

Time Series Mapping and Monitoring of Agroforestry Area in Yamunanagar District of Haryana State Using Geospatial

Bojja Harish Babu

harishagf9@gmail.com

Choudhary Charan Singh Haryana Agricultural University

Sandeep Arya

Choudhary Charan Singh Haryana Agricultural University

K. E. Mothi Kumar

Haryana Space Applications Centre (HARSAC), CCS Haryana Agricultural University Campus

Krishma Nanda

Choudhary Charan Singh Haryana Agricultural University

Research Article

Keywords: Agroforestry, Remote sensing, Geospatial Techniques, Climate change, Global Positioning System

Posted Date: April 9th, 2024

DOI: <https://doi.org/10.21203/rs.3.rs-4191121/v1>

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Additional Declarations: No competing interests reported.

TIME SERIES MAPPING AND MONITORING OF AGROFORESTRY AREA IN YAMUNANAGAR DISTRICT OF HARYANA STATE USING GEOSPATIAL

¹*Bojja Harish Babu, ¹Sandeep Arya, ²K.E. Mothi Kumar, ¹Krishma Nanda

¹ Choudhary Charan Singh Haryana Agricultural University, Hisar 125004

²Haryana Space Applications Centre (HARSAC)

CCS Haryana Agricultural University Campus, Hisar 125 004

*E-mail: harishagf9@gmail.com

Abstract

Diverse agroforestry practices are prevalent in different Agro-Climatic regions of India and occupies substantial area. In Northern India's Indo-Gangetic plains, agroforestry activities with respect to (eucalyptus) *Eucalyptus tereticornis* and (poplar) *Populus deltoides* based practices are very dominant. These agroforestry systems not only satisfy the need for wood to Wood-based Industries, but also contribute significantly to employment generation and the reduction of atmospheric Carbon dioxide (CO₂) vis-à-vis mitigating climate change. Mapping and monitoring agroforestry areas by using the LISS-III and LISS-IV Multispectral High Resolution Satellite Remote Sensing data in the Yamunanagar district of Haryana has been undertaken to develop an operational method in the present research. Supervised classification method was used for land use land cover analysis for the year 2010 and 2019 in which training sites for seven parameters viz, agroforestry (Poplar, Eucalyptus based), agriculture, plantations (Horticulture, Scrub plantations, miscellaneous plantations) water bodies, forest, buildups, riverbed areas were mapped and monitored. The maximum area was estimated under agroforestry systems i.e. 4.06 and 9.69 percent, which includes both poplar and eucalyptus based Agri-silviculture and boundary systems for the year 2010 and 2019 respectively. Agricultural land, forests and other plantations constitute about 73.56%, 11.08% and 1.96% in 2010 and 67.77%, 10.99%, 1.7% in the year 2019 respectively of total district area. The accuracy of the image classification was delineated based on the ground truth data collected from the Yamunanagar district by using GPS (Global Positioning System) and accuracy found in Agroforestry was 90%.

Key words Agroforestry, Remote sensing, Geospatial Techniques, Climate change, Global Positioning System

One liner

With judicious use of Geospatial technologies, assessment of natural resources like Agroforestry can be done accurately, which will provide desired spatial information for planners and decision makers.

Introduction

Several forms of agroforestry are common throughout the country that contribute to local communities and produce raw material for industry. Pathak et al. (2000) gave an account of prominent agroforestry systems in different agro-climatic regions of India. Agri-silviculture and agri-horticulture systems in western and eastern Himalayan regions; Agri-horti-silviculture system in upper and trans-gangetic plains; agrisilviculture and silvipastoral systems in southern plateau and Hilly regions are some of them. The prominent agroforestry systems practiced by farmers in Yamunanagar district are Poplar and Eucalyptus based agrisilviculture systems, boundary plantations and mango based agri-horticulture system. Reason for growing Poplar and Eucalyptus species is their fast growth and also the availability of wood market. A chief use of remotely sensed data is to produce a classification map of the identifiable or meaningful features or classes of the land cover types in a scene. In the field of remote sensing, image classification is a process in which pixels or the basic element unit of an image are assigned to classes. By comparing pixels to one another and to those known identity, it is possible to assemble

groups of similar pixels into classes and produce a thematic map. Image classification is defined as the process of creating thematic maps from satellite imagery (DeFries et al. 1999).

