GIS BASED CADASTRAL LEVEL FOREST INFORMATION SYSTEM USING WORLD VIEW-II DATA IN BIR HISAR (HARYANA)

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ABSTRACT:

Identification and demarcation of Forest lands on the ground remains a major challenge in Forest administration and management. Cadastral forest mapping deals with forestlands boundary delineation and their associated characterization (forest/non forest). The present study is an application of high resolution World View-II data for digitization of Protected Forest boundary at cadastral level with integration of Records of Right (ROR) data. Cadastral vector data was generated by digitization of spatial data using scanned mussavies in *ArcGIS* environment. Ortho-images were created from World View-II digital stereo data with Universal Transverse Mercator coordinate system with WGS 84 datum.

Cadastral vector data of Bir Hisar (Hisar district, Haryana) and adjacent villages was spatially adjusted over ortho-image using *ArcGIS* software. Edge matching of village boundaries was done with respect to khasra boundaries of individual village. The notified forest grids were identified on ortho-image and grid vector data was extracted from georeferenced cadastral data. Cadastral forest boundary vectors were digitized from ortho-images. Accuracy of cadastral data was checked by comparison of randomly selected geo-coordinates points, tie lines and boundary measurements of randomly selected parcels generated from image data set with that of actual field measurements.

Area comparison was done between cadastral map area, the image map area and RoR area. The area covered under Protected Forest was compared with ROR data and within an accuracy of less than 1 % from ROR area was accepted. The methodology presented in this paper is useful to update the cadastral forest maps. The produced GIS databases and large-scale Forest Maps may serve as a data foundation towards a land register of forests. The study introduces the use of very high resolution satellite data to develop a method for cadastral surveying through on - screen digitization in a less time as compared to the old fashioned cadastral parcel boundaries surveying method.

1. INTRODUCTION

Information and monitoring systems for the forest sector are instrumental for effective policies and planning, prioritizing interventions, valuation of forest resources, efficient investment, and engendering accountability. Relevant forest information that is systematically and periodically collected can enable effective implementation of policies, inform decision making, and guide management. The emerging new satellite technologies enabling earth observation at a spatial resolution of 0.6m or even 0.41m together with powerful and high speed computing and processing capabilities have brought revolutionary changes in the field of GIS-based cadastral land information system. The high-resolution satellite imagery (HRSI) is showing its usefulness for cadastral surveys due to which traditional cadastre and land registration systems have been undergoing major changes worldwide (UN-FIG, 1999).

Land information refers to physical, legal, economic or environmental information or characteristics concerning land, water and sub-surface resources (Holstein, 1990). Land Information System (LIS) is similar to GIS but more focused on land records. GIS and LIS systems provide tools that support many types of records keeping, analysis and decision-making. Land information is an integral part of government, non-profit and private sector activities. The GIS/LIS techniques advance broader social purpose by helping to make more effective decisions for using natural resources in a more optimal way (Barnes, 1990). Land Information System (LIS) consists of spatial and non-spatial data. Both these spatial data (such as parcel boundary, shape, and location) and non-spatial data (such as ownership, rights, and area) are stored, maintained, and accessed in the database environment. Spatial data is acquired through cadastral surveys which are concerned with geometrical data of each land parcel. Cadastral mapping goes a step further and produces complete maps, which are based on cadastral surveys (Steudler, 2004).

The dynamically changing relationship of humankind to land has a great influence on the development of land administration systems (Gopala Rao, 2000). The cadastre is a public record of location, extent, value and ownership of land in a district for the purpose of taxation (Ting and Williamson, 1999). The cadastral system provides an integrated approach to deal with land, law and land owner (Angus, 1989; Dhal, *et al*,. 1994; Clarissa and Oriando, 1999). The basic elements of the cadastral system include; clear identification of parcel limits, creation of Records of Right (ROR), provision of legal coverage to land owners. The digital cadastral map, the fundamental component of cadastral system, is not a map, in the traditional sense. It is neither stored nor it is an image of a geographic area. Instead, the data are stored, from which it is possible to draw a desired view. Although it can be displayed and printed at different scales, projections and colours, it is in fact an analytical tool (Krishna Murthy *et al.,* 1996a; Piotr, 1999; Gopala Rao, 2000).

Cadastral forest mapping deals with forestland boundary delineation through extraction of parcels registered for forest areas and their associated characterization (forest/non-forest) based on the land cover characteristics from high resolution satellite data. Spatial data and information about forestlands are among the most critical in the context of forest and environment protection, spatial planning, monitoring and forest governance.

