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Bojja Harish Babu
Research Scholar, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Mothi Kumar KE
Senior Scientist, Haryana Space Applications Centre (HARSAC) CCS HAU Campus, Hisar, Haryana, India

Sandeep Arya
Associate Professor, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Bimlendra Kumari
Professor, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Krishma Nanda
Research Scholar, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Corresponding Author
Bojja Harish Babu
Research Scholar, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Monitoring and identification of potential agroforestry sites in Panchkula district of Haryana state, India using geospatial techniques

Bojja Harish Babu, Mothi Kumar KE, Sandeep Arya, Bimlendra Kumari and Krishma Nanda

Abstract
Ambala, Panchkula and Yamunanagar, the districts of Haryana in India are considered as the model districts for the adoption of agroforestry and are dominated with eucalypts and poplar based agroforestry systems. These systems has an important ecological role which prevent high surface runoff and reduce soil erosion, minimize the flood hazards and protect crops from strong winds. Poplar and eucalyptus based agroforestry system has been found to produce higher economic returns than sole annual crops. With the help of on screen digitization techniques, an attempt has been made to delineate areas such as fallow lands, scrub lands and piedmont zones. These additional areas in conjunction with the help of other resources such as Soil type, Groundwater quality and Rain fall pattern *etc.* were suggested to practice the agroforestry in the study area. In Panchkula district, potential agroforestry sites such as scrub lands, fallow lands and piedmont areas were identified and mapped for future practices of agroforestry. An area of totally 4,023.45 ha of the wastelands (Scrub lands, Fallow lands and Piedmont areas) in the Panchkula district was suggested for additional potential sites for agroforestry cultivation. Satellite data for 2019 driving forces behind agroforestry changes have also been investigated by GPS (Global Positioning System) based Ground Truth verification.

Keywords: Agroforestry, remote sensing, geospatial techniques, climate change, global positioning system

Introduction

Agroforestry practices come in many forms but fall into two groups – those that are sequential, such as fallows, and those that are simultaneous, such as alley-cropping (Cooper and others, 1996). In all, some 18 different agroforestry practices have been recognized by Nair (1993), although each has an infinite number of variations. Thus, at the moment, agroforestry is viewed as a set of stand-alone technologies that together form various land-use systems in which trees are sequentially or simultaneously integrated with crops and/or livestock. In agroforestry research, practices are often applied after diagnosis and design, participatory research or characterization studies, as appropriate, depending on the social, economic and environmental problems in an area. Agroforestry is generally practiced with the intention of developing a more sustainable form of land use that can improve farm productivity and the welfare of the rural community.

Geospatial techniques have been successfully used in certain areas of their applications, which include various fields such as agriculture, forestry, wetland management and other related fields especially in developing countries where agricultural systems are well-acknowledged and methodologies are developed. However, these techniques have yet to be utilized in agroforestry research extensively. Suitable agroforestry areas were mapped in a spatial database approach in 19th Century Canadian Landscape. The importance of Geographic Information Systems (GIS) in the classification and change detection of agroforestry areas was also emphasized (Bernard and Depommier, 1997) [4]. A GIS environment to conduct a spatial database of the census and geomorphic data to investigate agroforestry dynamics. The output of a classification map of recognizable or significant features or groups of land-use types in a scene is a common use of remote sensing data. As a result, the main output is a thematic map covering topics like land use, vegetation types, and geology. A thematic map, by description, is an informative representative of an image that communicates knowledge about the spatial distribution of data (Paquette and Doman, 1997) [11].

The present research work has been undertaken to identify and monitor potential agroforestry sites in the Panchkula district of Haryana state using LISS-IV satellite of 2019.

Study Area

The present study was conducted at Panchkula district of Haryana state, India. It is situated in the North Eastern region of the state and shares its borders with the states of Himachal Pradesh and Uttar Pradesh on one side and with districts of Ambala and Kurukshetra on the other side. It is located at 77°13' to 77°36' east longitude and 29°50'to 30°3' north latitude at the altitude of 255 m and having the total geographical area of 1756 sq km. The area falls in Survey of India Toposheet Numbers of 53/ F,2,3,4,7,8,11 and 12 on 1:50,000 scale.