District Yamunanagar is located in the state of Haryana towards North-Western India. Yamunanagar is considered as the model district for the adoption of agroforestry and this district is mostly dominated by eucalyptus and poplar based agroforestry systems (Kumar *et al*, 2004). These systems has important ecological role as these planted trees help to prevent high surface runoff and thus prevent the soil erosion. It also helps to minimize the flooding and works as fence to protect crops from strong winds. Some estimations on area and production of wood for the trees outside forest are available (FSI 2013), but these estimates also include trees on canal side, on roadside and in urban regions and thus do not represent true agroforestry area. Mothi *et al*, (2011) mapped trees outside forest by utilizing merged satellite data products of LISS-IV and Cartosat-1 and found that area under Trees Outside Forest (TOF) was 11.09 % in Bilaspur block of Yamunanagar district. Ahmed *et al*, (2007) proposed a methodology to estimate the area under agroforestry. However, the exact figure of area and change detection from 2010 to 2019 under agroforestry systems in the district is not yet known.

The present research work has been undertaken to map and monitor the areas under agroforestry in the Yamunanagar district from 2010 to 2019 time period using Indian Remote sensing satellite data of LISS-III and LISS-IV respectively.

1. Study Area

Yamunanagar is a district located in Haryana, known for its well conserved forests as well as vast tracts of cultivation, interspersed with pioneer efforts in Agroforestry based development. The study area represented in Fig. 1. It is located at height of 274 mt. from sea level and is between the longitude of 77 ~ 13' to 77 ~ 36' and North latitude of 29 ~ 50' to 30 ~ 03' and occupies an area of 1,75,644 ha. The Yamunanagar district comprises of six blocks, namely Sadaura, Bilaspur, Chhachhrauli, Mustafabad, Jagadhri and Radaur. Champion and Seth (1968) classified the forests of Shiwalik hill tracts of the region as Northern tropical dry deciduous. Large part of the district is located in Shiwalik foothills. The forests types in the Shiwalik hill tracts of the district are Shiwalik chir pine, dry Shiwalik Sal, Northern dry mixed deciduous and dry bamboo brake (Kumar and Goel, 2001) which are said to be rich in floral diversity. The tree species mainly exists are *Populus deltoides*, *Eucalyptus species*, and *Acacia catechu* etc.