Forest Information System present an accurate picture of forest lands geographic location and their boundaries, make relevant, reliable, accurate, and up to date spatial forest data and information continuously available to the government, land authorities and communities. It provides consistency in reporting, reduce cost through the sharing of information technology, facilitate citizens, professional, research, and build the land market (Vogiatzis, 2014).

High-resolution space-borne remote sensing image data show a high level of detail and provide many opportunities to be used as base for cadastral map generation. Orthoimage generated by using satellite data having 0.5 m spatial resolution are ideally suited for deriving cadastral plot vectors for plain areas. The obscured areas need ground survey intervention by DGPS & ETS (Parida, 2012). Remote Sensing and GIS techniques in forest resource management realizes modern forest space-time adjusting, predicting, decision, inspecting, mapping and evaluating, which provide a scientific foundation for realizing forest resource development and classification management (Muhammad, 2011). The use of GIS technology and web mapping has significantly accelerated the process of Forest mapping and make easy public access, information and participation. The combination of GIS and GPS activities play a crucial role in developing the survey of the forest boundary points and making forest cadastral maps. Area, length other measures in the GIS numerical database are considerably easy (Hulusi, *et.al.,* 2002).

The present study is undertaken to create the digital data base of forest lands in Bir Hissar PF areas. The forest land maps of Bir Hisar P.F. (H.B.No.124), showing the ownership details have been prepared by extraction of land parcels registered for forest areas based on the land cover characteristics from ortho-rectified satellite data.

2. STUDY AREA

Hisar is the west central district of Haryana State with a total geographical area of 4050.00 sq. km. The study area Bir Hisar is situated in Hisar tehsil, lies between the north latitudes 29^o 07' 23": 29^o 18' 50" and east longitudes 75^o 37' 31": 75^o 46' 34" with 42,692 acres of total geographical area. The district is divided into nine community development blocks namely Agroha, Adampur, Barwala, Bass (Hansi-II), Hansi-I, Hisar-I, Hisar-II, Narnaund, and Uklana Mandi. The climate of Hisar district can be classified as tropical steppe, semi-arid and hot which is mainly dry with very hot summer and cold winter except during monsoon season when moist air of oceanic origin penetrates into the district. The district area forms a part of Indo-Gangetic plain. The area as a whole is almost flat alluvial plain dotted with sand hummocks and sand dunes. The location of these study areas is shown in Figure 1. The study area comprises of Bir Hisar P.F. (Notification No. S.O. 41/C.A.16/27.S.29/87), Chikanwas P.F. (Notification No. S.O.11/C.A.16/1927/S.29/2014) and Forest Complex P.F. areas (Notification No. S.O.117/C.A.16/1927/S.29/2013).

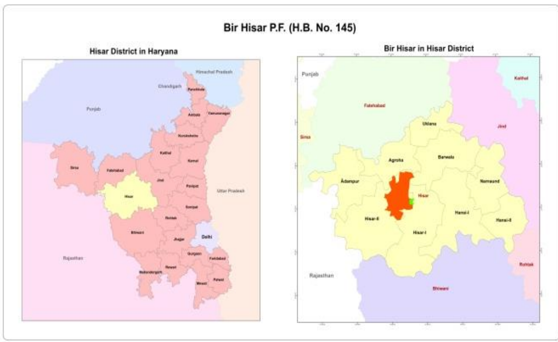

Figure 1. Location of study area.

3. DATABASE AND METHODOLOGY

The methodology used in the present study is shown in Figure 2.

3.1. Data sets used

(a) Satellite Imagery
High resolution World View-II panchromatic images of 0.50 m resolution and colored images of 1.86 m GSD of date 25/01/2011 were acquired for study areas.
(b) Cadastral Map
The mussavies of the study areas were collected from District Revenue Office and used to generate cadastral planimetric vector data. These maps were georeferenced and overlaid on the satellite imagery for further analyses.
(c) Forest Maps
The Forest map of Bir Hisar P.F. provided by Haryana Forest Department was utilized to fix forest boundary and for consideration of min. proportion of some khasra no. within forest land. Min. refers to a portion of khasra (killa) without specific dimensions & different khasra no.
(d) GPS Data
Garmin GPS navigation receiver was used for GCPs collection.