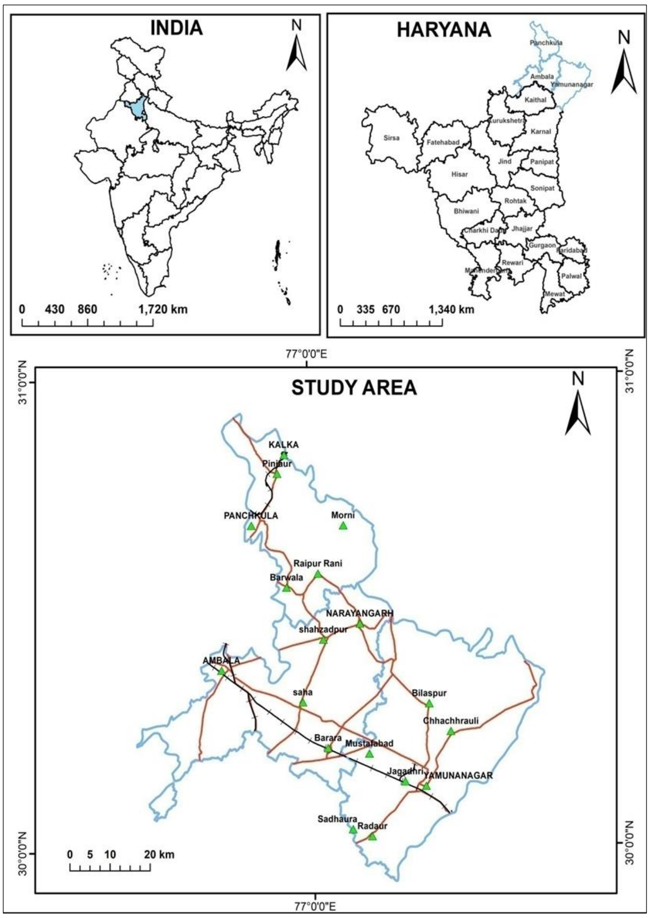

Fig 1: Location map of Panchkula district

Data base & Methodology

With the help of on-screen digitization techniques on satellite image LISS-IV of 2019, an attempt has been made to delineate areas such as fallow lands, scrub lands and piedmont zones. These additional areas in conjunction with the help of other resources such as soil type, rain fall pattern, ground water quality *etc.* were suggested to practice the agroforestry in the study area. The methodology adopted are given in flow chart below Figure 2.

Software Used

On screen digitization was done by using ERDAS-2011 standard image processing software and ARC-MAP.

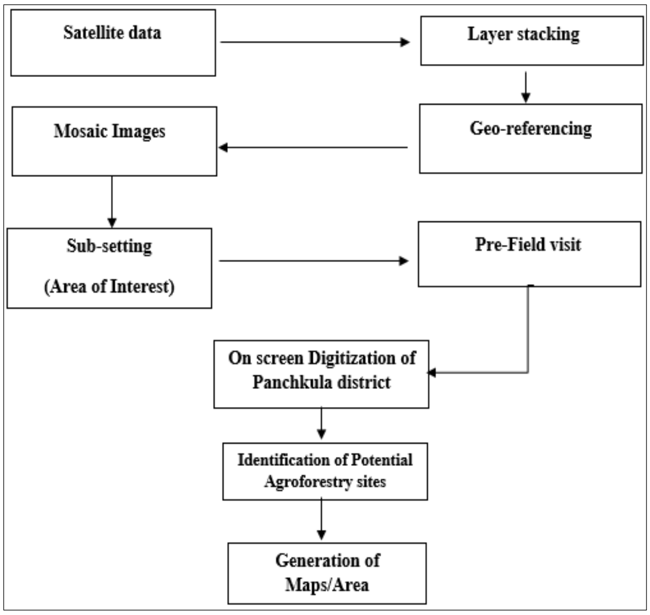

Fig 2: Flowchart for methodology adopted to Identify potential Agroforestry sites

Soil in the district

In Panchkula the soil pertaining in the district is highly undulating and eroded piedmont zone of the Shiwalik hills interspersed with a number of rivulets and channels falling into the Ghaggar river. The foot hills of the Shiwaliks covering this area are highly unstable mounts of loose soil and gravel, which is prone to severe soil erosion. The soils of the district is excessively drained, highly permeable and have low to medium productivity. These soils mainly fall into two orders *viz.*, Entisols and Inceptisols. (Haryana Geography, 2019) [6].