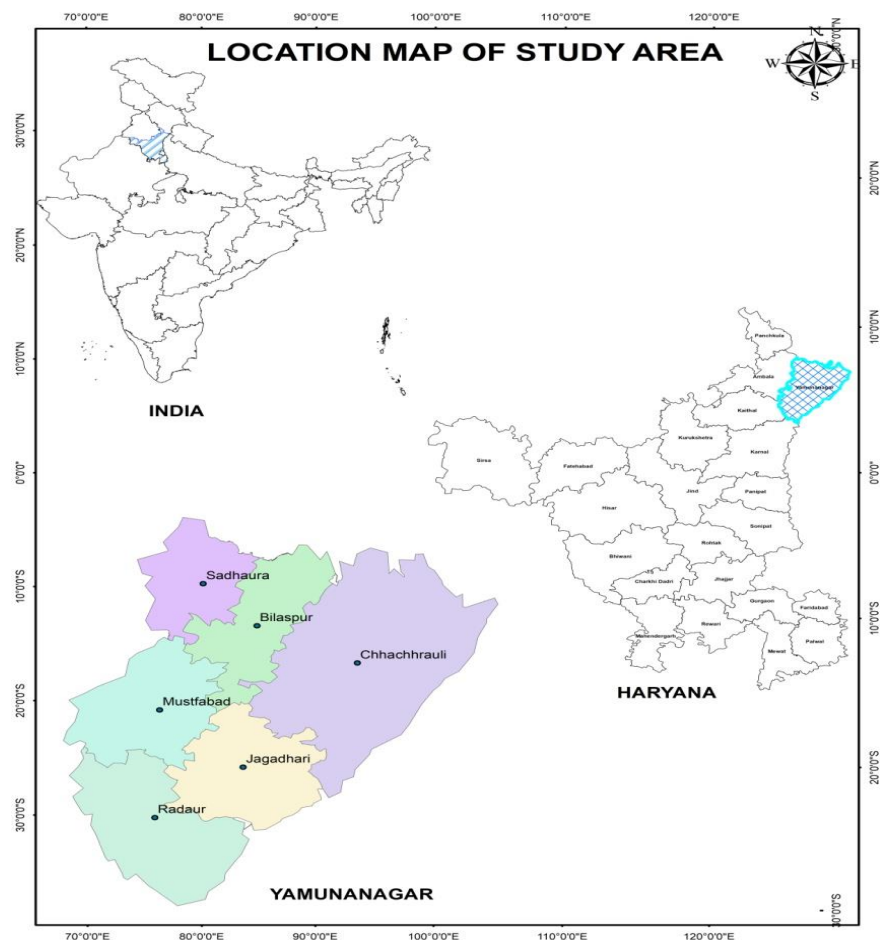


Fig.1 Location map

3. Methodology adopted

Agroforestry refers to cultivation of agricultural crops along with forest species which are sustainable and systematically in same unit of land area. No accurate figures are available for agroforestry areas in parts of Haryana and there is need to develop the methodology scientifically for agroforestry area for Monitoring and Mapping by using Geospatial Techniques. Rizvi *et al*, (2016) have developed agroforestry mapping methods and Ahmed *et al*, (2016) have used LISS-IV high resolution data for agroforestry area estimations in Ludhiana, Punjab. Therefore, methodology was developed for mapping and monitoring of agroforestry area from 2010-2019, using LISS-III satellite data for the year 2010 and LISS-IV High Resolution Multispectral satellite data for the year 2019 in this study, District area has been classified into various land use categories and area was identified based up on the standard image interpretation technique. Within the study area classes such as agroforestry, agriculture (crop land), build up areas, water bodies (Rivers, Ponds and Canals), forest area, plantation (horticulture) and sandy areas were classified using Satellite image, the methodology adopted are given in flow chart below (Fig. 2).