3.2. Methodology

3.2.1. Ortho-rectification

Ortho-images were created from World View-II digital stereo data with Universal Transverse Mercator coordinate system with WGS 84 datum. The following inputs were required for the generation of the Ortho-rectified image

- Digital Satellite Images
- Digital Elevation Model data
- Foot Print Index
- Adjusted Satellite triangulation parameters
- RPC (Rational Polynomial Coefficients) File
- Description and co-ordinates of Primary Control point, Tertiary control Points and Auxiliary control points for connection of vertical control points

Individual scene was Ortho-rectification using the triangulated satellite imageries and DTM as per the defined GSD of sensor. Geometric accuracy of the Ortho was verified by using the available control points. Seam line/cutline was generated along roads, rivers, and streams with ensuring that seem line did not cross important cultural features. Mosaicing and automatic global tone balancing was done. Review of tone balance in the mosaic. Accuracy measurement of ortho-image was done by using check points and control points. Positional accuracy was checked with the help of control points.

3.2.2 Cadastral vector data generation

The cadastral maps of the villages collected from the Land Record Department (LRD) were scanned and converted to vector format in *ArcGIS* environment. Vector cadastral maps were combined with attribute data. Scanning, digitization of Mussavies, updation of digital Mussavies and generation of vector data pertaining to the parcels was done using *ArcGIS* softwareMussavi refers to mapping sheet consists 16 murraba. Each murrba comprised of 25 killa (5x5). Killa is the smallest land parcel with ownership represented by the positive integer from 1 to 25 in mussavi. Murraba grids (200 karam x 180 karam) and khasra grids (40 karam x 36 karam) were generated. The murrba grid was generated using same origin as that of killa grid in *Arc GIS* software. The line feature forming murrba grid was converted to polygon feature and the label of each murrba placed at its centroid. Each musavi comprises of the 16 murrba. The features such as village tri-junctions, bi-junctions etc. were digitized as point features. The digitization of the features was done as per the dimension specified on the map. The bifurcated / Bata parcels were generated by splitting the killa line boundary as per the distance / dimension specified in the map. Spatial data base was geo-linked by integrated with RoR data and converted into *.shp/*gdb file format. The quality assurance was complying with the positional accuracy, attribute accuracy, logical consistency, completeness and mosaicing fit of the data. Total area of the village by aggregating the parcels, etc. was compared with the area available with the Land Records in the RoRs.

3.2.3 Field Survey

Field visits were carried out along with Forest Department officials to locate and draw cadastral forest boundaries using field data and photogrammetric techniques.

3.2.4 Geo-Referencing of village map

For geo-referencing the cadastral map, the real world coordinates for sufficient numbers of Ground Control Points (GCPs) are required. The real world coordinates of the GCP's are obtained through primary sources or secondary sources. The primary sources consists of three modes viz., ground survey, topographical maps and coordinates obtained from GPS (Srinivaso Rao *et al.,* 2003). The secondary sources consist of aerial images or high resolution satellite images.

Sufficient numbers of GCP's were identified on the vector cadastral map, for generating the transform model. The spatial and radiometric resolutions of the satellite data play a major role in identifying the GCP with good geometric definition. GCP's were spread uniformly in the entire map and labelled uniquely for identification in similar coordinate-based survey. Second order polynomial model or affine transformation model was applied for geo-referencing of cadastral map. The transformation model was assessed by the values arrived for residual error at each GCP and root mean square for the entire model. The rms error contribution is less than 3 m in either direction. The threshold value for the residual error at each GCP is 6 m in either direction (Srinivaso Rao *et al.,* 2003).

The transformation model was accepted when the actual rms and residual errors arrived is less than the threshold values, and the vector cadastral map is geo-referenced though affine transformation in GIS environment. New vector files were generated for the polygon, line and point features separately. The geo-referenced vector file of each village was validated with reference to the ortho-rectified image. The geo-referenced vector file is overlaid on the reference image and initial validation was carried out through visual checking. The displacement was measures as the distance between the image point and the vector point. If the shift was more than allowable limits, geo-referencing was carried out once again. The validation of geo-referenced map, with neighbourhood, using ortho-rectified image was carried out to ensure that the village boundary is matching with all adjoining village boundaries. Due to flat nature of the study area, it was not so difficult to identify respective cadastral boundaries on satellite image.

3.2.5. Accuracy Checking

The accuracy of the cadastral maps is analysed through the accuracy of the transformation models, location accuracy and finally the area accuracy of each parcel. The accuracy of digital cadastral maps is assessed through one-to-one matching of the vectorised cadastral maps with the original analog map to ensure the shape and number of the respective parcel and the total number of parcels & other features in the village, particularly zero labels and duplicate labels and assessment of parcels area in vector layer with respect to the area of parcels mentioned in revenue records.

