal logging.
   - **Health Assessment:** They facilitate the assessment of forest health by integrating data on vegetation indices, soil moisture levels, and other environmental factors.

2. **Conservation Planning:**

   - **Habitat Mapping:** Geospatial servers are used to map critical wildlife habitats and biodiversity hotspots. This information aids in the design and implementation of conservation strategies.
   - **Corridor Analysis:** They support the analysis of wildlife corridors, ensuring that connectivity between habitats is maintained for species migration and genetic diversity.

3. **Resource Management:**

   - **Timber Inventory:** Forest managers can use geospatial servers to maintain an inventory of timber resources, optimizing harvesting schedules and ensuring sustainable yield.

- **Water Resource Management:** These servers help in managing water resources within forest areas by mapping watersheds, water points and monitoring water quality.

4. **Disaster Management:**

   - **Fire Risk Mapping:** Geospatial servers assist in identifying areas at high risk of wildfires and developing mitigation plans.

   - **Flood Management:** They support flood risk assessment and the planning of flood control measures within forested regions.

Recent advancements in geospatial solutions have significantly improved forestry operations By integrating real-time data processing, advanced analytics, and intuitive visualization, geospatial servers empower stakeholders to respond proactively to environmental challenges, ensuring the long-term health and resilience of forest ecosystems.

The Haryana Forest Department has leveraged these technologies to establish a sophisticated system for monitoring and managing its forest resources. The department deployed its server at the data centre in 2018 using the ArcGIS Enterprise server for hosting GIS layers. This system was further upgraded to a Geospatial Hub Server in 2024, allowing multiple GIS applications to run on the same platform, meeting the demanding requirements of the department.

4.3 Key Features of the Geospatial Hub Server

1. **Digitized Forest Boundaries:**

   - **Accurate Delineation:** The platform accurately delineates forest areas and plantation boundaries, providing a clear and precise mapping of the forest landscape. This helps in identifying the exact locations of various forest assets and interventions.

   - **Integration with Satellite Imagery:** By overlaying digitized boundaries with high-resolution satellite and drone imagery, and time-series historical imageries, the platform offers detailed visualization of the forest area. This integration allows for the identification of changes in forest cover, monitoring of canopy growth, and detection of any unauthorized activities.

2. **Real-time Data Collection and Monitoring:**

   - **Mobile Applications for Field Data Collection:** Field users employ mobile applications to geotag plantation boundaries, individual plants, and other forestry interventions. These applications capture geospatial data, photos, and videos, ensuring comprehensive documentation of field activities.

   - **Real-time Data Transfer:** The collected data is transferred in real-time to centralized servers, allowing for immediate access and analysis by forest managers. This feature ensures timely updates and quick decision-making based on the latest information.

3. **Data Analytics and Visualization:**

- **Dashboards and Analytical Tools:** The platform includes dashboards and analytical tools that provide insights into plantation success, health, and survival rates. These tools enable forest managers to assess the effectiveness of interventions and make data-driven decisions.
- **Historical Data Comparison:** The system allows for the comparison of current data with historical records, facilitating the tracking of changes and improvements over time. This feature is crucial for evaluating the long-term impact of forestry interventions.

4. **Enhanced Transparency and Accountability:**

- **Ensuring Transparency:** Geotagging ensures transparency in reporting and operations by providing verifiable data on plantation activities. It reduces the likelihood of data manipulation and ensures that reported activities match on-ground realities.
- **Preventing Duplication:** The comprehensive record-keeping system prevents duplication of plantation activities by maintaining detailed records of all interventions. This ensures that resources are used and monitored efficiently.

5. Development of Geo-Portal

The web portal developed by the Haryana Forest Department serves as a Decision Support System (DSS) for field functionaries and forest managers. Key features include:

1. **Seamless Data Integration:** Provides integrated forest data overlaid with maps and high-resolution satellite images in an Arc-GIS Hub portal.
2. **Tools for Site Suitability:** Allows the creation of catchment polygons for water harvesting dam sites in hilly terrains like Shivaliks and Aravalli.
3. **Encroachment Assessment:** Facilitates the assessment and digital marking of encroachments, enabling the calculation of encroachment areas and the creation of geo-referenced polygons.
4. **Geo-spatial Queries:** Supports queries based on any Management Information System (MIS) data linked to GIS shape files, displaying results on the map.
5. **Forest Cover Assessment:** Integrates Forest Survey of India's biennial forest cover density data (2003-2019) for easy comparison and analysis. This allows the user to see changes in forest cover as per FSI's ISFR on state, division, range, block, beat, village, and individual forest levels.

6. Forest Fire Alerts and Management System

6.1 Forest Fire Alerts and Past Fire Records

The portal is integrated with the MODIS (Moderate Resolution Imaging Spectroradiometer) satellite system to provide real-time fire alerts within forest areas. This integration allows for easy visualization of active fire incidents on the map, facilitating an immediate response and enabling a better understanding of fire patterns to plan for corrective actions.

6.2 Forest Fire Vulnerability Mapping

The Haryana Forest Department has conducted forest fire vulnerability mapping using a multi-criteria analysis approach. This analysis takes into account several factors that contribute to forest fires in Haryana, such as fuel load, elevation, slope, and proximity to habitation and roads etc. Each factor is assigned a specific weight based on its impact on fire risk. This comprehensive model identifies highly vulnerable and moderately vulnerable areas, allowing the department to plan and execute targeted fire prevention activities. The model's accuracy has been validated against actual fire incidents, achieving a significant accuracy rate of over 90%.

6.3 Past Fire Locations

The portal also includes a database of past fire incidents, displaying historical fire locations. This feature helps in identifying fire hotspots, which are areas with a higher frequency of fire occurrences. By analyzing these hotspots, the department can implement effective preventive measures to reduce the likelihood of future fires.

6.4 Enhanced Capabilities of the Forest Fire Management System

1. **Real-Time Monitoring:** The integration with Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer (VIIRS) satellite provides almost real-time fire alerts, enabling forest managers to monitor fire activities in real-time. This allows for prompt decision-making and resource allocation to mitigate fire spread.

2. **Pattern Analysis:** The visualization of fire alerts and historical data helps in analyzing fire patterns over time. Understanding these patterns is crucial for developing long-term strategies for fire management and prevention.

3. **Strategic Planning:** By mapping forest fire vulnerability and identifying hotspots, the department can prioritize areas for fire prevention efforts. This strategic planning ensures that resources are allocated efficiently and effectively.

4. **Community Safety:** The proximity analysis of fire-prone areas to human habitation and roads helps in implementing safety measures for nearby communities. This proactive approach minimizes the risk to human lives and property.

5. **Environmental Protection:** Accurate mapping and timely alerts help protect valuable forest resources and biodiversity. Preventing and managing forest fires effectively contribute to the overall health and sustainability of forest ecosystems.

6. **Training and Preparedness:** The data from the portal can be used to train forest personnel and local communities on fire prevention and response strategies. This increases overall preparedness and resilience against forest fires.

7. In-House GIS Unit

The department's in-house GIS unit at Panchkula trains field functionaries to collect spatial data of forest assets, resources, and interventions using GPS devices. This spatial data is layered with various thematic maps, aiding in the development of a GIS-based DSS for effective forest and wildlife management.

8. GIS Projects by Haryana Forest Department

8.1 Digitization of Block Forest Boundaries in Haryana

The project for digitizing forest boundaries in Haryana commenced in 2015, with the Haryana Space Applications Centre (HARSAC) as a key supporting partner. Since the project's inception, forest-wise shapefiles have been meticulously created and integrated into the geospatial server, enabling advanced GIS analysis and effective forest management.

This year, an additional 69 block forests, which had not been digitized earlier due to the unavailability of revenue records or because they were newly designated since the last digitization effort, have been assigned to HARSAC for digitization. This ongoing effort ensures that all forest boundaries, including newly recognized forest areas, are accurately mapped and incorporated into the central geospatial database. By continually updating and expanding the digital map inventory, the Haryana Forest Department enhances its ability to monitor, manage, and protect its forest resources efficiently.