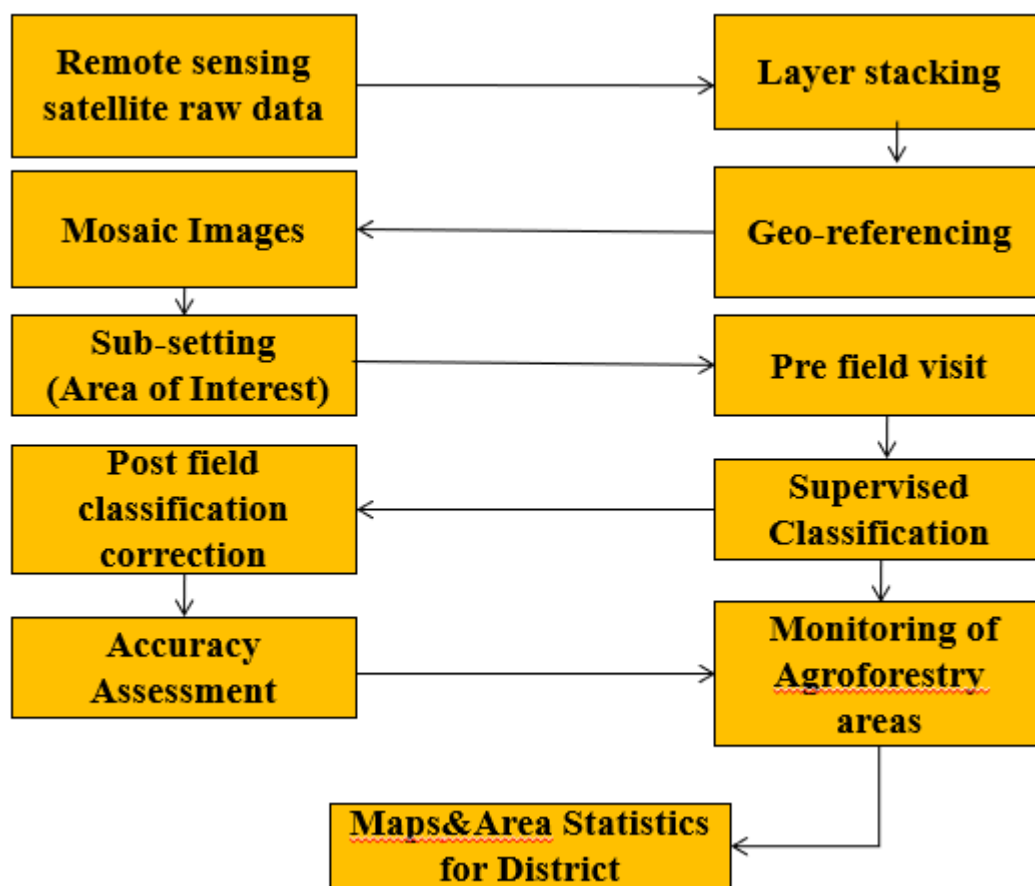


Fig.2 Flowchart for methodology adopted to estimate Agroforestry area

3.1 Database Preparation

Remote sensing data:

Remote Sensing data is the key source for the mapping of agroforestry. For identification and monitoring of agroforestry area in the Yamunanagar district for the year 2010 to 2019, Remote Sensing satellite data such as IRS P6 Resourcesat LISS IV multispectral and LISS-III was used to prepare Land use /Land cover (LULC) maps on 1:50000 scale and for Land use/Land cover analysis. Pre-processing of remote sensing images includes layer stacking, mosaicing and subsetting with district boundary by Geo referencing/rectification was done.

Software Used

Land use Land cover classification was done by Supervised method of classification in the district using ERDAS 2011 ENVI 5.5.2 standard image processing software and ARC/INFO.

3.2 Ground Truth Survey

Ground truth survey for image analysis was conducted at Bilaspur, Chhachhrauli, Jagadhari, Sadhaura, Mustafabad and Radaur blocks in the district. The data collected through Geographical Position System (GPS) during Ground truthing survey was treated as training site data and it was applied to interpretation of the whole image. It was observed during Ground truth survey that mainly Eucalyptus and Poplar plantations are associated with agricultural lands as agroforestry systems. Mostly agroforestry with block formations and boundary

plantations like linear formations of poplar and eucalyptus species were seen which extensively covered along the river, roads, railway line and nearby canals. In Agri-Silviculture systems poplar with wheat, poplar with sugarcane, rice with eucalyptus mainly as boundary plantations are the main cultivation practices followed in the Yamunanagar district which are shown in the following maps and photographs (Fig. 3). However, it was observed that poplar and eucalyptus species are the major tree species under different agroforestry practices in the district.

