MAPPING OF FUEL WOOD TREES IN KOLAR DISTRICT USING REMOTE SENSING DATA AND GIS

Jagadeesh, K.*   Rao, G.R.*   Kiran, M.K.*   Jagadish, K.S.**
Ramachandra, T.V.*

Abstract:

In India around 75% of population resides in rural area. Recent surveys show that of total domestic fuel needs, 60% in rural areas and 40% in urban areas are being met from wood fuel. Tradition fuel such as wood, agriculture residues and animal residues, still meets 85-95% of fuel needs in rural areas of Kolar district. Fuel wood is the most preferred fuel for cooking while, bioresidues are used for other purposes such as water heating, etc. In view of these, Bioresource play a dominant role in the energy planning of a region. Integrated energy planning for Kolar district is being undertaken under UNDP-NRDMS programme of Ministry of Science and Technology, Government of India. In this regard comprehensive survey were carried out to gain an understanding of the consumption pattern, mapping of bioresources, develop consistent and rigorous database,and to formulate a long term strategy for sustainable development. Remote sensing data, Geographic Information System (GIS),field surveys and destructive sampling is used to assess the standing wood stock and its sustainable productivity. Multispectral data of IRS-1C is used for land cover analysis while PAN imageries are used (with multispectral data) to get a species level information. Field survey in Kolar indicates that rural household depends on species such as *Prosopis juliflora, Acacia nilotica,Acacia auriculiformis* to meet fuel wood requirement for domestic activities. Villages as sampling units were selected randomly. Training data through field surveys for *Prosopis juliflora* and other fuel wood species in Kolar taluk covering 30 villages were collected. A maximum likelihood classification criterion is used to determine vegetation cover type and to identify various tree species in remote sensing data. The spectral response pattern for *Prosopis juliflora* and other fuel wood species is determined with the training data. Mapping of *Prosopis juliflora* in other taluks of Kolar district was done with these information. Validation exercise carried out in Gauribidanur taluk indicates the level of accuracy of about 88%.

Address for Correspondance
Dr. T.V.Ramachandra,
Energy and Wetlands Research Group,
Centre for Ecological Sciences,
Indian Institute of Science
Bangalore 560 012, India

E Mail : cestvr@ces.iisc.ernet.in
Cestvr@hamsadvani.serc.iisc.ernet.in

Fax : 91-080-3601428 / 3600085 / 3600683 [CES-TVR]
Tel : 91-080-3600985 / 309 2506

* *Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012*
** *Department of Civil Engineering, Indian Institute of Science, Bangalore 560 012*

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INTRODUCTION :

Biomass refers to the weight of dry matter of living organisms (phytomass for plants and zoomass for animals) at any time per unit area. Plant biomass provides the primary energy source by absorbing small amount of solar energy through photosynthesis and acts as the foundation for all life forms. Nearly 75% of the rural population of India still depend on biofuels (firewood, agricultural residues, and cowdung) for meeting over 80% of their energy needs. An analysis of the distribution of the different energy forms in rural India reveals that the share of non- commercial energy is 65%, human energy 15% and commercial energy 20%. This clearly shows that 80% rural energy is met from traditional sources. In India, the total requirement of fuelwood is calculated to be about 150 million tonnes per annum whereas the annual availability is estimated to be about 50 million tonnes. A recent survey on energy sources and sectorwise consumption revealed that traditional fuel such as firewood (7.44 million tonnes of oil equivalent -42.99%), agro residues (1.510 million tonnes of oil- 8.72%), biogas conditioning (0.250 million tonnes of oil - 1.44%) accounts for 53.2% of total energy consumption in Karnataka (T. V. Ramachandra et. al., 1997). This necessitates estimation of available bio resources and demand spatially available to evolve better management strategies and ensure renewability of resources. In this regard spatial tools such as GIS and Remote sensing data help immensely in providing geographically referenced spatial distribution of potential and demand.

Base maps of study site is prepared using the Survey of India (SOI) toposheets of scale 1:50 000. This includes administrative boundaries, road and drainage networks, contours and boundaries of vegetative areas (areas under forest department).LISS-III multispectral and PAN imageries were classified with ground data (collected using GPS). LISS-III has a spatial resolution of 23.5m and PAN with a spatial resolution of 5.8 m. By merging LISS-III multispectral bands with PAN helps in determining the spectral response patterns of vegetation. Merging helps in retaining the spectral advantage of multispectral bands while taking an advantage of PAN's spatial resolution. The spectral patterns of the different land cover were determined with a detailed mapping in 30 villages in Kolar taluk using GPS (Global Positioning System).This also helped in arriving at spectral response pattern of predominant tree species in Kolar taluk. This information was extrapolated to other taluks. This paper discusses an attempt in this regard to map *Prosopis juliflora* in Gauribidanur taluk based on training data collected from 30 villages of Kolar taluk and accuracy of mapping is about 88%. *Prosopis juliflora* - a fuelwood tree grows in basic soil (black cotton soil) and has the ability to lower soil pH.