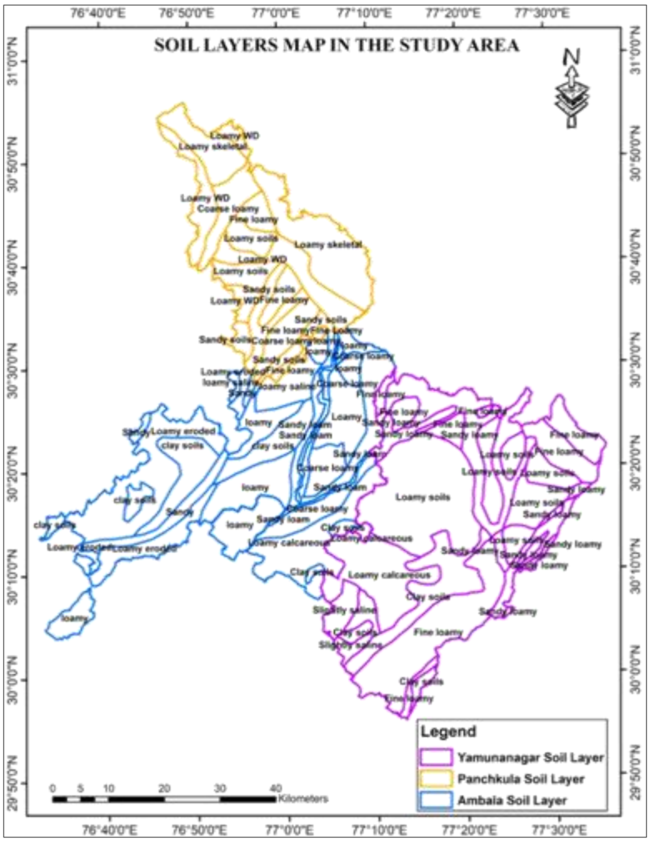

Fig 3: Soil layers map

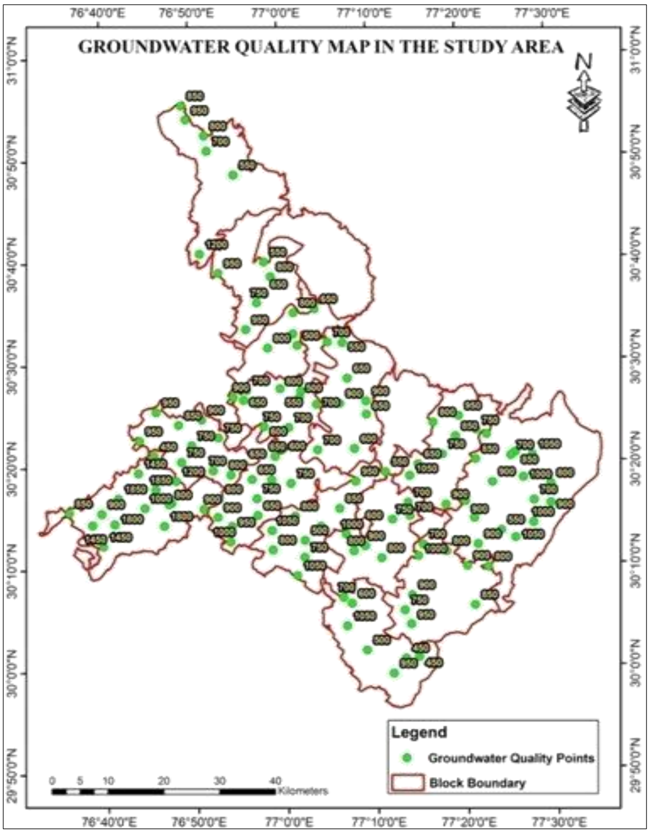

Fig 4: Groundwater quality map

Groundwater in the district

The groundwater in the districts are generally fresh and suitable for domestic and irrigation purpose. The Electrical Conductivity (EC) is a measure of water capacity to convey electric current. The most desirable limit of EC in irrigation purpose is prescribed as 1500 µmhos/cm (WHO-2004).

Table 1: Classification of Irrigation water based on Electrical Conductivity

Type	EC (µmhos/cm)	Water Class	Salt significance
Type-I	<1500	Good	Low salt enrichment
Type-II	1500-3000	Not Permissible	Moderate salt
Type-III	>3000	Hazardous	High salt enrichment

Results

Identification of potential agroforestry sites in the Panchkula district

With the help of on screen digitization techniques, an attempt has been made to delineate areas such as fallow lands, scrub lands and piedmont zones. These additional areas in conjunction with the help of other resources such as soil type (Fig. 3), groundwater quality (Fig. 4) and rain fall pattern *etc*. were suggested to practice the agroforestry in the study area. In Panchkula district, potential agroforestry sites such as scrub lands, fallow lands and piedmont areas were identified and mapped for future practices of agroforestry. An area of totally 4,023.45 ha of the wastelands (Scrub lands, Fallow lands and Piedmont) in the district was suggested for additional potential sites for agroforestry (Table 2).