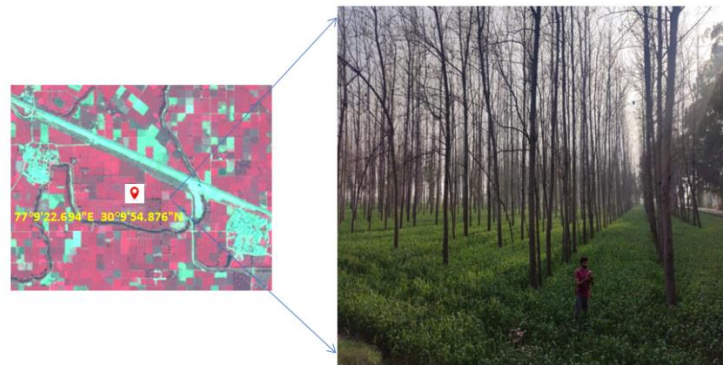
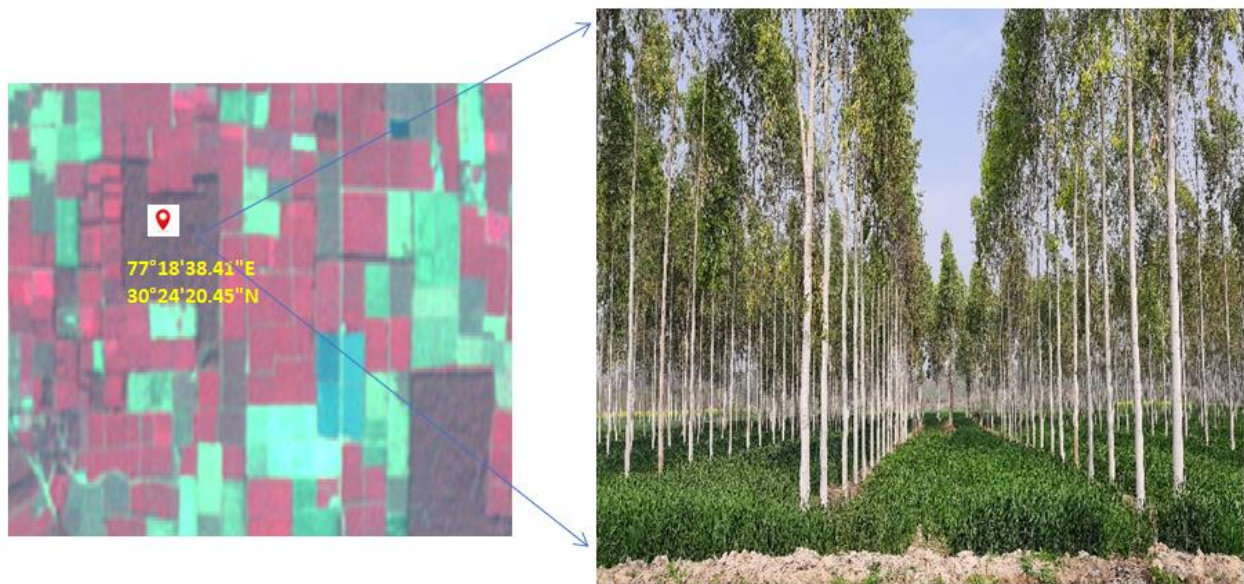


Fig. 3. (a) Poplar & Wheat based Agroforestry



(b) Eucalyptus and Wheat based Agroforestry

Fig. 3. (a,b) Field Photographs of Agroforestry Systems in Yamunanagar district of Haryana.

3.3 Post classification correction

Corrections were made by visually comparing the classified image to False Colour Composite (FCC) image, delineating the agroforestry area and obtaining a statistical area. The recoding classification and accuracy estimation of remote sensing images were performed and post classified.

4. Results and Discussion

Image classification is a procedure to automatically categorize all pixels in an image into land cover classes. Normally, multispectral data are used to perform the classification of spectral pattern present within each pixel as the numerical basis for the categorization. Based upon the analysis of the satellite data, seven LU/LC (Land Use Land Cover) classes were identified in the district namely agroforestry, agriculture, forest, plantations which includes horticulture, scrub and miscellaneous plantations, built-up areas and riverbed areas. By using Supervised method of classification, the estimation of area under agroforestry along with other classes were obtained. In classification it was observed that sandy areas and dry streams were intermixed with buildup areas, so in order to rectify such an error, buildup area and river bed areas were masked and recoded with the help of FCC and toposheets. Similarly agroforestry area and forest were intermingled, to minimize the intermingled pixels, same approach was implemented to find area under Agroforestry category.