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Remote Sensing :

Remote sensing techniques are important tool today, to acquire useful data on earth or its part by 'sensors'. Inventory and mapping of resources are today facilitated by remotely sensed imageries.The multispectral images can be used for quantification of resources and monitoring resources during a period of time. Remote Sensing techniques help in demarcating areas of deforestation,changes in crop productivity, etc. Remote sensing makes diverse contributions to the management of renewable resources. Major application include:

- Classification and evaluation of land resources
- Mapping of land use, and
- Monitoring of vegetation covers and crops.

Land use / land cover classification of vast area by traditional methods is a time consuming and expensive process. Remote Sensing offers a quick and efficient approach to the classification and mapping of land uses/land cover classes form a basis for future planning. Keeping this in view the present study has been undertaken to identify and delineate various land use/land cover categories and types of tree species present in the particular area. An important objective is how to quantitatively derive the biomass variation from the high dimensional data collected from multi -frequency, dual - polarized, multi - day, multi-angle, and passive sensors.

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OBJECTIVES :

- Land cover analyses - to distinguish vegetative and non-vegetative area.
- Classification of vegetation in Kolar district - Supervised classification approach
- Village level land use analysis to determine spectral response patterns of predominant species.
- Mapping of *Prosopis juliflora* - fuelwood tree in Gauribidanur taluk (with the help of training data from Kolar taluk) of Kolar district
- Validation of spectral signatures for *Prosopis juliflora* in Gauribidanur taluk

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STUDY AREA :

Kolar district is located in the southern plains region of the Karnataka State. It lies between 77°21' to 78°35' east longitude and 12°46' to 13°58' north latitude and extends over an area of 8225 sq. km divided into 11 taluks.

Kolar belongs to semi arid zone of Karnataka. The distribution of rainfall is during southwest and northeast monsoon seasons. Out of about 280 thousand hectares of land under cultivation, 35% is under well and tank irrigation. Secondary data from the forest department shows that 7 taluks have forest cover less than 10%, 2 taluks are in the range of 10% to 20% (Gudibanda and Srinivaspura) while remaining 2 taluks (Bagepalli and Chikballapur) have forest cover greater than 20%.

The average population density of the district is 2.09 persons/ha (rural) and 2.69 persons/ha (rural+urban). The population density ranges from 1.44 (Bagepalli),1.69 (Gudibanda), 1.70 (Srinivaspura) to the maximum of 2.55 (Kolar).While, the population density in taluks lies within this range - Bangarapet(2.52), Malur(2.38), Gauribidanur (2.36), Sidlaghatta (2.16), Chintamani (2.10), Mulbagal (2.04), Chikballapur (1.92).

Gauribidanur taluk, lies in northwestern side of the district has basic soil and allows the growth of *Prosopis juliflora*, was chosen for mapping and verification of fuel wood trees.

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STATUS OF BIORESOURCE :

The tree species predominant in Kolar are *Acacia nilotica, Acacia auriculiformis, Albizia amara, Albizia lebbek, Azardirachta indica, Eucalyptus sp. , Mangifera indica, Pongamia pinnata, Prosopis juliflora, Tamarindus indica* etc. The mainly used fuelwood trees are *Acacia nilotica , Acacia auriculiformis, Eucalyptus sp. , and Prosopis juliflora.* Due to scarcity of fuelwood in some parts of the district, a section of population meets its cooking and heating fuel through use of shrubs and weeds like *Lantana camara and Cassia auriculata.*

Kolar taluks has a woody biomass productivity of 3.6 t/ha/yr. (evergreen, semi - evergreen), 3.9 t/ha./yr. (deciduous) and 0.9 t/ha/yr. (scanty and scrubby vegetation). The ratio of bioresources availability to demand ranges from 0.11 (Kolar) to 0.73 (Srinivaspura), fuelwood demand is taken as 1.3 kgs/person/ day (Ramachandra et al., 1999). The efficiency of conversion of the biomass to useful energy is between 5% to 15%.