A close perusal of Table 2 has revealed that about 2,289.57 ha of area was identified in the Piedmont zones in which EC (Electrical Conductivity) of groundwater was ranged in between 550 to 950 µmhos/cm, while the soil type condition was found to be moderately shallow to moderately deep, somewhat excessively drained loamy skeletal hills, moderately eroded and moderately gravely soils. About 1,127.73 ha of land was identified under scrublands, the groundwater EC was ranged in between 550 to 1200 µmhos/cm, while the area of scrub lands was occupied by fine loamy soils slightly eroded slight saline and flooded, they were associated with very deep drained coarse loamy characteristics. An area of 606.15 ha land was identified under fallow lands for which the EC of groundwater was ranged in between 500 to 1200 µmhos/cm, and the area was occupied by fine loamy soils slightly eroded slight saline and flooded and associated with very deep drained coarse loamy soils which are suitable to agroforestry practices. The monthly average rainfall recorded in the district was 62.7 mm in 2019. The potential sites suggested in the Panchkula district are shown in the Fig.5 (Piedmont areas), Fig. 6 (Scrub lands), Fig. 7 (Fallow lands).

Discussion

Based on the soil layers acquired from (NBSS & LUP) National Bureau of Soil Survey and Land Use Planning, the type of soil present in these areas are very deep, well drained, fine loamy and clay soils on very gently sloping plain with loamy surface, moderately eroded which the soil is suitable for cultivation of agroforestry species in scrub lands, fallow lands and piedmont areas. The status of estimating soil nutrient for identifying potential agroforestry sites (Fallow lands) *i.e.* eucalypts based agroforestry systems was reported by Kumar *et al.* (2021a) [7]. And also similar results, identifying potential sites based on soil maps have been reported by Singh *et al*. (2011) [14], Ahmad *et al*. (2019) [18], Ahmad *et al*. (2018) [2] and Shepherd *et al*. (1996) [13]. Similar studies like identification of fallow lands and piedmont slopes for agroforestry practices through geospatial techniques were carried out by Rizvi *et al*. (2014) [12] and Otsuki, (2010) [10], respectively.

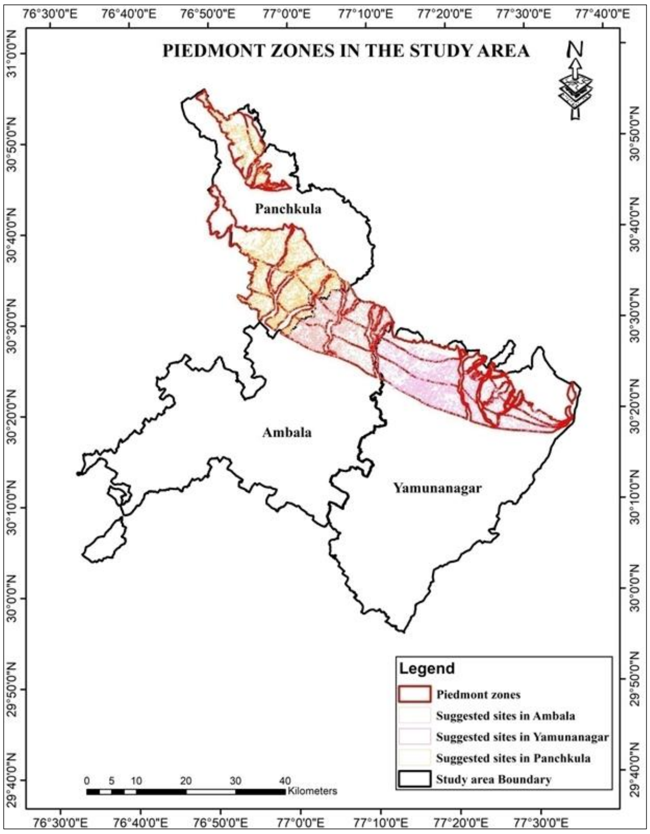

Fig 5: Piedmont zones in Panchkula district

Table 2: Identification of Potential agroforestry sites in Panchkula district

District	Identified Potential sites	Area (ha)	Type of soil	Groundwater quality (EC) (micro mhos/cm) Water class: (WHO, 2004)	Monthly Average Rainfall (mm)	Remarks
Panchkula	Piedmont zones	2,289.57	Moderately shallow to moderately deep, somewhat excessively drained loamy skeletal hills, moderately eroded and moderately gravely soils.	550-950 (Good for Irrigation)	62.7	Suggested for future agroforestry practices
	Scrub lands	1,127.73	Fine loamy soils slightly eroded slight saline and flooded, associated with very deep drained coarse loamy soils	550-1200 (Good for Irrigation)		
	Fallow lands	606.15	Fine loamy soils slightly eroded slight saline and flooded, associated with very deep drained coarse loamy soils	500-1200 (Good for Irrigation)		
	Total area	4,023.45				