Land-Use/Land-Cover of Yamunanagar district for the year 2010 showed that agriculture occupied a sizeable area in the district and followed by forest, built-up and agroforestry. The analysis of 2010 data revealed that about 1,29,210.25 ha (73.56% of TGA) was reported to be under agriculture land, while the agroforestry area was found to be 7,134.9 ha (4.06% of TGA). And also estimated area under forest was 19,473 ha (11.08% of TGA), built-up land 9,947.98 ha (5.66% of TGA), waterbodies 2,160.29 ha (1.22% of TGA), riverbed 4,256.69 ha (2.42% of TGA) and plantations occupied 3,460.15 ha (1.96% of TGA) within the district for the year 2010. Land-Use/Land-Cover of Yamunanagar district for the year 2019 showed that agriculture land occupied major part of the district followed by forest, agroforestry and built-up land. The analysis of 2019 data revealed that about 1,19,048.6 ha (67.77% of TGA) was reported to be under agriculture land, while the agroforestry was found to be 17,022.76 ha (9.69% of TGA). And also estimated area under forest was around 19,308.6 ha (10.99% of TGA), built-up land 11,125.7 ha (6.33% of TGA), waterbodies 2,455.28 ha (1.39% of TGA), riverbed 3,693.58 ha (2.1% of TGA) and plantations occupied 2,991.16 ha (1.7% of TGA) within the district for the year 2019. The Land-Use/Land-Cover map of the Yamunanagar district for the year 2019 was shown in Fig. 4.

Table 1. Land use land cover analysis of the Yamunanagar district for the year 2010 and 2019.

S.No.	Land use/land cover classes	2010		2019	
		Area (ha)	Area (%)	Area (ha)	Area (%)
1	Agroforestry	7,134.90	4.06	17,022.76	9.69
2	Agriculture	1,29,210.25	73.56	1,19,048.60	67.77
3	Forest	19,473.00	11.08	19,308.60	10.99
4	Built-up area	9,947.98	5.66	11,125.70	6.33
5	Plantations (Horticulture/Scrub/Miscellaneous)	3,460.15	1.96	2,991.16	1.70
6	Water bodies	2,160.29	1.22	2,455.28	1.39
7	River beds/Sandy area	4,256.69	2.42	3,693.58	2.10
	Total	1,75,644	100	1,75,644	100