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Fuelwood species - Prosopis juliflora :

These are spiny shrubs and trees, very variable, small to medium sized, aggressively fast growing, semi-evergreen to evergreen, large crowned, with drooping low branches, with bipinnate leaves, greenish-yellow flowers cylindrical or flat and flowering almost throughout the year. The species include several varieties and forms; two important and well-known varieties beside *chilensis* are *velutina* and *glandulosa.* Six species are reported in India; *Prosopis cineraria* is indigenous and others have been introduced. *Prosopis chilensis* , an American species , and its variety glandulosa have run wild in many parts (CSIR, 1990).

When the growth of *Prosopis juliflora* is disturbed like hacking or cutting axillary bud becomes more active than the terminal bud and start producing innumerable number of branches. So the tree attains more bushy form or shrub like instead of a tree. But if left undisturbed it can grow to a tree form even with a girth at breast height of more than 100 to 200 cm. Prosopis grow well in basic soils like the black cotton soil and hence widely distributed in black soils of Andhra Pradesh and northern Karnataka. It prefers plain land soils, instead of hilly soils as the latter have less surface soil volume. It prefers soils well drained but can't survive in deep standing waters. The best example is Bychapura lake (in Gauribidanur taluk) where the stagnant water show poor or no growth compared to wet, but well drained soil.

Prosopis juliflora attains the highest Mean Annual Increment (MAI) and the Current Annual Increment(CAI) reaches a peak on six year old stands (Garg, V.K. 1999). This shows six year stand is an optimum age for harvesting *Prosopis juliflora.* In six year stand, the above ground biomass production is about 57 ± 3.5 t/ha and mean annual litter productivity is about 7.4±1.13 t/ha. In many villages of Gauribidanur taluk, *Prosopis juliflora* is preferred for fuelwood due to its calorific value, higher growth rate, cycling time of six years (comparable to any other fuelwood species), coppicing power and its capability to produce more extensive root system and deeper penetration to rehabilitate sodic soils more effectively.

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Datasets Used :

- Spatial (village, taluk, district maps) and non-spatial data (demography, population, etc.),
- Survey of India maps of scale 1:50,000 used to generate vector layers of road network, administrative boundaries, contours, drainage network, etc.
- Village revenue maps-digitised to map resources at village level,
- Village wise vector layer showing all trees (species wise) was prepared through an extensive field survey using GPS (Global Positioning System)
- Remotely sensed data of 23.5 m (IRS-LISS-III) and 5.8 m spatial resolution (IRS-PAN) having a cloud cover less than 2 percent - for land cover and land use analyses. Classification of this data requires collection of primary data (Ground control points) to correlate the ground information with remotely sensed data.

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METHODOLOGY :

An integrated approach involving compilation of data from government agencies and institutions, application of spatial and temporal analyses using remote sensing data , Geographic information system (GIS techniques) and conventional field survey (ground truthing) have been adopted in this study. The vegetation map for Kolar district(talukwise) were prepared based on the interpretation of IRS-1C satellite imageries, using the visual interpretation keys such as tone, colour, texture pattern, association, size, shape, topography and drainage. This involves :

- Data acquisition, loading, composite generation and georeferencing
- Training sites, Ground truth collection (field data collection)
- Signature generation for classification
- Extraction of statistics
- Demarcation of boundaries
- Villages, taluk and district boundaries and road network were digitized from SOI toposheets.
- Georeferencing has been done by extracting ground control points from topographical map and using GPS (Global Positioning System). Multispectral image classification was carried out using Maximum likelihood classification technique with the help of training data.

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Mapping of Tree Species :

Village land revenue maps obtained from the Department of Settlement and Land Records were used for detailed mapping of various landscape elements. Individual trees, plantation, area under agriculture and horticulture , waterbodies were mapped with its geographic co- ordinates using GPS. This exercise was repeated in 30 villages, selected so as to represent Kolar taluk. The parameters such as zone number, survey number, tree type, girth at breast height (GBH), height, agriculture type and soil type along with the co-ordinates (latitude, longitude and elevation) were noted down. In case of a patch, a sample plots (polygon) were chosen. Sample plots dimension depends on density of trees and the type of patch (homogenous or heterogeneous). In case of homogenous uniform patch (like Acacia, Eucalyptus plantations), sample plot size is 100 sq.m, while in the case of heterogeneous patch sample plot size is 400 sq.m. Tree density and species density were computed for each sample plot. This field map is digitised to vector layer using GIS software- Mapinfo version 5.5.