Accuracy assessment was done by comparison of geo-coordinates of randomly selected points generated by computer with that of observed through GPS, comparison of length measurement (of tie lines) generated by computer with that of actual field measurement and comparison of area of randomly selected parcels generated from image data set with that of actual field measurements. Table 1 & Figure 3 (a), (b), (c) & (d) shows the results of tie-line measurement. Spatial

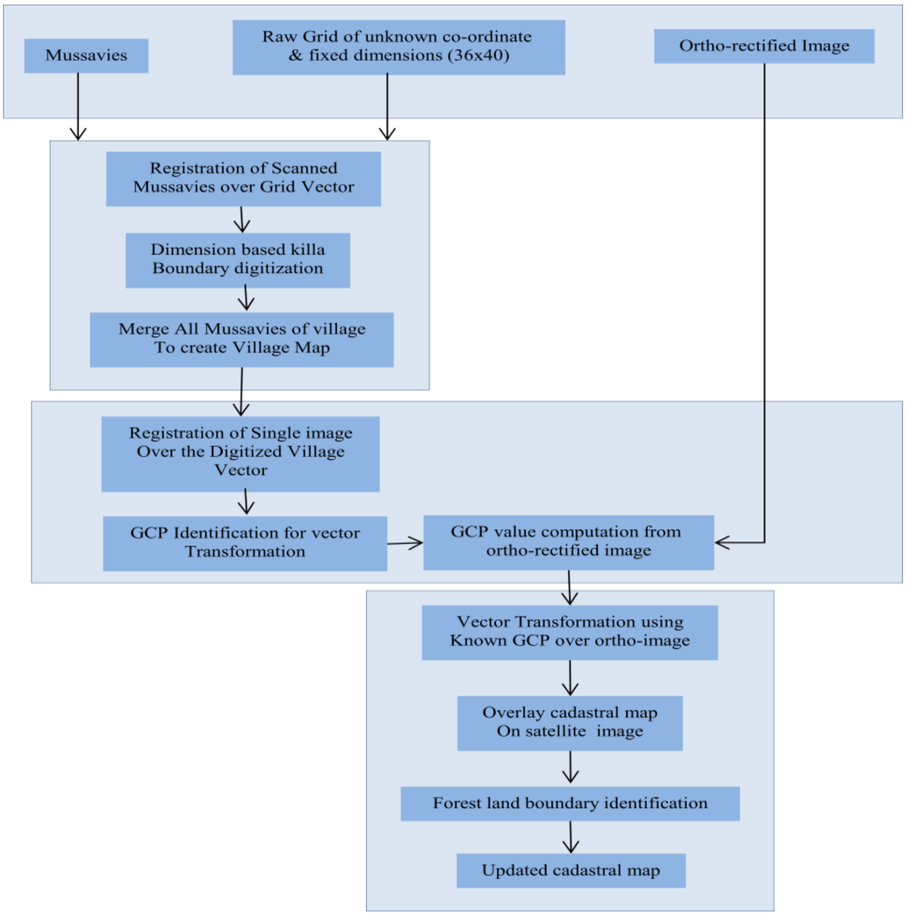

Figure 2. Process Flow of Integrated Approach

adjustment (Transformation) of village vector over the ortho-rectified high resolution satellite image with length / area accuracy of individual plots / killa not less than 98% was attained. Edge matching of individual villages was done with accuracy of 98% – 100%, measured on length / area variations on plots / killa boundaries located at the boundary of Bir Hisar village.

(a) (b)

(c) (d)

Figure 3. (a) Tie-line road triangulation points on satellite image, (b) Tie-line measurement points on ground, (c) Tie-line Forest Complex points on satellite image, (d) Tie-line measurement points on ground.

Table 1. Tie-line Measurements

S. No	Area	Points	Distance (mtrs)		Difference (mts)
			Image	Ground	
1	Bir Hissar (Nr. Forest Complex)	A - B	11.7	11.6	0.1
		B - C	8.64	8.7	0.06
		C -A	10.35	10.8	0.45
2	Bir Hissar (Air Strip)	A - B	30.3	30.3	0.0
		B - C	23.41	23.9	0.49
		C - D	9.34	9.00	0.34
		D - A	24.23	24.0	0.23
3	Forest Complex (C F Office)	A-B	12.5	12.6	0.1

4. Results and Discussion

4.1 Demarcation of Forest land of Bir Hisar P.F.

Killa / murraba grid number under notified forest land were identified on cadastral map of study area. Separate forest land grid vector layer was prepared from village cadastral map. Forest boundary map of Bir Hisar was scanned and geo-referenced using ortho-rectified image. Forest boundary was digitized from that geo-referenced map. Forest land grid vector layer was overlaid on world view image and partitioning of killa grids with min. numbers was done using that digitized forest boundary as reference. Forest area generated from vector layer was compared with total forest area mentioned in notification.