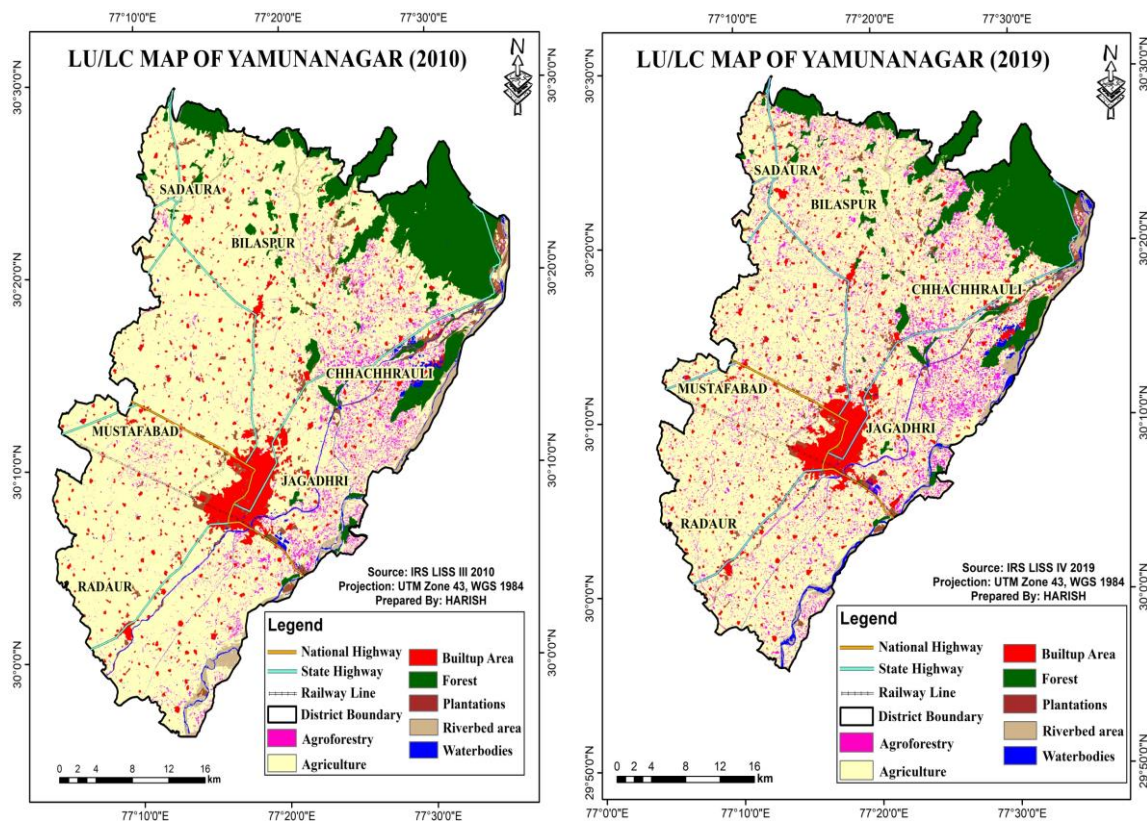


Fig. 4 Land use/Land cover map in 2010 and 2019 of Yamunanagar district

4.2. Accuracy Assesment

Accuracy assesment of agroforestry category was tested in terms of Kappa Co-efficient (Congalton 1991). Based on Supervised method of classification, Ground Truth based data on different land uses with agroforestry was gathered from the blocks of the district and classification accuracy was being computed, using Maximum likelihood method. Error matrix was generated and the classification accuracy, Kappa coeffiecient were acquired. The producers and users accuracy of agroforestry class was assessed over 90% and 91.01% respectively, and overall accuracy of 90% and 0.87 of Kappa Co-efficient was obtained using confusion matrix method of accuracy assessment. (Table 2)

Table 2. Classification accuracy using Maximum likelihood method

	Class_reference							Row Total	Users Accuracy
	Riverbed	Agricu lture	Agro forestry	Builtup Area	Plantations	Forest	Water bodies		
Riverbed	13	0	0	2	0	0	0	15	86.67
Agriculture	0	65	3	0	2	0	0	70	92.86
Agroforestry	0	1	81	0	6	1	0	89	91.01
Builtup Area	2	1	0	27	0	0	0	30	90.00
Plantations	0	1	5	0	38	2	0	46	82.61
Forest	0	1	1	0	2	26	0	30	86.67
Waterbodies	0	0	0	0	0	0	20	20	100

Column Total	15	69	90	29	48	29	20	300	
Producers Accuracy	86.67	94.20	90.00	93.10	79.17	89.66	100.00	Overall Accuracy =	90
							Kappa Coefficient =		0.87

4.3 Monitoring of Agroforestry area (2010-2019)

Monitoring of areas under agroforestry for the year 2010 and 2019 based on the supervised method of classification in Bilaspur, Chhachhrauli, Jagadhri, Sadaura, Mustafabad and Radaur blocks of Yamunanagar district. In total, it was observed that in 2010 the area under agroforestry is found to be 7,134.90 ha which includes Sadaura (159.81 ha), Bilaspur (430.01 ha), Chhachhrauli (4,418.35 ha), Mustafabad (362.75 ha) Jagadhri (1309.28 ha) and Radaur (454.7 ha) in the form of block formations and boundary plantations along with agricultural land. And also, it was observed that in 2019 the area under agroforestry is around 17022.76 (ha) which includes Sadaura (1519.67 ha), Bilaspur (2363.05 ha), Chhachhrauli (6848.65 ha), Mustafabad (1717.82 ha), Jagadhri (2543.04 ha) and Radaur (2030.53 ha) in the different blocks of district (Table 3). In between these 10 years from 2010 to 2019, it was observed that 10417.29 hectares of the area was being increased under Agri-Silviculture systems which includes majorly poplar-wheat or eucalyptus-wheat based cropping systems in the whole district in between this time period.

Table 3. Monitoring of Agroforestry area in Yamunanagar district from 2010-2019.