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Digital Image Analysis :

LISS-III and PAN images for the study area (Kolar District) were geometrically corrected taking the location (Latitude and Longitude) values of known points from the image as well as their corresponding ground values. These points were then resampled to get the corrected image. Boundary, roads network, streams and contour layers of the study area were digitised using SOI toposheets of scale 1:50,000. These vector layers were overlaid on the geometrically corrected image and the study area was cropped from the LISS-III and PAN imageries.

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Land Cover Analyses :

Level I classification through computation of Normalized Difference Vegetation Indices (NDVI) is done to distinguish vegetative and non- vegetative areas in the district. Band-3 and Band-4 images were used to compute NDVI. NDVI is defined as

$$NDVI = (NIR-RED)/ NIR+RED$$

Where NIR is the spectral radiance in the near infrared band and RED is the spectral radiance in the red band. The index normalizes the difference between the bands so that the values range between -1 and +1. Vegetative and non-vegetative components from the NDVI image were delineated using Classification Trees approach. Classification Tree approach uses Decision Tree method. Trees provide a hierarchical and non-linear classification method and are suited to handling non-parametric training data as well as categorical or missing data. Classification Trees reduce the dimensionality of the data sets. Classification Trees use a set of independent variables to predict class membership. A tree is constructed by recursively partitioning a data set into purer homogeneous subsets. The method uses a deviance measure, the likelihood ratio statistic, to compare all possible splits of the data to find the one split that maximizes the dissimilarity among resulting subsets. Possible splits of each independent variable is examined and the particular split within a particular variable that produces the largest deviance measure is chosen to partition the dependent data (Madhu M.K., et.al. 2000).

Data coinciding with maximum vegetative cover were selected for identification of training sites. The training sites were selected such that they show distinct vegetative covers and are homogenous with large extent. The sites for which detailed ground data had been collected were located on the imagery and the digital numbers of blocks of pixels were extracted for the classification. Signature files were generated using the training data for each vegetative type. Maximum Likelihood classification was performed and the groups defined by this classification were then related to the ground data. Accuracy assessment was made for the classified image using signature files, classified image and PAN image.

Extensive mapping of fuelwood trees-*Prosopis juliflora* was carried out in Iragasandra and Huthur villages of Kolar taluk. The study was done in two phases. In the first phase all the areas with *Prosopis juliflora* were identified. A polygon was drawn surrounding this patch, taking the co-ordinates every 10 to 15 m (latitude and longitude) and the same is marked in village map (cadastral map). Details like age of a tree, its girth, type of soil and associated tree species, if any were noted down in a field map. Then the PAN data corresponding to these villages were analysed to get the spectral signatures corresponding to field data. There was a large variation in spectral response for each homogenous patch. Further field investigations were carried out to identify the factors responsible for variations. In the second phase, sub polygon was taken with in the polygon to indicate thick patches, patches with adult trees, patches with only juveniles and patches with trees sparsely spread. This approach enabled in identifying the factors for variation in spectral signatures. In order to extend this investigation to other taluks of Kolar district, spectral signatures corresponding to *Prosopis juliflora* were mapped in Gauribidanur taluk. Various parameters such as age, density, etc. were taken in to consideration for this purpose. In order to take advantage of spectral properties of LISS III and spatial resolution of PAN, LISS and PAN data were merged, which helped in identifying the patches of *Prosopis juliflora.*

In order to verify the mapping accuracy, sampling units were selected which includes all type of *Prosopis juliflora* patches along with parameters such as density, age, etc. In order to get village wise information, vector layer of Gauribidanur taluk with village boundaries was over laid. Road and stream layers were overlaid to identify the location of patches precisely.

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Results and Discussion :

IRC-1C Data

Land Cover Analyses : The NDVI image generated from the LISS-III bands(Red and NIR) of IRS-1C was used to distinguish the vegetative and non-vegetative areas. It roughly indicates the extent of canopy in the region. NDVI computed for Kolar district is shown in **Figure 1.** The vegetative cover in Kolar district as per NDVI analyses is 49.3 % while, 50.7 % is non-vegetative.

Land Use Analyses : Kolar district multi spectral data of IRS-1C is classified through supervised classification approach. The Maximum likelihood classification method is found to be more appropriate (based on confusion matrix analyses). Composition of land use (hectares) in Kolar as per maximum likelihood classification approach is given in **Figure 2** , corresponding details are given in Table 1.