Digitized Block and Strip Forests

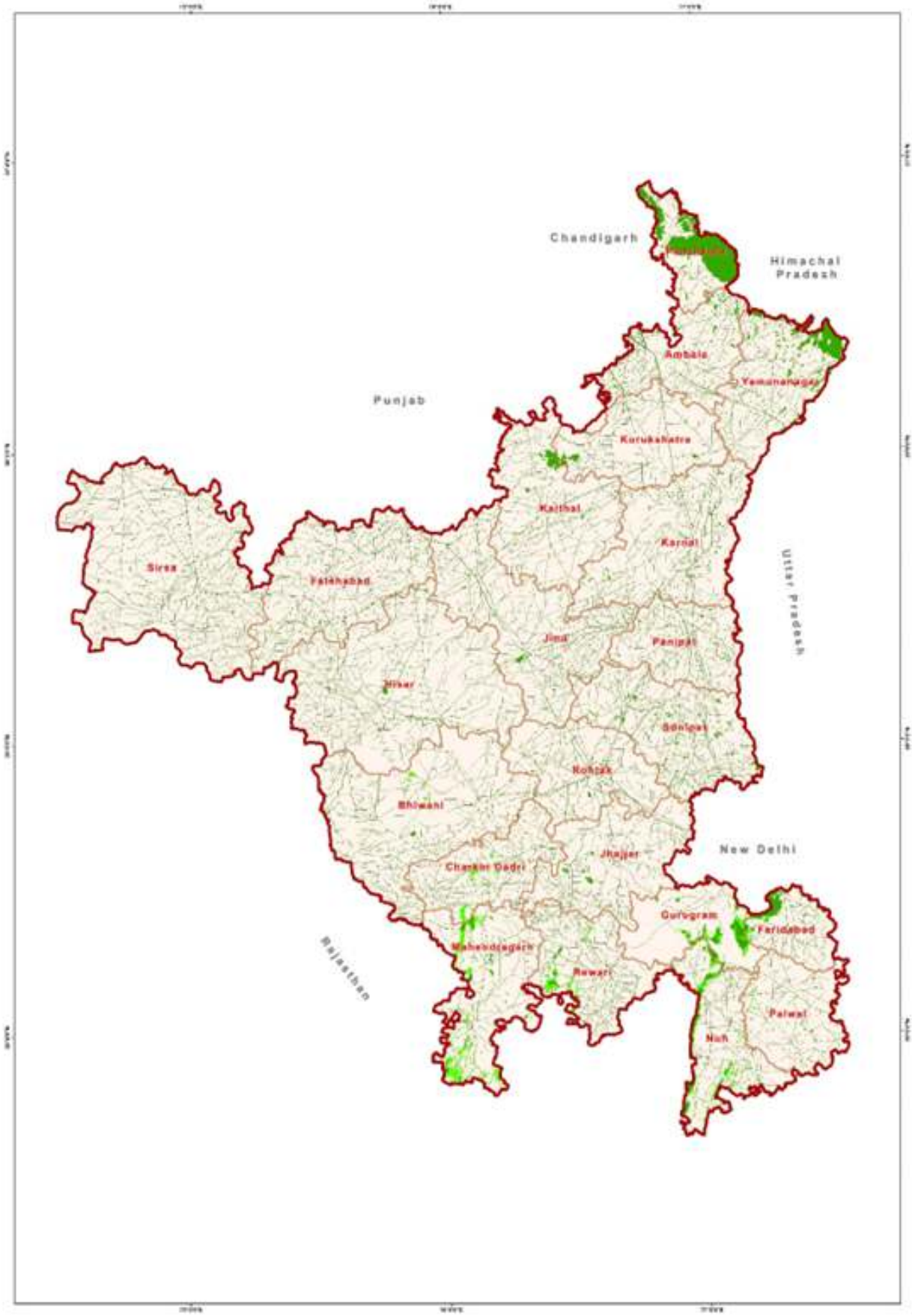

Figure 3 : Digitized and georeferenced compact and Strip Forests

Figure 4 : Forest boundary digitization and georeferencing

8.2 Digitization of Strip Forest in Haryana

Following the success of block forest digitization, strip forests were also digitized to ensure comprehensive mapping of all forest areas.

8.3 Assessment of Forest and Trees Outside Forests (ToF) in Panchkula & Yamunanagar

Using IRS high-resolution data, the department assessed in collaboration with HARSAC the forest cover and trees outside forests in specific districts to understand vegetation patterns.

8.4 Mapping of Forest Canopy Density (FCD)

The Haryana Forest Department, in addition to the biennial forest cover analysis conducted by the Forest Survey of India (FSI) using 24-meter resolution LISS-III data, has undertaken an initiative to create detailed forest cover maps. This initiative, in partnership with the Haryana

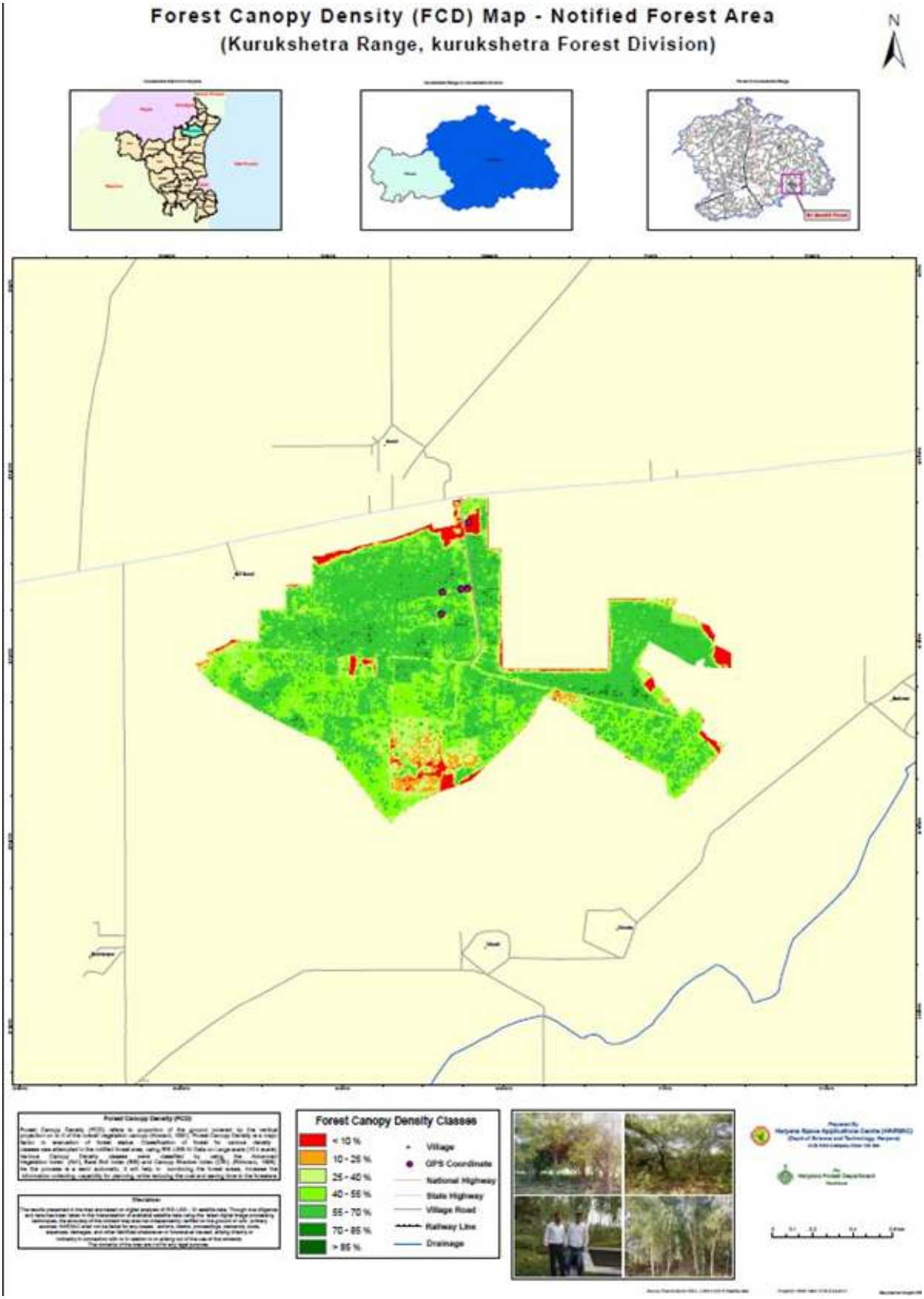

Figure 5: Forest Density Mapping

Space Applications Centre (HARSAC), utilizes high-resolution datasets from Cartosat-2 and LISS-IV, providing an effective resolution of 2.5 meters. This higher resolution offers a significantly enhanced view of forest density distribution across the state.

These high-resolution maps are instrumental in several key areas:

1. **Detailed Forest Density Analysis:** The improved resolution allows for a better understanding of forest density, helping to identify areas of varying canopy cover. This detailed analysis provides better insights into the overall health and distribution of forest areas.

2. **Identification of Low-Density and Blank Areas:** The maps enable the identification of regions with low forest density or completely blank areas. These areas are prime candidates for targeted afforestation interventions under various plantation schemes, ensuring that reforestation efforts are directed where they are most needed.

3. **Enhanced Monitoring and Management:** By providing a clearer picture of forest cover, these maps facilitate more effective monitoring and management of forest resources. Forest managers can use this data to plan conservation activities, track changes over time, and respond proactively to emerging issues.

4. **Support for Afforestation Schemes:** The detailed canopy density maps are essential for planning and implementing afforestation and reforestation projects. They help in selecting appropriate sites, monitoring the progress of plantations, and assessing the impact of these interventions on forest cover.

5. **Improved Biodiversity Conservation:** Understanding the distribution and density of forest canopy aids in conserving biodiversity. High-density forest areas often serve as critical habitats for various species, and maintaining these areas is crucial for ecological balance.

6. **Informed Decision-Making:** The data provided by these high-resolution maps supports informed decision-making at various levels of forest management and policy formulation. Accurate and detailed information is crucial for developing effective strategies and policies for forest conservation and sustainable management.

8.5 Demarcation of Eco-Sensitive Zones

The identification and mapping of Eco-Sensitive Zones (ESZ) surrounding Protected Areas (PAs) have been carried out using an advanced GIS platform. This initiative aims to visualize and manage unauthorized activities within these zones, ensuring compliance with the regulations and restrictions imposed by the respective ESZ notifications for each PA.