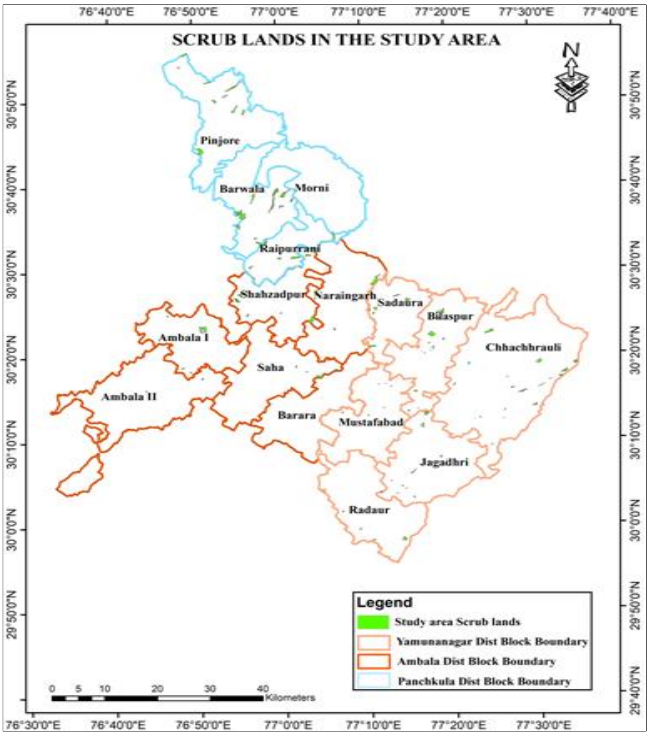

Fig 6: Scrub lands in Panchkula district

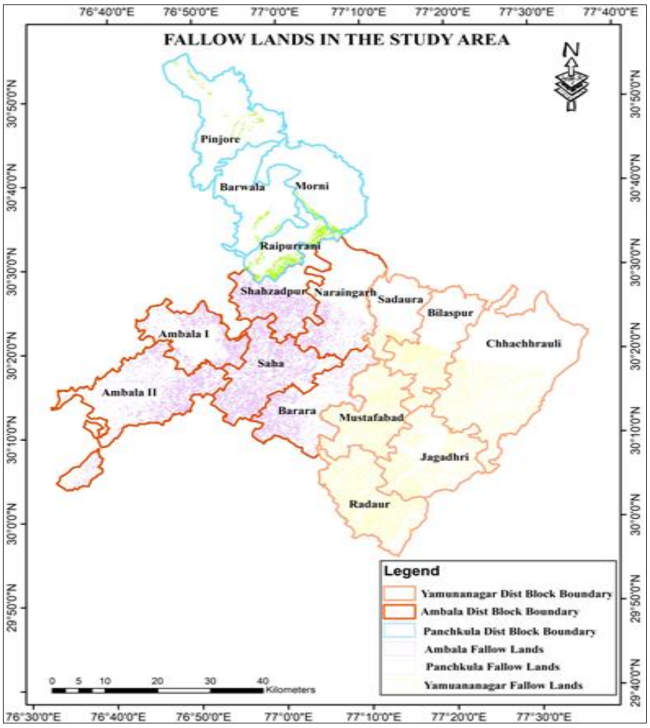

Fig 7: Fallow lands in Panchkula district

Conclusion

The present research has its own importance because such agroforestry suitability mapping has been done for first time in the state of Haryana for the past 20 years using geospatial techniques and agroforestry suitability mapping. Hence it will greatly help the agroforestry policy makers of Haryana for extending it in new areas. This research also showed the ability of Remote sensing, GIS in estimating agroforestry which is seen as an extremely useful solution which can sustain the extreme weather events and simultaneously fulfill the demand for food, fodder, nutrition, energy, employment and can protect our fragile environment. Panchkula district (4023.45 ha) which includes scrub lands, fallow lands and piedmont areas, these potential sites identified and mapped by geospatial techniques were suggested for future agroforestry cultivations.

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