Table 1: Land use details of Kolar district

Land use	Area (Hectares)	Area (%)
Forest	22986.791	2.77
Plantation	25439.607	3.07
Agriculture	386942.527	46.69
Wastelands	350801.616	42.32
Built-up	38221.290	4.61
Waterbodies	4360.774	0.53

Talukwise Land use Analyses: Overlaying district layer with taluk boundaries on the classified district image, talukwise land use details were obtained, same is listed in **Table 2.1** and corresponding percentage share is given in **Table 2.2**

Village level Land use Analyses

Availability of Bioresource from *Prosopis juliflora*

The area under *Prosopis juliflora* in Gauribidanur taluk is found to be 5404 hectares (adult). Considering the average annual productivity of 7.4 t/ha, total bioresource available would be about 39,990 t/yr.

Fuelwood Demand :

Household survey show that fuelwood requirement in Kolar district ranges from 1.75 to 2.5 kg/person/day and average consumption is 1.3 kg/person/day. The annual fuelwood demand in taluk is 124,212 tonnes (as per 2001 population).

This computation shows, that *Prosopis juliflora* patches would cater the annual fuelwood requirement of 32.2% of Gauribidanur taluk households.

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Talukwise Land use Analyses :

Table 2.1: Talukwise land use in sq. mts

Land use categories						
Taluk	Built-up	Agriculture	Plantation	Forest	Wasteland	Waterbody
Bagepalli	78262804	302588384	1651144	9057743	541044633	6725094
Bangarpet	23401330	345763272	76659964	90931670	329943303	3071688
Chikballapur	18005322	314445680	15463977	30601668	252458918	8664962
Chintamani	50742715	428909577	4982603	1047592	409684258	2988682
Gauribidanur	51583721	325848722	715004	5231485	511821016	2923661
Gudibanda	6979791	100746730	7468088	6420581	104023932	1798618
Kolar	25776587	406980304	17404056	14502390	330176813	3233435
Malur	10757792	414674734	47107322	3530337	168509131	4283196
Mulbagal	49806214	428676044	15265975	6357961	321250676	4720204
Sidlaghatta	33953924	320396089	35154341	4731491	276296233	2080268
Srinivaspur	32942688	480395727	32523586	57454985	262807237	3117927
District	382212894	3869425267	254396066	229867910	3508016155	43607739

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Talukwise Land use Analyses :

Table 2.2 : Talukwise percentage share of land use

Taluk	Land use (%)					
	Built-up	Agriculture	Plantation	Forest	Wasteland	Waterbody
Bagepalli	8.33	32.21	0.18	0.96	57.60	0.72
Bangarpet	2.69	39.75	8.81	10.46	37.93	0.35
Chikballapur	2.82	49.16	2.42	4.78	39.47	1.36
Chintamani	5.65	47.74	0.56	0.12	45.60	0.33
Gauribidanur	5.74	36.28	0.08	0.58	56.99	0.33
Gudibanda	3.07	44.30	3.28	2.82	45.74	0.79
Kolar	3.23	50.99	2.18	1.82	41.37	0.41
Malur	1.66	63.91	7.26	0.54	25.97	0.66
Mulbagal	6.03	51.89	1.85	0.77	38.89	0.57
Sidlaghatta	5.05	47.64	5.23	0.70	41.08	0.31
Srinivaspur	3.79	55.27	3.74	6.61	30.23	0.36
District %	4.62	46.69	3.07	2.77	42.33	0.53

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Village level Land use Analyses :

Thirty villages in Kolar taluk were chosen for detailed land use analyses and determine the spectral signatures of fuelwood species. The villages were selected such that it represents all types of land use and vegetative cover. Selected villages were surveyed in two phases and are listed in **Figure 3**. Each land use element is mapped in these villages using GPS. **Figure 4.1** and **figure 5.1** provides the digitised field maps of Iragasandra and Huthur villages of Kolar taluk respectively. Corresponding IRS 1C data are given in **Figure 4.2** and **Figure 5.2**. Spectral response patterns of various land use elements and fuelwood species is obtained by over laying these layers (**Figure 4.1** and **Figure 4.2**, **figure 5.1** and **Figure 5.2**). Similar exercise is being carried out for all 30 villages and the spectral response pattern of predominant species in selected villages is given in Table 3.