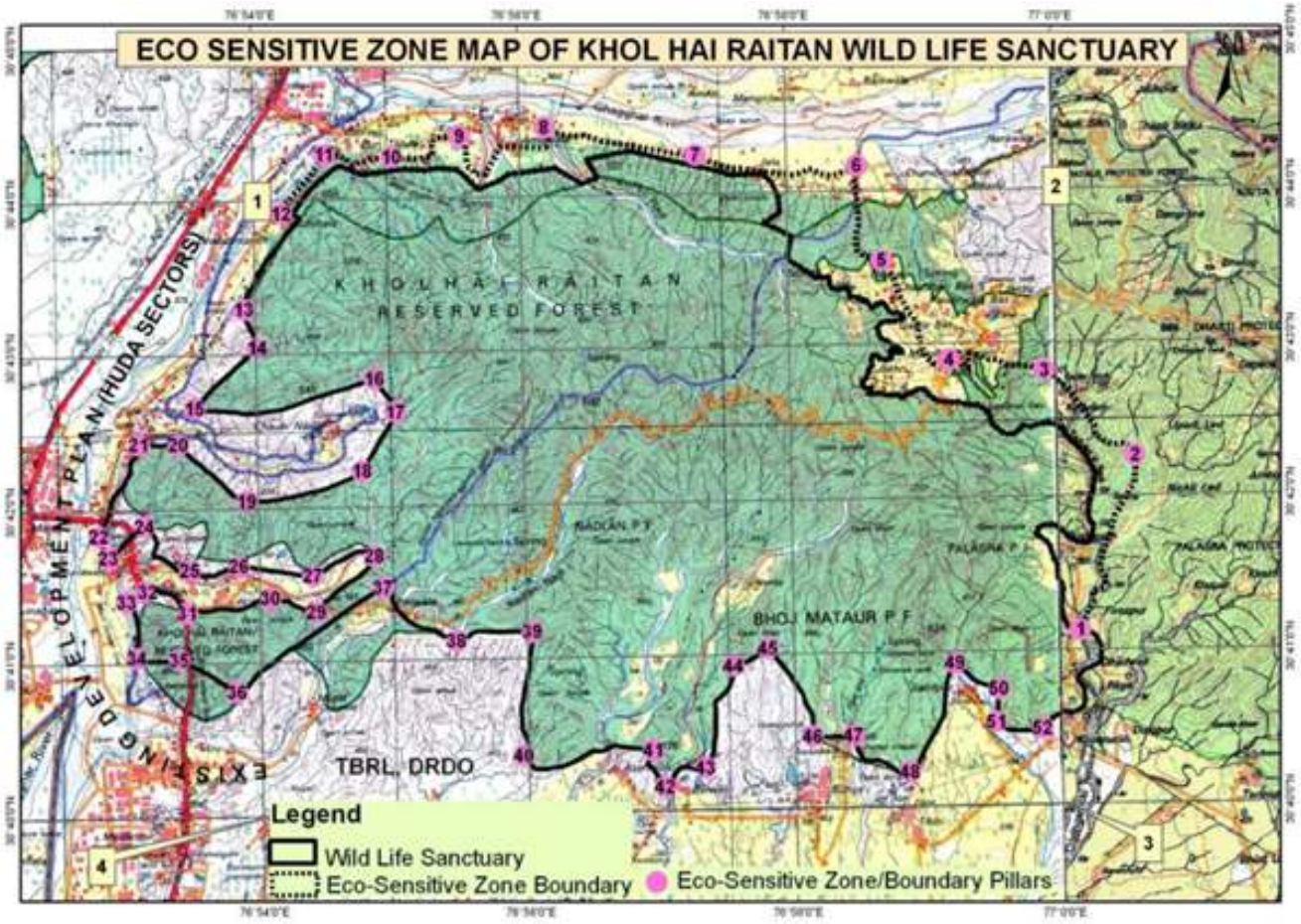

Figure 6 : ESZ mapping

By leveraging GIS technology, the Haryana Forest Department can effectively:

1. **Visualize Eco-Sensitive Zones:** The GIS platform provides a detailed and interactive map of the ESZs, highlighting their boundaries and the geographical extent of the protected areas. This visualization helps in better understanding and managing these critical zones.

2. **Monitor Unauthorized Activities:** The GIS system allows for real-time monitoring of activities within the ESZs. Any unauthorized activities that contravene the regulations and restrictions can be easily identified and addressed promptly. This proactive monitoring is crucial for maintaining the ecological integrity of these sensitive areas.

3. **Regulate and Enforce Restrictions:** The mapping of ESZs aids in the enforcement of restrictions and regulations imposed by the respective ESZ notifications. By clearly delineating the zones and identifying potential violations, the department can ensure that activities within the ESZs are strictly regulated to protect biodiversity and ecological balance.

4. **Support Conservation Efforts:** The detailed mapping and monitoring of ESZs support conservation efforts by providing critical data on habitat conditions, human encroachments, and other environmental pressures. This information is vital for developing and implementing effective conservation strategies.

5. **Enhance Decision-Making:** The GIS-based demarcation of ESZs provides forest managers and policymakers with accurate and up-to-date information. This enhances decision-making processes related to land use, development projects, and conservation measures within and around protected areas.

6. **Public Awareness and Participation:** The availability of ESZ maps on a public GIS portal can increase awareness among local communities and stakeholders about the importance of these zones. It encourages community participation in conservation efforts and compliance with environmental regulations.

The demarcation of Eco-Sensitive Zones using GIS technology is a crucial step in safeguarding the ecological sanctity of Protected Areas in Haryana. This advanced approach not only facilitates the regulation and restriction of activities within ESZs but also supports broader conservation objectives, ensuring that these critical areas are preserved for future generations.

8.6 Mapping of Water Harvesting Structure (WHS) Locations on GIS

The Haryana Forest Department has successfully mapped more than 100 Water Harvesting Structures (WHS) in the Shiwalik area using GIS technology. These structures have been accurately geotagged and integrated into the department's geospatial portal. This allows for comprehensive visualization of existing WHS locations, facilitating strategic planning for new structures.

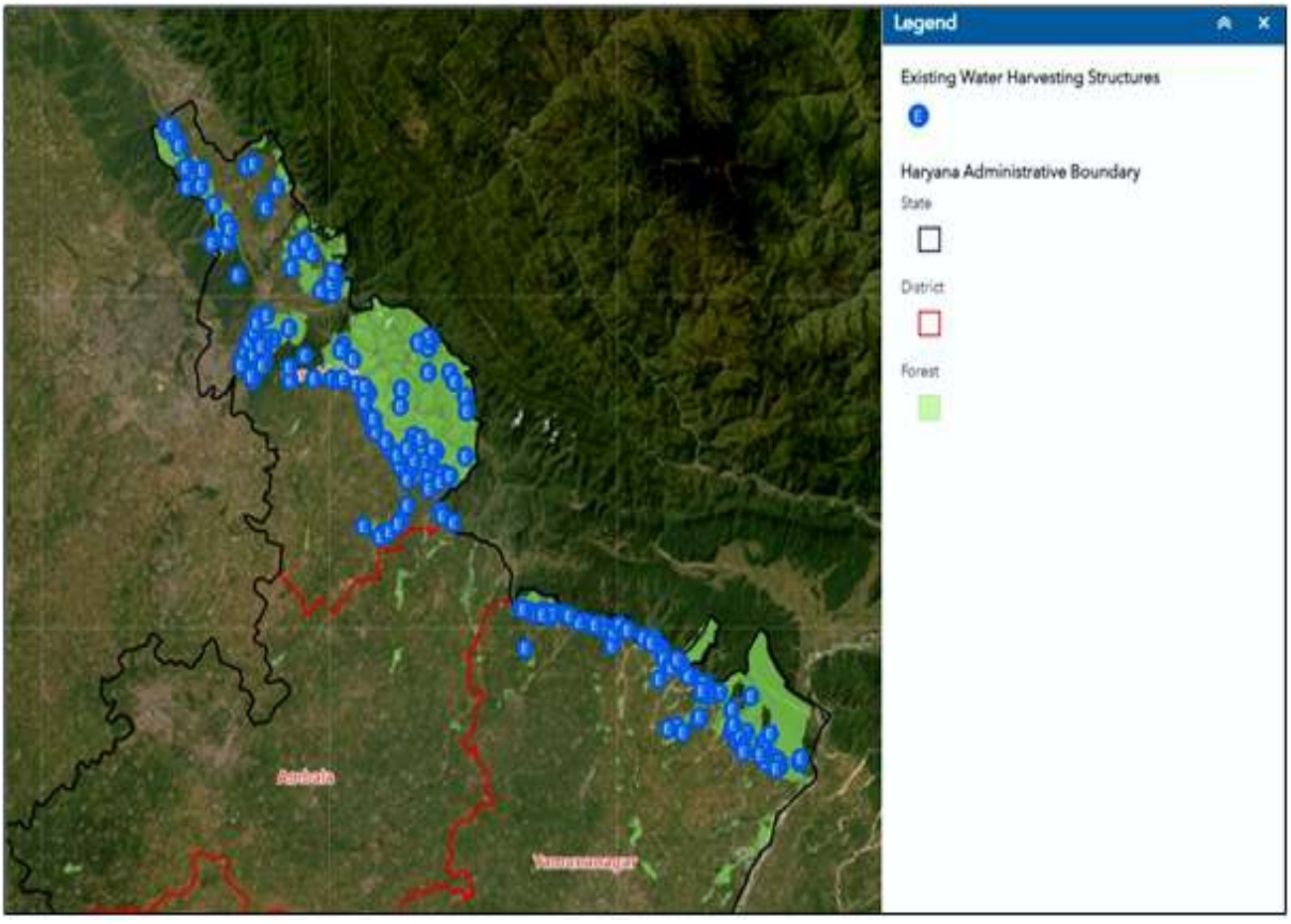

Figure 7 : Location of Water Harvesting Structures by HFD on Shiwalik hills

Using the GIS platform, combined with Digital Elevation Model (DEM) data, the department can perform detailed water flow analyses and determine catchment areas. These tools are essential for understanding the hydrology of the region and for planning effective water conservation strategies. By analyzing terrain and water flow patterns, the department can identify optimal locations for new water harvesting structures, ensuring maximum efficiency and sustainability.