Block name	Agroforestry area (ha)		Change (ha)
	2010	2019	
Sadaura	159.81	1519.67	+1359.86
Bilaspur	430.01	2363.05	+1933.04
Chhachhrauli	4,418.35	6848.65	+2430.3
Mustafabad	362.75	1717.82	+1355.07
Jagadhri	1,309.28	2543.04	+1233.76
Radaur	454.70	2030.53	+1575.83
Total area	7,134.90	17022.76	+9887.86 (Increase)

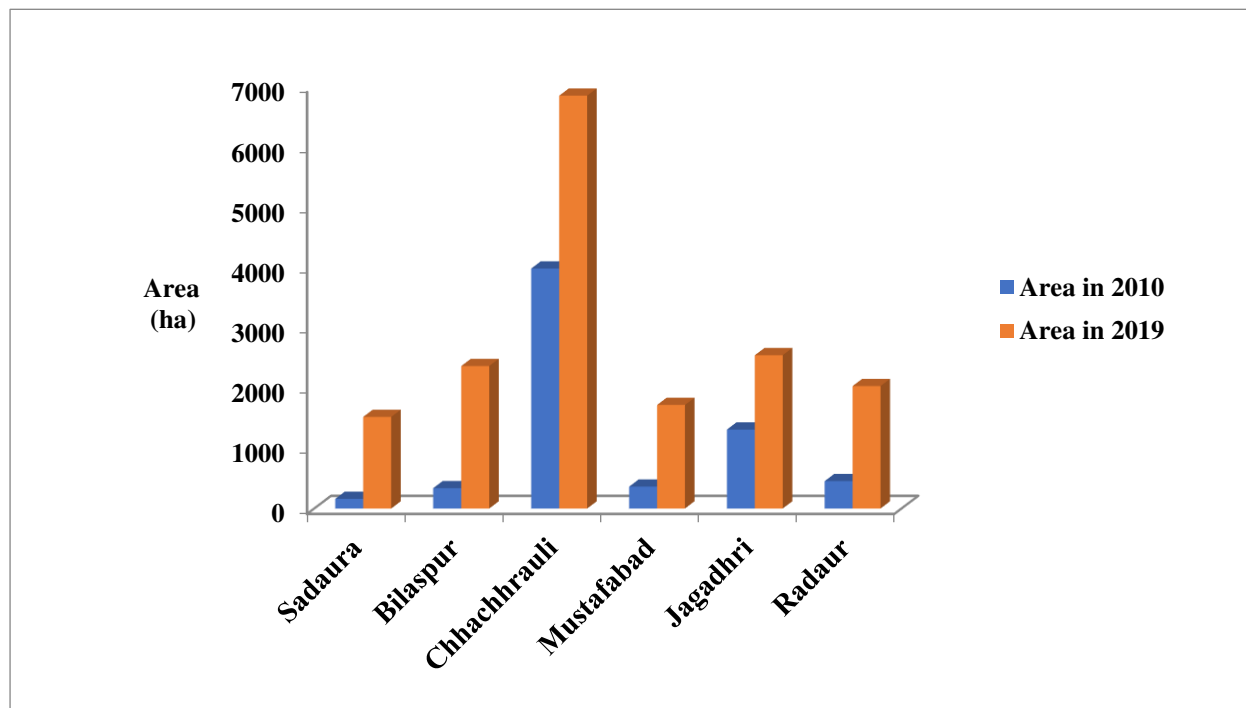


Fig. 7 Block wise Agroforestry area in 2010 and 2019 of Yamunanagar district

Conclusion

In order to harness the full potential of agroforestry, an accurate estimation of extent of area under agroforestry in the country is required. This can be done with the help of Geospatial technologies (GIS, GPS and Remote sensing). This study concluded that agroforestry based systems in the district occupied maximum area along with agriculture and other classes. Poplar and eucalyptus based agroforestry systems occupied considerable area in Yamunanagar and have significant contribution towards rising green cover in the state. The methodology adopted in this current study for mapping and monitoring of agroforestry area using high resolution remote sensing data yielded promising results. It was also concluded that with judicious use of Geospatial technologies, assessment of natural resources like agroforestry can be done accurately, which will provide desired spatial information for planners and decision makers.

5.Acknowledgements

Authors are thankful to the Director, Haryana Space Applications Centre (HARSAC) for carrying out research work and providing satellite data, and also thankful to Head, Deptt. of Forestry, CCS HAU, Hisar, Haryana.

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214 • Total number of words (including references): 2913

215 • Total number of words (excluding references): 2602

216 • Abstract number of words: 242

217 • Number of words in Supplementary Information:36

218

219