Table 3 : Spectral pattern of predominant species in Kolar taluk

Village Name	Eucalytptus sp.	A.auriculiformis	A.nilotica	P.juliflora	P.pinnata	M.indica	T.indica
Antarganga RF	97 - 103						
Ganeshapura	105 - 113				100 - 107	98 - 106	109 - 118
Huthur	97 - 108		82 - 88	93 - 104	96 - 105		91 -98
Iragasandra	113 - 124			90 - 98	115 - 125	115 - 126	100 - 117
Kaparasiddanahalli	99 - 107	102 - 108					
Kondasandra		99 - 107				102 - 109	98 - 104
Ramasandra	96 - 103		105 - 113			100 - 107	

Prosopis juliflora is predominant in Iragasandra and Huthur villages and spectral signature varies between 93 - 104. Further investigation was carried out in these villages to find out spectral response pattern and reasons for variations. For this purpose, training sites such as areas with adult trees, juvenile plants, trees sparsely spread, mixed with other species were mapped with GPS. This effort narrowed down the spectral response of adult thick patches of *Prosopis juliflora* to 95-97.

This information was used to carry out *Prosopis juliflora* mapping in Gauribidanur taluk and the distribution is given in **Figure 6**. In order to verify the accuracy of mapping, few sites were chosen. Figure 7 provides IRS 1C - **Band 2**, **Band 3**, **Band 4** and PAN Images. **Figure 8.1** provides the fused image of multispectral and PAN images for Gauribidanur taluk. Merging of multispectral and PAN data enabled in distinguishing *Prosopis juliflora* patches. **Figure 8.2** maps the patches chosen for verification and validation of mapping. Accuracy of mapping is about 88%.

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Conclusions :

- Land cover analyses show that Kolar District has a vegetative cover (Forest, Agriculture and Plantation) of 49.3% and non-vegetative cover of 50.7%.
- Talukwise land use analyses show that among 11 taluks, Bangarpet has maximum forest cover of 10.46%, followed by Srinivasapur (6.61 %), Chikballpur (4.78 %) and Gauribidanur has cover of 0.58%. Area under plantation ranges from 8.81% (Bangarpet) to 0.08% (Gauribidanur). Area under agriculture ranges from 63.91% (Malur) to 32.21 % (Bagepalli).
- Wasteland in the district is about 42.33 % and talukwise it ranges from 25.97% (Malur)to 56.99 % (Gauribidanur) to 57.60% (Bagepalli).
- Villagewise land use analyses show the spectral signature of *Prosopis juliflora* is in the range 93-104 and for adult plants range is 95 - 97, which is mapped in Gauribidanur taluk. Validation and verification indicate the level of accuracy of 88%.
- *Prosopis juliflora* standing biomass production is about 57±3.5 t/ha and annual litter productivity is about 7.4±1.13 t/ha with MAI (Mean Annual Increment) and CAI (Current Annual Increment) of six years.
- Annual productivity of *Prosopis juliflora* in Gauribidanur is about 39,990 tonne/hectare. Fuelwood demand is about 124,212 tonne/year, which means that Prosopis juliflora patches meet about 32.2 % of annual fuel wood demand.

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NDVI Vegetation Index of Kolar district image