The mapping and analysis of WHS locations on the GIS platform provide several key benefits:

1. **Enhanced Visualization:** The geospatial portal allows for easy visualization of all existing water harvesting structures, providing a clear and detailed overview of the region's water conservation infrastructure.

2. **Strategic Planning:** With the help of DEM data and hydrological analysis tools, the department can strategically plan the placement of new WHS. This ensures that new structures are located in areas where they will be most effective in capturing and storing water.

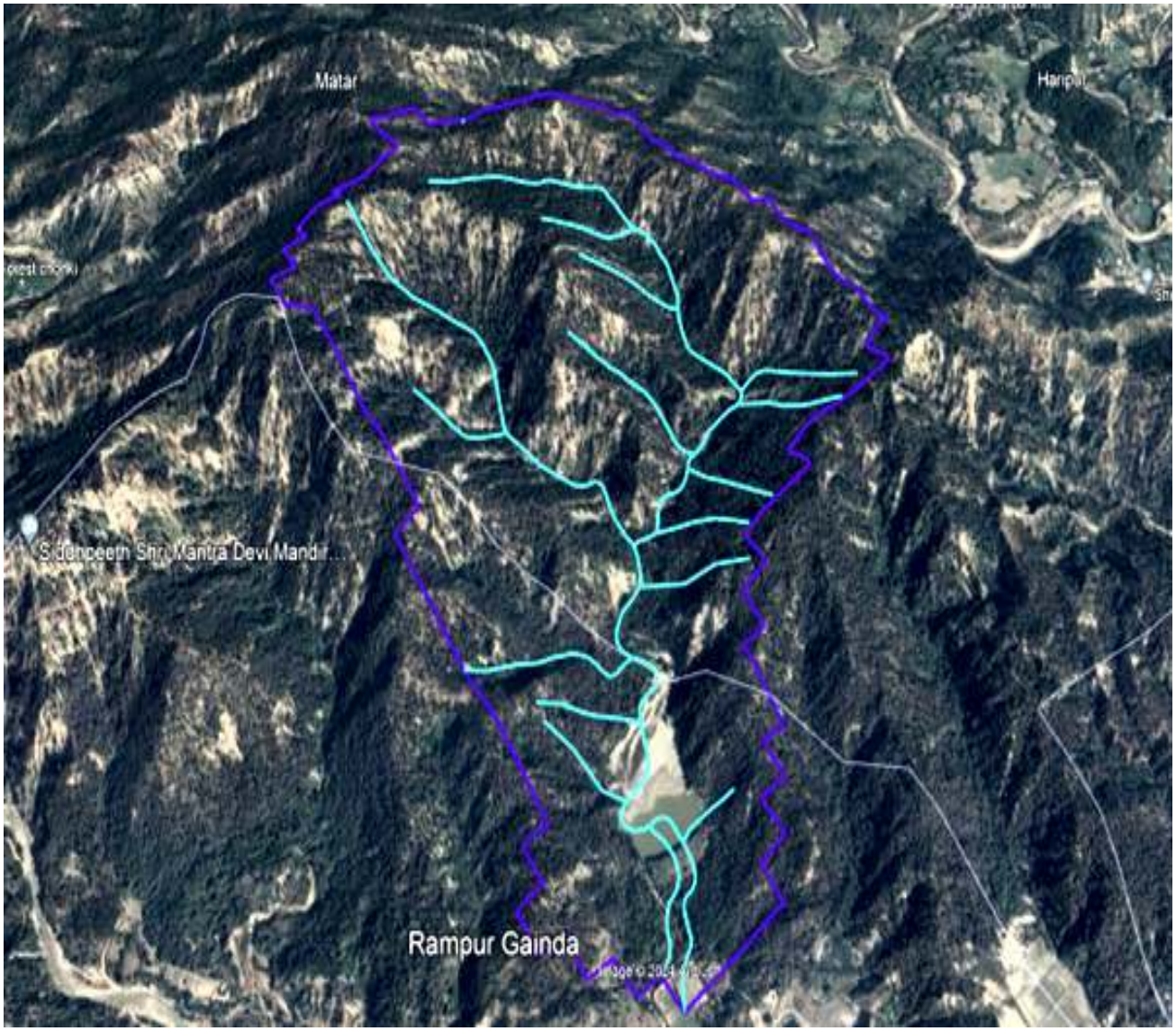

Figure 8 : Identification of Catchment area and drainage lines using DEM for WHS Rampur Gainda, Yamunanagar

3. **Optimized Water Conservation:** By accurately locating and mapping WHS, the department can optimize water conservation efforts, ensuring that resources are used efficiently and that water is conserved in the most critical areas.

4. **Catchment Determination:** The GIS tools enable precise determination of catchment areas for each WHS. This helps in understanding the source and volume of water that can be harvested, leading to better design and management of water harvesting systems.

5. **Sustainable Management:** The integration of WHS data into the GIS platform supports sustainable water management practices. By continuously monitoring and analyzing water harvesting structures, the department can adapt to changing environmental conditions and ensure long-term water security.

6. **Resource Allocation:** Detailed mapping helps in the efficient allocation of resources for the construction and maintenance of WHS, ensuring that funds and efforts are directed towards the most beneficial projects.

8.7 Mapping of Afforestation and Wildlife Habitat Maps

The Forest Department conducted mapping of afforestation during 2021-22 using a mobile-based application to geotag plantation boundaries for plantations in compact and strip forests. To visualize and address man-animal conflicts, a GIS-based leopard habitat mapping was done in the Gurugram district. This mapping assessed habitat fragmentation and identified roads passing through leopard habitats, which have previously resulted in leopard fatalities.

Figure 9: Leopard habitat in Gurugram

8.8 3D Forest Mapping of Aravalli Areas (Gurgaon and Faridabad)

A 3D model of the forest areas in Aravalli, Faridabad, and Gurugram was created using Digital Elevation Models (DEM) and high-resolution imagery. This initiative resulted in detailed topographical maps, significantly aiding in improved forest management.

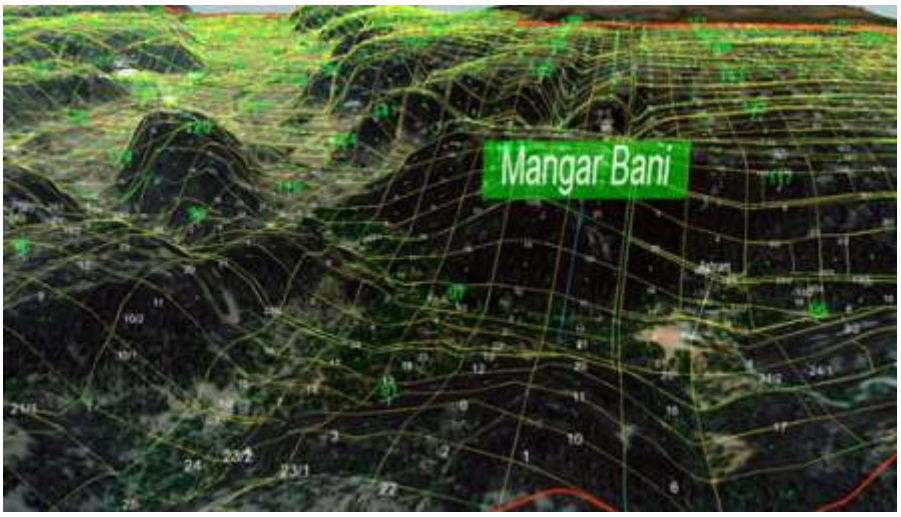

Figure 10 : 3D Forest mapping with land parcel details in Aravalli areas.

8.9 Forest Fire Vulnerability Mapping

The Haryana Forest Department's portal integrates with the MODIS satellite system to provide real-time forest fire alerts and visualize active incidents, enabling immediate response and a better understanding of fire patterns for corrective actions. The department has also conducted forest fire vulnerability mapping using a multi-criteria analysis approach, considering factors such as fuel load, elevation, slope, and proximity to habitation and roads. This model, validated with an accuracy rate of over 90%, identifies highly vulnerable areas, facilitating targeted fire prevention activities. Additionally, the portal includes a database of past fire incidents to identify hotspots and implement effective preventive measures.