This study introduces an integrated approach for acquiring cadastral data and mapping parcel boundaries by integrating cadastral data, GPS survey and high resolution satellite imagery. Existing cadastral information was acquired from Revenue Office. Mussavies were geo-referenced and mosaiced village-wise including 17 adjoining villages and Bir Hisar. Parcel boundaries were digitized on geo-referenced mussavies using on-screen digitization technique. Village-wise cadastral vector layers were prepared within permissible tolerance limit ± 1 % of total area of vector data compared to ROR data. The cadastral layers of Bir Hisar P.F., Chikanwas P.F. and Forest Complex P.F. overlaid on ortho-rectified image are shown in Figure 4, 5 & 6.

It was found in the study that high resolution satellite image with a level of detail similar to that obtained by aerial photography, make this technology more suitable for cadastral map generation. The village area from revenue department is collected for the village. The corresponding areas of vector files and geo-referenced files for village area analysis are shown in Table 2. It was observed that in case of Bir Hisar P.F. areas, an area of about 1133.89 acres against the notified area of 1131.29 (2.6 acres difference). In case of Chikanwas P.F. an area of 12.48 acres were calculated against the notified area of 12.50 acres and in case of Forest Complex P.F. an area of 14.40 acres were calculated against the notified area of 14.15 acres (0.25 acres of difference). Map. 1 shows final output product, prepared for Bir Hisar P.F. showing the ownership details. The study has revealed that a difference of about 2.6 acres was found to be in Bir Hisar P.F. (1160.74 acres) area from notified forest (1157.94 acres) area.

Table. 2. Comparison of Village vector area with ROR area.

S. No.	Village	ROR area (Acres)	Geo-referenced cadastral map area (Acres)	Difference (Acres)
1.	Bir Hisar P.F.	1131.29	1133.89	2.6
2.	Chikanwas P.F.	12.50	12.48	0.02
3.	Forest Complex P.F.	14.15	14.37	0.22

Figure 4. A part of cadastral layer of Bir Hisar (P.F) overlaid on ortho-rectified image.

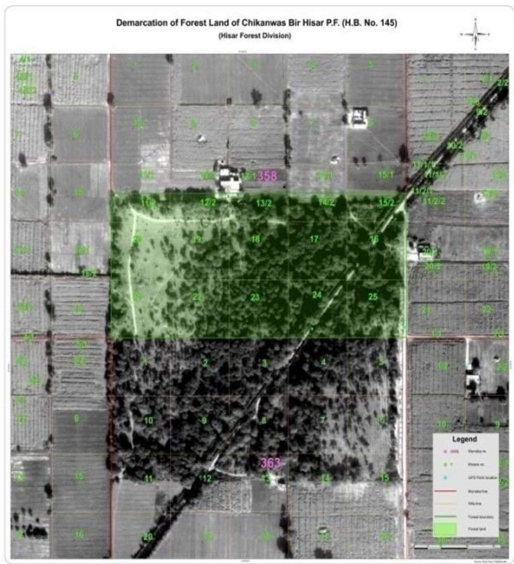

Figure 5. Cadastral layer of Chikanwas P.F. overlaid on ortho-rectified image.

Figure 6. Cadastral layer of Forest Complex P.F. overlaid on ortho-rectified image.

5. Conclusion

Forest Information System refers to the process of generating geospatial data, sharing of spatial information about forestlands and their associated resources and management activities, for their sustainable management. The present study was done to prepare the cadastral map of Forest land of Bir Hisar using high resolution satellite data, GPS survey and existing cadastral data. This study illustrates development of geospatial infrastructure for assessment and monitoring of forestlands and their resources to develop transparency in forestland administration that support better decision and policy making.

The accuracy assessment of the cadastral map has been carried out. It is found that area of village vector data is matching with RoR data within ± 1 % tolerance limit. Total area of forest land of Bir Hisar (1160.77 acres) having 0.24 % of difference with notified area (1157.94 acres). The present study demonstrates the capability of HRSI data in the demarcation of forest lands at the cadastral level showing the appropriate ownership details.