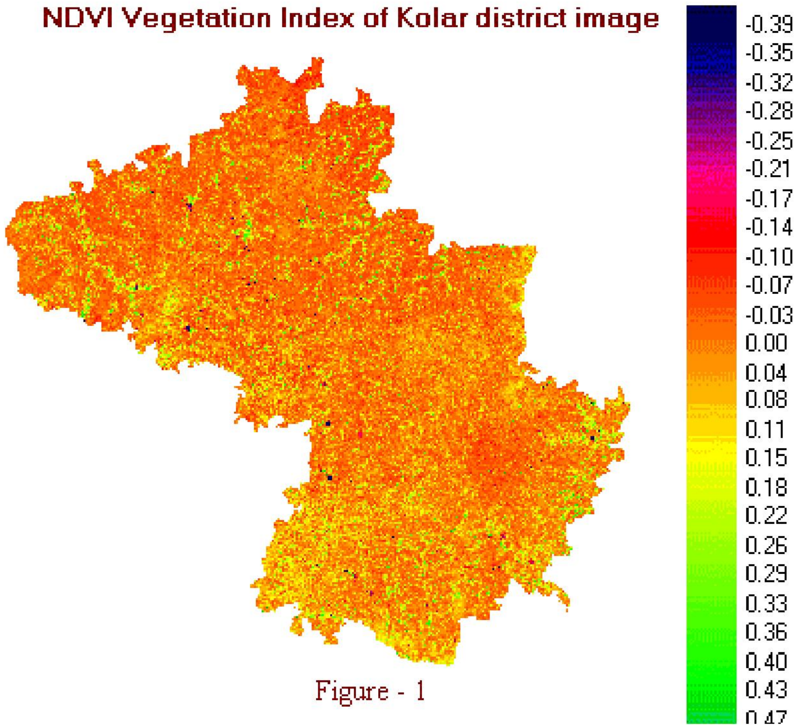


Figure - 1

Maximum Likelihood classified image of Kolar district

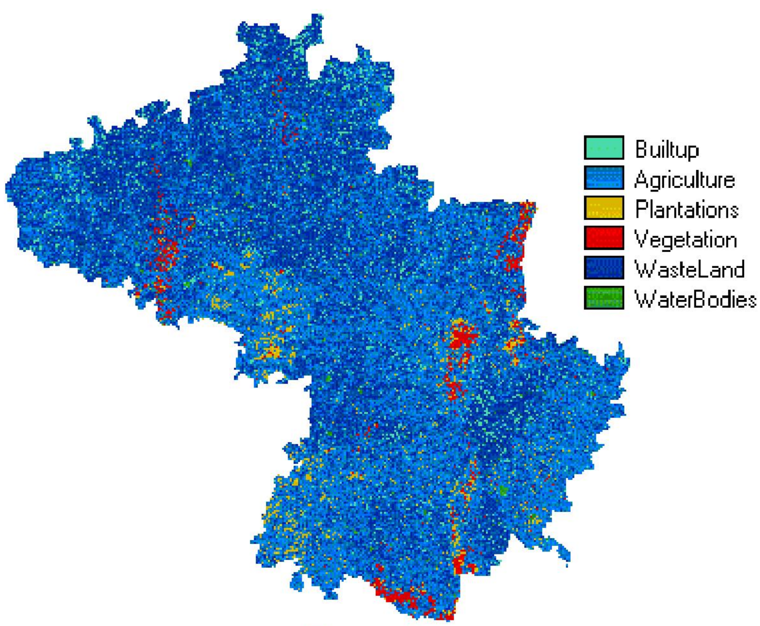
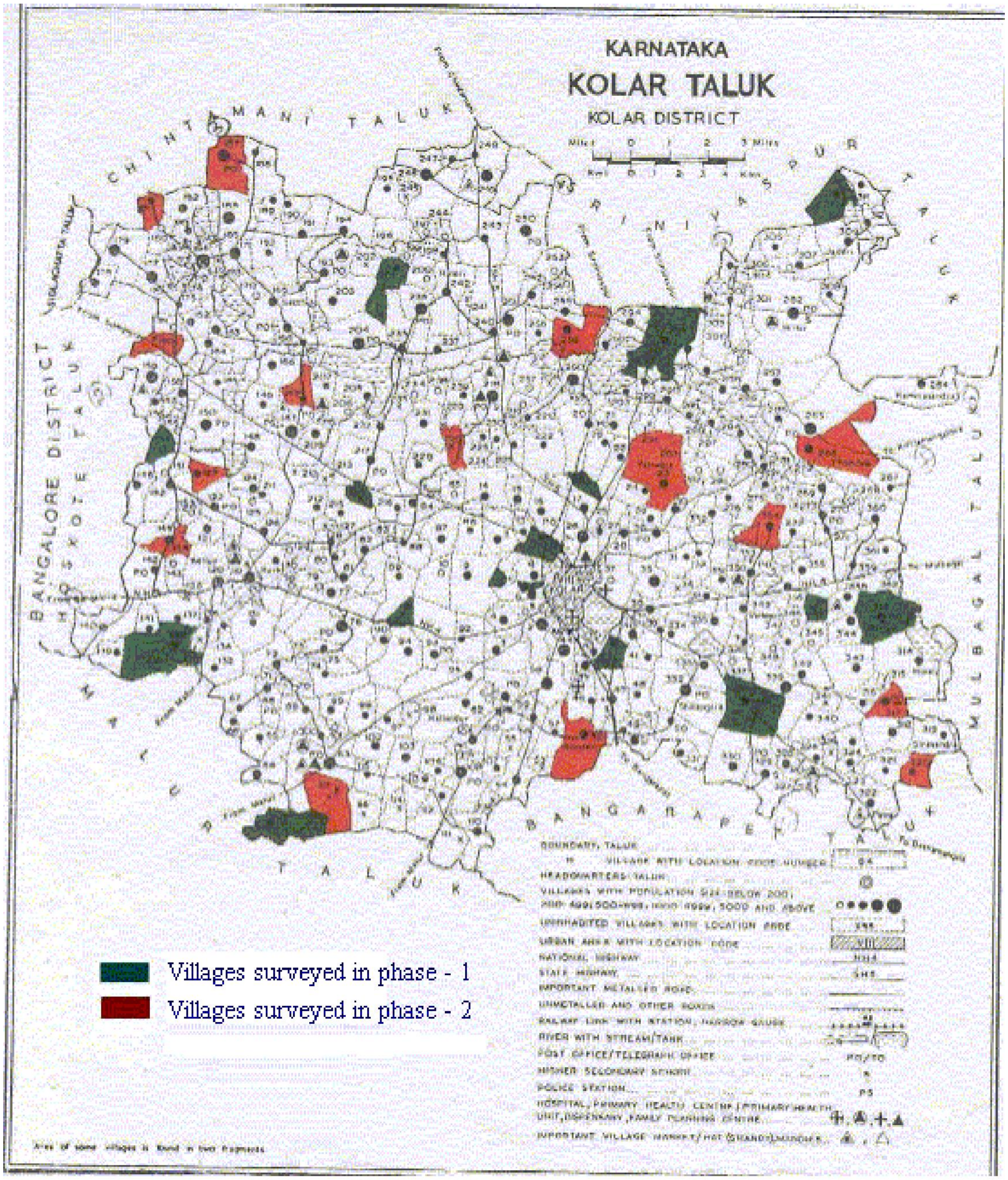