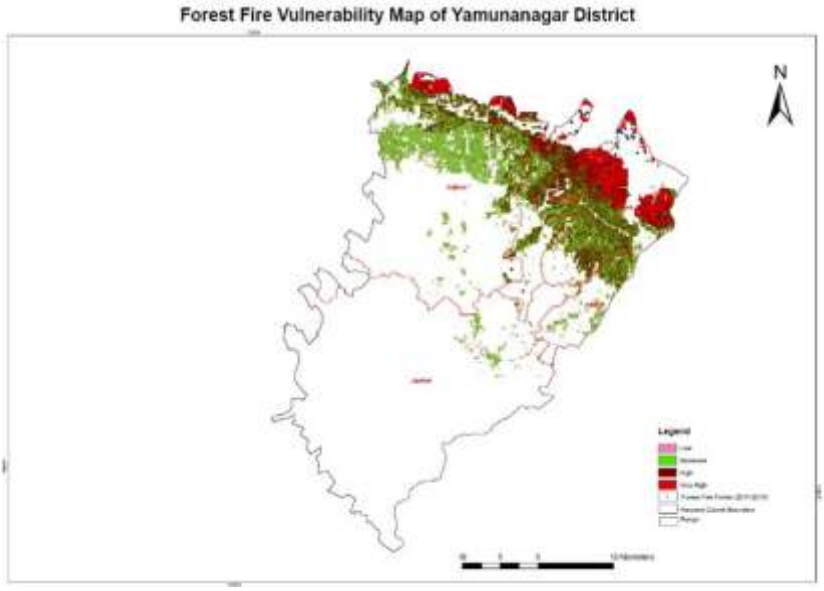

Figure 11 : Forest Fire Vulnerability map

Status of Fire Vulnerablity in Forest Cover of Haryana							
Sr. No.	Division	RANGE	LOW (Ha.)	MODERATE (Ha.)	HIGH (Ha.)	VERY_HIGH (Ha.)	TOTAL(Ha.)
1	**Ambala**	Ambala	715	1014	88	0	1817
2	**Ambala**	Naraingarh	2397	4594	911	1	7904
3	**Ambala**	Saha	24	40	0	0	64
			3136	**5648**	**999**	**1**	
Ambala Total							**9785**
4	**Faridabad**	Ballabgarh	22	38	1	0	61
5	**Faridabad**	Faridabad	1578	2328	379	0	4286
			1600	**2366**	**380**	**0**	
Faridabad Total							**4347**
6	**Gurgaon**	Gurgaon	594	625	60	1	1280
7	**Gurgaon**	Haily Mandi	1	1	0	0	2
8	**Gurgaon**	Sohana	1926	2536	490	8	4959
			2520	**3162**	**550**	**9**	
Gurgaon Total							**6241**
9	**Hisar**	Adampur	4	3	0	0	7
10	**Hisar**	Hansi	0	0	0	0	0
11	**Hisar**	Hisar	464	399	20	0	883
			469	**402**	**20**	**0**	
Hisar Total							**891**
12	**Kaithal**	Kaithal	809	1540	3	0	2352
13	**Kaithal**	Pundari	51	15	0	0	67
14	**Kaithal**	Saraswati	664	444	1	0	1109
			1524	**1999**	**4**	**0**	
Kaithal Total							**3527**
15	**Karnal**	Assandh	105	87	0	0	192
			105	**87**	**0**	**0**	
Karnal Total							**192**
16	**Kurukshetra**	Kurukshetra	91	96	0	0	187
17	**Kurukshetra**	Pehowa	348	315	12	0	675
			439	**411**	**12**	**0**	
Kurukshetra Total							**862**
18	**Mewat**	Nuh	1287	2311	280	0	3878
			1287	**2311**	**280**	**0**	
Mewat Total							**3878**
19	**Panchkula**	Kalka	73	1313	5038	2210	8634
20	**Panchkula**	Morni	0	32	1545	4937	6514
21	**Panchkula**	Panchkula	906	3734	5556	1786	11981
22	**Panchkula**	Pinjore	27	643	3702	1920	6291
23	**Panchkula**	Raipur Rani	1962	5342	5514	3697	16515
			2967	**11064**	**21355**	**14550**	
Panchkula Total							**49935**
24	**Yamunanagar**	Chhachrauli	482	2818	4448	774	8522
25	**Yamunanagar**	Jagadhari	1011	1800	752	1	3564
26	**Yamunanagar**	Kalesar	530	3607	5822	2906	12865
27	**Yamunanagar**	Sadhora	3609	8826	5117	1069	18622
			5632	**17052**	**16139**	**4751**	
Yamunanagar Total							**43573**
Grand Total (Ha)							**123231**
Grand Total (km^2)							**1232**

Figure 12 : Forest fire vulnerable areas

8.10 Creation of Geo-Referenced Maps in FCA Cases

Generating geo-referenced maps for Forest Conservation Act cases to provide accurate spatial data for legal and regulatory purposes.

8.11 Mapping of 14 Bhoj, Morni Using LiDAR Data

The Haryana Forest Department, in collaboration with the Survey of India and Haryana Revenue Department, has embarked on a significant project to accurately delineate the forest boundaries of the 14 Bhoj region in Morni, Panchkula district. This initiative addresses the complex landscape comprising diverse land uses such as habitations, agricultural fields, village pathways, and metalled roads, which have developed over years of local land occupation. The primary objective is to distinguish between forested and privately held areas, ensuring precise boundary demarcation to identify and address encroachments effectively.

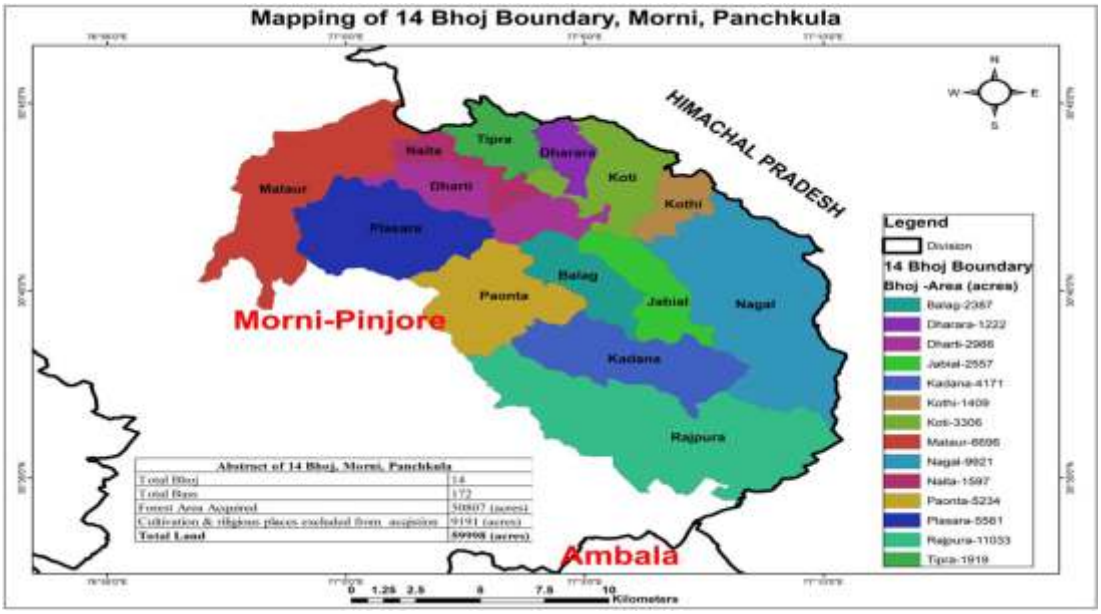

Figure 13: 14 Bhoj Morni

8.11.1 Challenges and Solutions

Challenges:

- The initial methods utilizing satellite imagery for boundary delineation faced several limitations, including restricted accuracy and difficulty in identifying land parcel boundaries due to tone matching with surrounding land.
- The undulating terrain of the 14 Bhoj region further complicated the creation of accurate ortho-images and constrained geo-referencing precision.

Solutions: To overcome these challenges, the project employs airborne LiDAR data combined with high-resolution aerial image data. This approach mitigates elevation-related geometric aberrations, enables the extraction of ground features with precise locations beneath forest canopies, and facilitates the creation of high-resolution ortho-images.

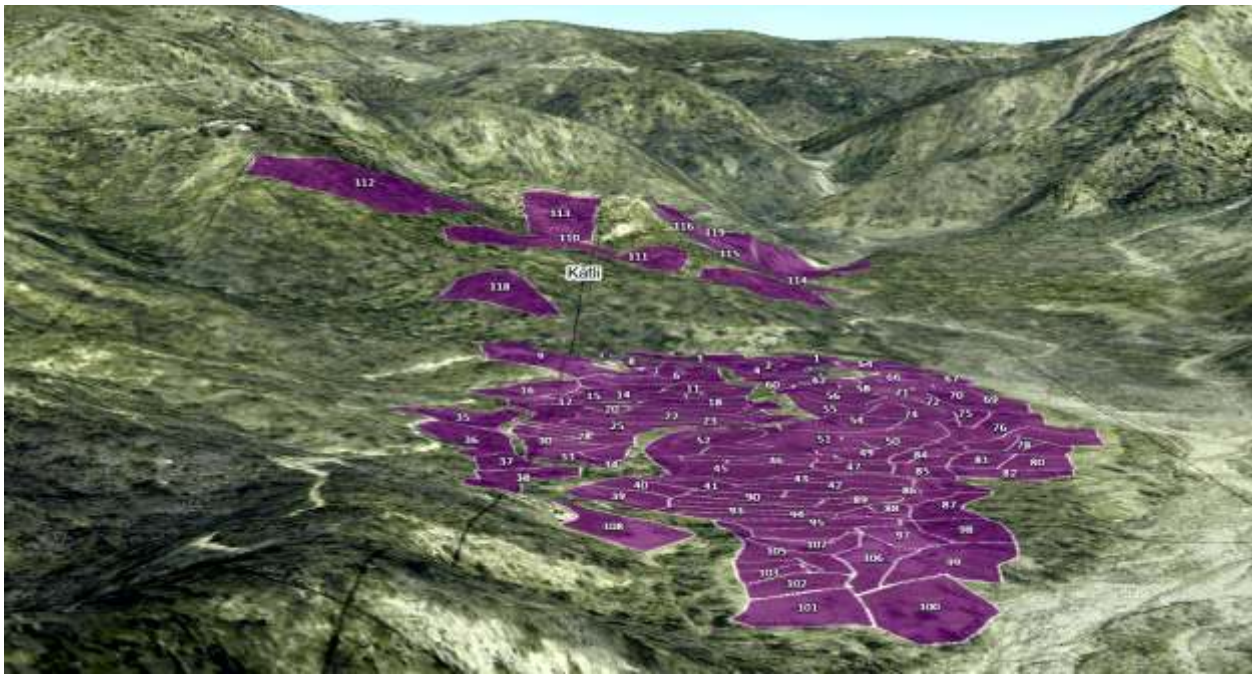

Figure 14: Georeferencing of Land parcels of Katli village, 14 Bhoj Morni

8.11.2 Project Execution

The project area covers approximately 250 square kilometers in the Shivalik Hills. The elevation ranges from 350 meters to 1500 meters, encompassing valleys and hills. The 14 Bhoj area includes 172 villages and a significant forest land area of 50,807 acres, acquired by the Forest Department between 1969 and 1979.