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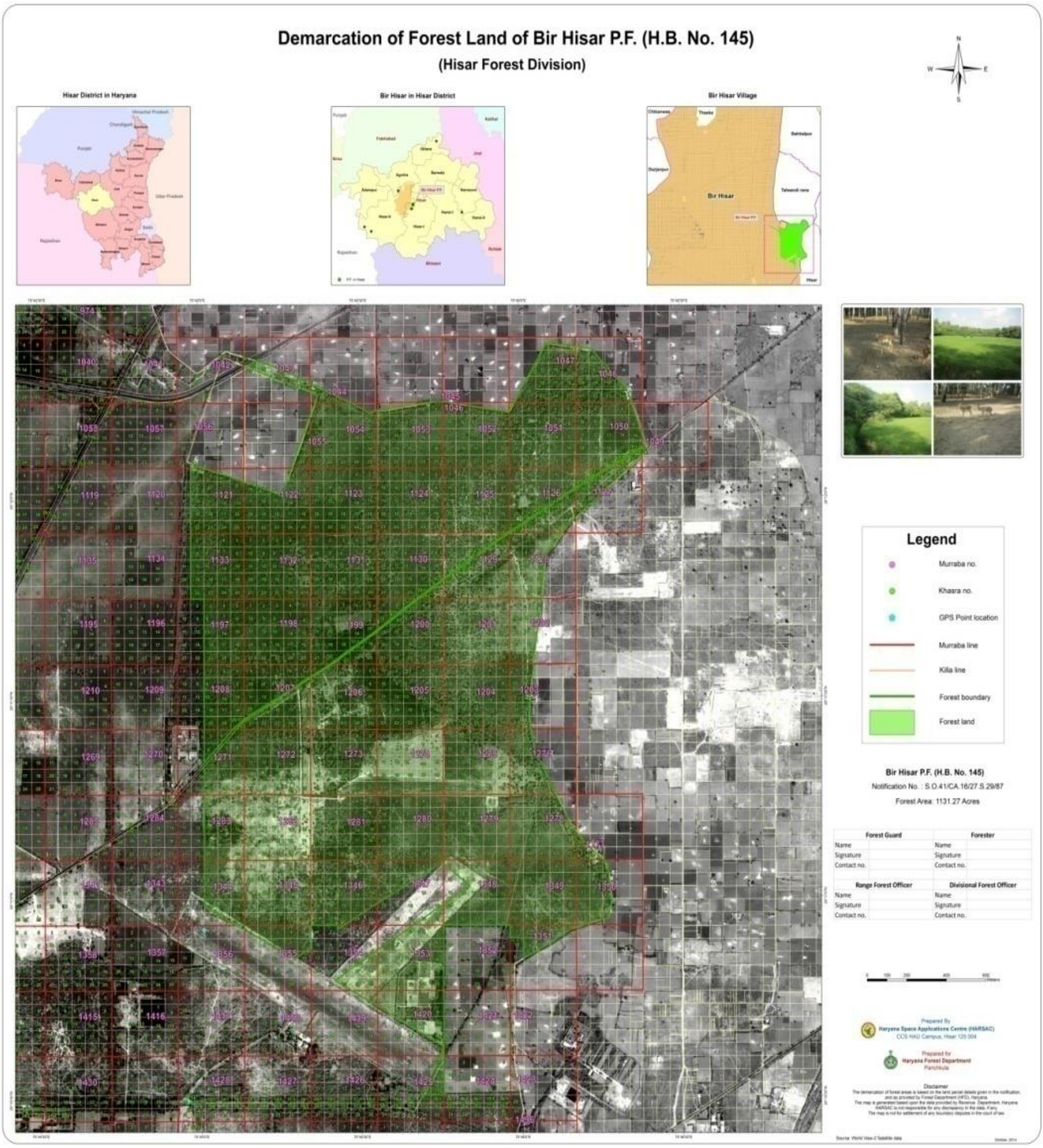
Demarcation of Forest Land of Bir Hisar P.F. (H.B. No. 145)
(Hisar Forest Division)
Hisar District in Haryana
Bir Hisar in Hisar District
Bir Hisar Village
Legend
Murraba no.
Khasra no.
GPS Point location
Murraba line
Killa line
Forest boundary
Forest land
Bir Hisar P.F. (H.B. No. 145)
Notification No. : S.O.41/CA.16/27.S.29/87
Forest Area: 1131.27 Acres
Forest Guard
Forester
Name
Signature
Contact no.
Range Forest Officer
Divisional Forest Officer
Name
Signature
Contact no.
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Map 1