The LiDAR data for the 14 Bhoj area was acquired in February-March 2022 and made available to the Haryana Forest Department on April 19, 2022. This data was subsequently provided to the Survey of India (SoI) for the georeferencing of Mussavis (village maps) for 172 villages. With the collaboration of Revenue officials, the SoI has completed the georeferencing for 150 villages.

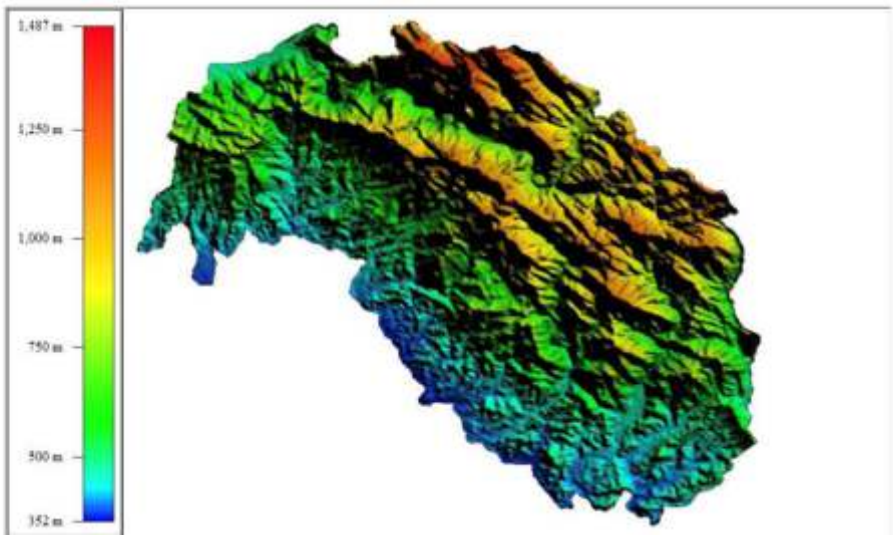

Figure 15: Digital Elevation Model (DEM) of 14 Bhoj Morni

A comprehensive landscape mapping of the 14 Bhoj area has been conducted, reflecting the current land use patterns as of the time the LiDAR data was captured. The georeferenced maps have been submitted to the Revenue Department for further ground validation. The project is currently in progress, ensuring that the mapped data accurately corresponds to on-ground realities.

8.12 Drone Mapping for Survey and Surveillance of Forest and Wildlife Areas

The use of drones represents a cost-effective and efficient technological intervention for developing decision-support tools in forest and wildlife management. In March 2018, the

Haryana Forest Department purchased two drones specifically for the survey and surveillance of the Aravalli area. These drones have significantly aided wildlife rescue operations and the monitoring of wildlife and forest areas in the Aravalli region. Following the creation of the Drone Imaging and Information Services of Haryana in September 2021, the Wildlife Department transferred the drones to this new unit for enhanced operational efficiency and broader application.

Figure 16 Drone for survey and surveillance in Aravalli

Haryana Forest Department purchased two drones specifically for the survey and surveillance of the Aravalli area. These drones have significantly aided wildlife rescue operations and the monitoring of wildlife and forest areas in the Aravalli region. Following the creation of the Drone Imaging and Information Services of Haryana in September 2021, the Wildlife Department transferred the drones to this new unit for enhanced operational efficiency and broader application.

8.13 Encroachment Mapping Using Forest Boundaries

For assessment of unauthorised constructions and encroachment within the forest, Protected areas and ESZ, drone-based high-resolution orthorectified imagery are utilized to identify such landuse changes within digitized forest boundaries to take appropriate legal and management actions.

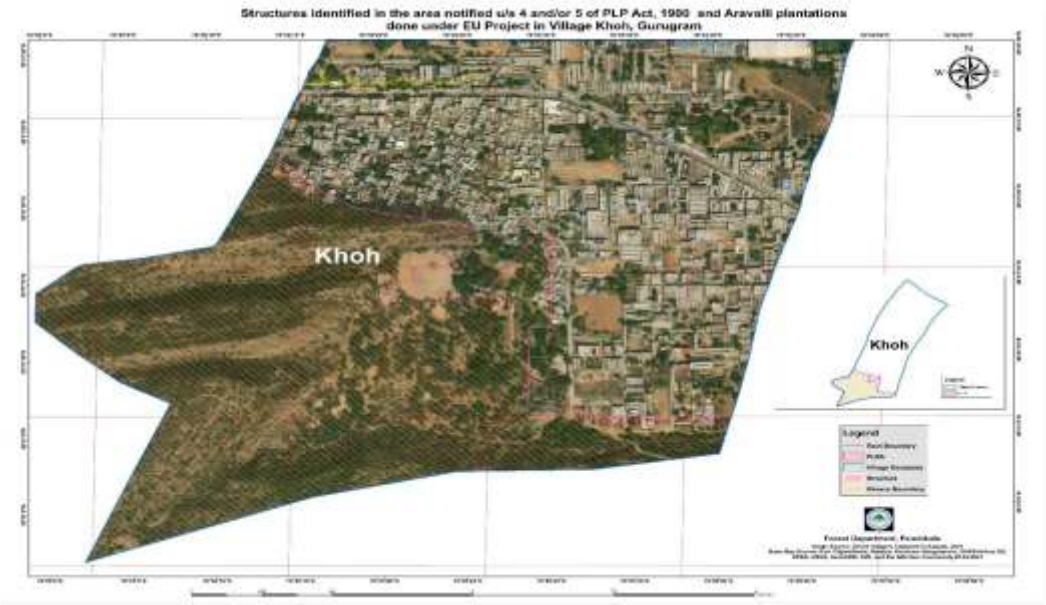

Figure 17: Identification of unauthorised structures in Khoh PLPA area in Gurugram on Drone imagery

8.14 Pilot Project on Drone Seeding (2019-20)

The Forest Department of Haryana has undertaken an innovative initiative to green the Aravalli and Shiwalik Hills by using drone technology for aerial seeding on pilot basis. This method is particularly useful for greening difficult terrain with steep slopes, fragmented areas, or regions without forest routes for traditional tree plantation activities. Additionally, drone seeding is employed in areas that require enrichment plantations through gap filling with tree seeds.

8.14.1 Implementation

The airborne dispersal involves seed pellets of species such as Bad, Peepal, Pilkhan, Amaltash, Bael Patra, Pahari Papri, Ronjh, Khairi, and others. These seeds are chosen based on site suitability and their germination percentage. The operation targeted Yamunanagar and Panchkula districts in the Shiwalik area, and Mahendergarh and Faridabad districts in the Aravalli area. Selecting local species with high survival rates, along with adequate seed treatment and optimal seeding timing, is crucial for the success of this initiative.

8.14.2 Drone Technology

Drone technology, though relatively new in seed dispersal, holds great potential for scientific and precise seeding. Utilizing geospatial technology and Digital Elevation Model (DEM) data, drones can analyze and identify suitable plantation areas and provide terrain information. This pilot project aims to evaluate the effectiveness of drone technology and its dispersal mechanisms.

The seeding drone, developed by an IIT Kanpur-incubated startup, can carry a payload of 2 kg of seeds and is equipped with a precise delivery mechanism for various seed sizes. It can drop seeds at predetermined intervals from a low height of 25-50 meters. A single drone is capable of planting 20,000 to 30,000 tree seeds in a day, significantly boosting vegetation in denuded and low-density areas, as well as inaccessible barren regions.

Figure 18 Seeding drone

8.14.3 Seed Pellets

Seed pellets, or seed balls, are seeds covered with a mixture of clay, compost, charcoal, and other components. These pellets provide the necessary weight for aerial drops and eliminate the need for ploughing and digging holes. This eco-friendly technique minimizes soil disturbance and is suitable for reforestation. Seed pellets follow a "fire and forget" model, meaning they are dispersed and left to sprout naturally when adequate rain falls. The protective clay shell and other additives safeguard the seeds from birds, ants, and insects, enhancing their survival rates.

Figure 19 Seed palleting

8.14.4 Species Selection

Ideal seeds for drone seeding have long-lived embryos and are small enough for aerial dispersal. Native species that are hardy and have suitable seed sizes for seed ball preparation are selected. For the Shiwalik area, species like Pipal, Pilkhan, Bad, Goolar, Lasoora, Amaltash, and Bael Patra are used. For the Aravalli area, species such as Acacia Senegal (Khairi), Acacia leucophloea (Ronjh), Zizyphus mauritiana (Beri), and Holarrhena spp (Inderjo) are chosen. Additionally, site-specific grass seeds like Sarala and Dhaulu are included as effective soil binders in denuded areas.

8.14.5 Assessment of Survival

Assessing the survival rate of drone-seeded plants is challenging due to the scattered nature of seed dispersal. Current assessments rely on visual interpretation of satellite imagery from 2020 and 2022, indicating a 2-5% increase in vegetation cover in such areas.

The pilot use of drone technology for seed dispersal in Haryana has revealed that the technology is still in its early stages and requires further refinement. Improvements are needed in the seed firing mechanism, drone carrying capacity, and the germination rates of seeds, which can be enhanced through prior treatment and pelleting. Despite these challenges, the technology holds a great future for large-scale afforestation efforts in the future.

9. Tree Census

Initiated as per the proposal in the 2022-23 budget speech by the Hon'ble Finance Minister, this comprehensive census involved counting and geo-tagging every tree across villages and urban centers outside compact forest areas to evaluate the green cover accurately. This extensive data collection, encompassing species, girth, and precise locations of trees with geotagged photographs of each tree on non-forest lands, was completed in 2023. The total number of trees counted was 4.1 crore. This data is a vital resource for crafting detailed afforestation plans at the village level.

Figure 20: Tree Census Dashboard showing Alika, Sirsa tree count with each tree's location, specie, girth & Photo

The benefits of such a tree census are manifold, including enhanced biodiversity conservation, improved urban planning, and targeted afforestation efforts. It enables informed decision-making for the preservation of native species, monitoring of tree health, and identification of areas needing greening efforts. The extensive village-wise data is being uploaded to the server for easy access, facilitating the use of this voluminous information in various forestry, environmental and urban planning initiatives

10. Geotagging Forestry interventions

Geotagged forestry interventions and resources serve as a robust decision support system for forest managers, offering several critical benefits specific to the context of the Haryana Forest Department:

10.1 Improved Monitoring and Evaluation

1. **Continuous Monitoring:** The integration of satellite imagery with geotagged data allows for continuous monitoring of plantation growth and health. This enables the detection of issues such as pest infestations or inadequate growth early, allowing for timely interventions.

2. **Detailed Logs:** The system generates detailed logs of field visits and interventions, providing a comprehensive record of activities. These logs are essential for performance assessment and accountability, ensuring that field officers are regularly monitoring their assigned areas.

10.2 Efficient Resource Management

1. **Accurate Mapping:** Accurate mapping of forest assets and resources allows for better planning and allocation of resources. Forest managers can identify areas that require intervention or additional protection, optimizing the use of available resources.

2. **Intervention Identification:** By analyzing geotagged data, managers can identify specific areas that need targeted interventions, such as reforestation or pest control, ensuring that efforts are focused where they are most needed.

10.3 Strategic Planning and Decision Making

1. **Data-Driven Insights:** The platform provides data-driven insights that facilitate informed decision-making. Forest managers can analyze trends, evaluate the effectiveness of interventions, and adjust strategies based on empirical data.

2. **Visualization Tools:** Visualization tools aid in communicating progress and challenges to stakeholders and policymakers. These tools present complex data in an accessible format, supporting effective communication and collaboration.

10.4 Enhanced Collaboration and Coordination

1. **Centralized Data Platforms:** The centralized data platform enables seamless collaboration among different levels of forest management. Field data is readily accessible to supervisors and policymakers, fostering a coordinated approach to forest management.

2. **Real-Time Data Sharing:** Real-time data sharing ensures that all stakeholders have access to the latest information, allowing for coordinated responses to emerging issues and facilitating joint decision-making.

The integration of geotagging and advanced geospatial solutions in forestry interventions marks a significant leap towards sustainable forest management. By harnessing the power of web-based geospatial platforms and the latest satellite imagery, the Haryana Forest Department has achieved greater transparency, accountability, and efficiency in its operations. As a robust decision support system, geotagged forestry interventions not only enhance resource management but also ensure the long-term health and sustainability of forest ecosystems. This innovative approach sets a benchmark for other regions aiming to improve their forest management practices through technology.

11. Geotagging Forest Plantations by the Haryana Forest Department

11.1 Introduction

The Haryana Forest Department has undertaken an initiative to geotag forest plantations, leveraging a mobile and web GIS application named 'Geo-Forest.' This innovative step, inspired by the Hon'ble Chief Minister of Haryana, aims to map all future plantations for enhanced transparency, accountability, and better monitoring of plantation activities. This report delves into the extensive efforts and features of the Geo-Forest application, the benefits of geotagging, and the overall impact on governance and plantation success.

Haryana Forest Department purchased two drones specifically for the survey and surveillance of the Aravalli area. These drones have significantly aided wildlife rescue operations and the monitoring of wildlife and forest areas in the Aravalli region. Following the creation of the Drone Imaging and Information Services of Haryana in September 2021, the Wildlife Department transferred the drones to this new unit for enhanced operational efficiency and broader application.

Figure 21: Plantation Boundary geotagging on Drone image

11.2 Main Features of the Geo-Forest App

11.2.1 Application Overview

The Geo-Forest application is divided into two primary modules:

1. **Geo-tagging Mobile App:**

    - **Designed for Field Users:** The mobile app is specifically created for field users to geotag plantation boundaries. This ensures that the data collected is accurate and comes directly from the plantation sites.
    - **Field Data Collection:** The app collects field data on a web GIS platform, integrating real-time data entry with geospatial mapping.

- **Monitoring Capabilities:** Users can monitor geotagged plantations through photos and videos, capturing the status and health of plantations over time.

- **Survival and Health Data:** The app collects information on survival rates and the overall health of plantations, providing directives to subordinate staff for necessary improvement activities.

2. Desktop Application:

- **For Supervisory Officers:** The desktop application is utilized by higher-level officers such as DFOs, Circle Incharges, APCCFs, and PCCF level officers.

- **Progress Tracking:** It tracks the progress of geotagging activities, ensuring that plantations are being geotagged as planned.

- **Data Visualization and Analytics:** The application visualizes geotagged plantations and performs data analytics on a dashboard, offering insights into various parameters of plantation success.

11.2.2 Detailed Functionalities

The Geo-Forest application provides several user-friendly methods and features for efficient geotagging and monitoring:

1. Geo-referenced Plantation Boundaries:

- **Visualization on Web-GIS:** Users can visualize plantation boundaries on the web-GIS application overlaid with satellite or drone-based images, providing a clear and accurate representation of plantation areas.

2. Methods for Digitizing Plantation Boundaries:

- **Walking the Boundary:** Users can draw plantation boundaries by walking around the plantation area with the mobile app.

- **Tapping Vertices:** Users can tap at vertices of the plantation area on the mobile app while walking along the boundary.

- **Satellite Image Tapping:** If the plantation area is easily identifiable on the satellite image, users can tap the vertices of the plantation on the satellite image within the app.

3. Multi-polygon Geotagging:

- **Geotagging Multiple Parts:** The app allows for geotagging multiple parts of a single plantation in one record, accommodating complex plantation layouts.

4. **Periodic Success and Coverage Visualization:**

- **High-resolution Imagery:** The app monitors plantation success and coverage using high-resolution imagery, which is especially effective for older plantations with significant canopy growth.

5. **Enhanced Transparency and Accountability:**

- **Mobile-based Monitoring:** The mobile app ensures transparency in monitoring, with geo-fencing features that prevent fake data entries.
- **Real-time Data Upload:** Field officers can upload real-time data, including survival percentages, monitoring comments, photos, and videos, making it available for nearly real-time viewing by controlling officers.

6. **Monitoring Logs:**

- **Log Generation:** The app generates logs each time an inspecting officer visits and monitors a site, aiding in the evaluation of field monitoring effectiveness.

7. **Dashboard Analytics:**

- **Insightful Dashboards:** Provides insights into plantation progress, geotagging status, survival rates, and health metrics. Offers district-wise and scheme-wise assessments of plantation success.

Figure 22: Monitoring growth/success of geotagged plantation on time series data

8. Prevention of Duplication:

- **Avoiding Redundancy:** Geotagging prevents duplicate plantations at the same site in subsequent years, maintaining authentic records of plantation health and survival.

11.3 Benefits of the Geo-Forest App Over Previous Methods

The Forest Department has been keeping records of lat-long of the plantation since 2012 and these details are available in year-wise printed Annual Plan Operations (APOs). However, previous geotagging efforts in Haryana relied on APOs with single-point latitude-longitude data, which gives the location of the plantation but may not delineate the plantation boundary. The current methodology, based on web GIS data collection, allows multiple field users to collect data on boundary polygon of plantation simultaneously with real-time automatic data transfer to a central server. This transition eliminates manual data entry errors and enhances the accuracy and efficiency of plantation monitoring.

11.4 Geotagging of Plantations in 2021-22

In the year 2021-22, the Haryana Forest Department successfully geotagged plantations at 3985 sites, encompassing 96.5 lakh plants. This comprehensive geotagging effort highlights the department's commitment to transparency and improved plantation management.

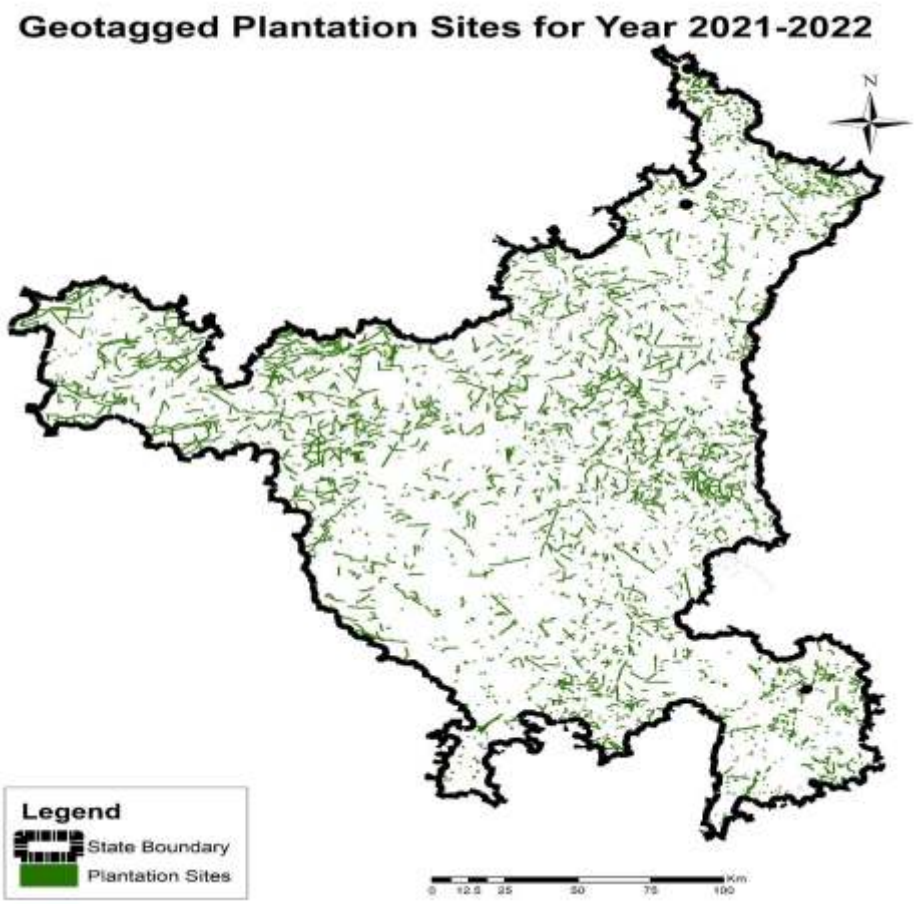

Figure 23 Geotagged Plantation boundary

11.5 Geotagging as an Example of Good Governance

The Geo-Forest application significantly contributes to good governance by:

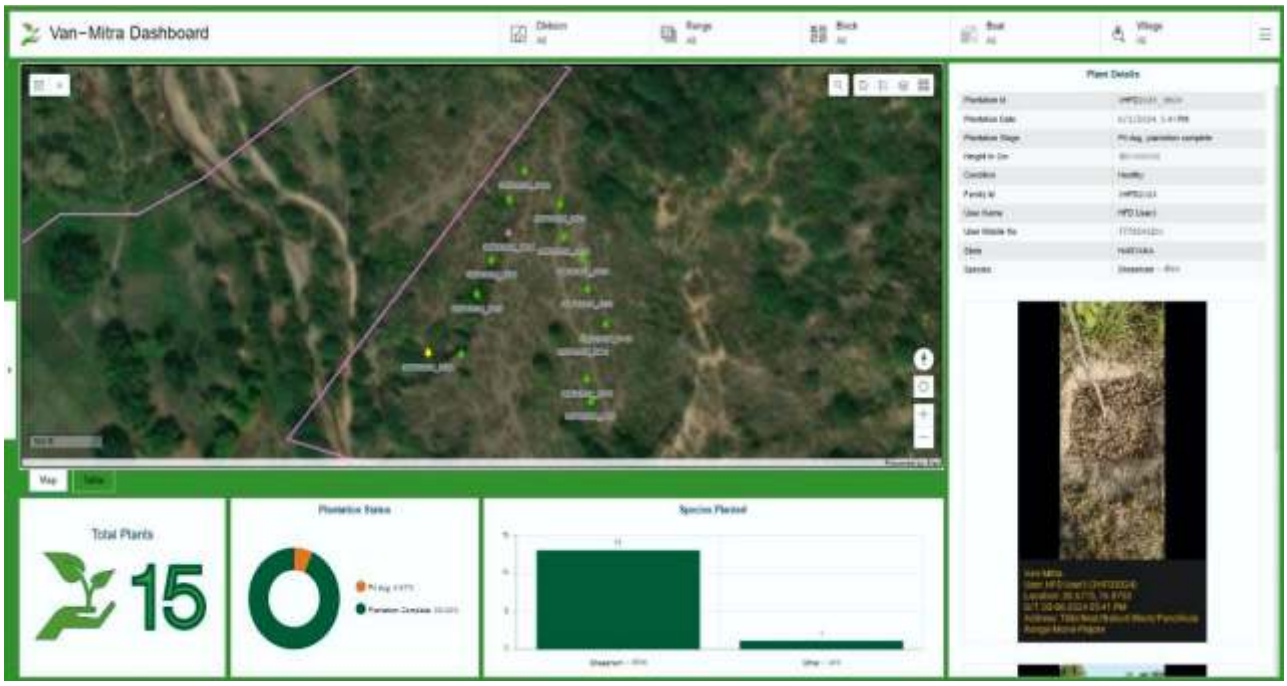

Figure 24: Van Mitra Dashboard with photo and geolocation of each plant

1. **Daily Progress Assessment:**
    - **Day-to-Day Tracking:** Allows day-to-day tracking of plantation progress through an online portal, enabling timely assessments and interventions.
2. **Confirmation of Plantation Targets:**
    - **Immediate Confirmation:** Provides immediate confirmation of the physical area planted, detecting any shortfall in targets and ensuring accountability.
3. **Prevention of Repetition:**
    - **Historical Record Maintenance:** Ensures plantations are not repeated at the same site without supervisory knowledge, maintaining a historical record of plantation locations.
4. **Enhanced Monitoring:**
    - **Accessible Monitoring Data:** Offers easy access to monitoring data, including photos and videos, with logs of each site visit by field officers, enhancing accountability and oversight.
5. **Satellite Data Utilization:**
    - **Visualization of Old Plantations:** Allows visualization of old plantations on freely available satellite platforms like Google Earth and Microsoft Bing, aiding in the assessment of plantation survival and growth.

6. **Comprehensive Dashboard:**

- **Detailed Knowledge:** Displays species distribution, scheme-wise plantation data, survival rates, and average site-specific survival statistics, providing a comprehensive view of plantation success.

The Geo-Forest app is built on a customizable and scalable platform. The app's capability for village-level data capture by local officers can facilitate large-scale data collection in a single day. Future enhancements may include capturing spatial and non-spatial data for specific needs, such as digitizing government assets and monitoring developmental works. The Geo-Forest application is a pioneering step in the geotagging of forest plantations, setting a benchmark for transparency, accountability, and efficient plantation management. This initiative not only aligns with the vision of improved governance but also ensures the sustainable success of forest plantations in Haryana. Through this innovative approach, the Haryana Forest Department has demonstrated a commitment to better forest management and conservation through technology integration.

11.6 Geotagging with the help of Google Earth mobile app

While web based data collection has its inherent advantages, field staff has been trained to collect spatial data as stand alone KML file using Google Earth mobile app for Geotagging plantations, assets, and other spatial data. Field staff can accurately document locations using the app's satellite imagery and GPS. For this, simply open Google Earth, navigate to the location, and drop a placemark to save the coordinates, adding descriptions and photos for a comprehensive record.

12. Way Forward and Conclusion

The Haryana Forest Department's consistent efforts in integrating geospatial technologies into forest management have set a new benchmark in forestry practices. Moving forward, the continuous enhancement of these technologies will be crucial in addressing the emerging challenges in forest conservation and management.

Emergent geospatial technologies hold immense potential for revolutionizing forest management. The adoption of multispectral and hyperspectral remote sensing data will allow for better spectral analysis of forests, enabling more detailed monitoring of forest health, species identification, and vegetation cover. Smaller and more powerful LiDAR sensors, particularly those mounted on drones, will facilitate high-resolution terrain mapping and 3D modeling of forests easier and more affordable, providing valuable insights into forest structure and topography.

Big data handling and cloud computing, including platforms like Google Earth Engine, will streamline the processing of vast amounts of satellite data will help in providing real time environmental data and in improving climate change analysis. This will enhance the ability to perform real-time analysis and make timely decisions. The integration of AI-based automatic delineation and remote sensing data processing will further improve the accuracy and efficiency of forest mapping and monitoring, enabling faster identification of deforestation and other changes in forest cover.

The development of faster supercomputers will make real-time satellite data processing for disaster management and forest analysis a reality. This will significantly improve the ability to respond to forest fires, pest outbreaks, and other emergencies, ensuring better protection of forest resources. Additionally, the potential for smarter drone mapping and drone-based seeding and plantation in large areas will open new avenues for afforestation and reforestation projects, making them more efficient and effective.

Collaborations with academic institutions, technology partners, and other stakeholders will be vital in driving innovation and ensuring the sustainable management of forest resources. These partnerships will foster the exchange of knowledge and expertise, leading to the development of cutting-edge solutions for forest conservation.

On a final note, the implementation of geotagging and geospatial solutions has significantly improved forest management in Haryana. By providing accurate and timely data, these technologies have empowered forest managers to make informed decisions, enhance transparency, and improve accountability. As we continue to refine and expand these capabilities, the commitment to preserving and protecting our forest ecosystems remains steadfast, ensuring a greener and more sustainable future for generations to come.

Drone Photo of Karoh Peak, Morni (4813 ft): Highest point in Haryana

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