Figure - 2

Karnataka, Kolar Taluk



Iragasandra village map with vegetative cover

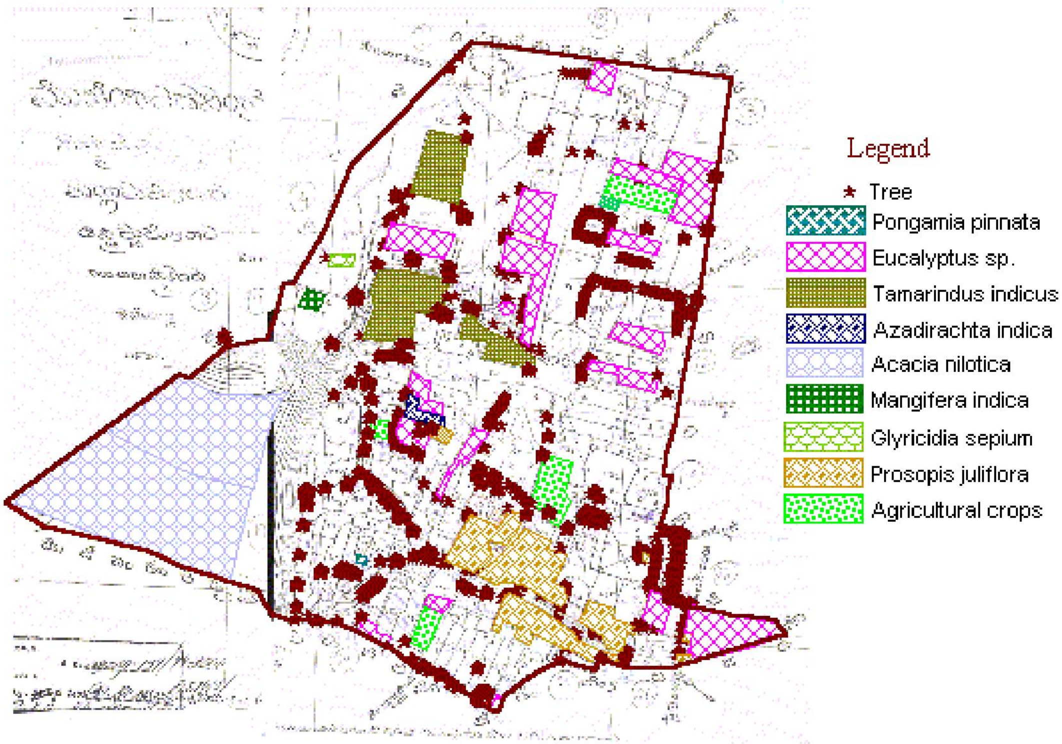


Figure - 4.1

PAN image of Iragasandra village with
Prosopis juliflora polygons

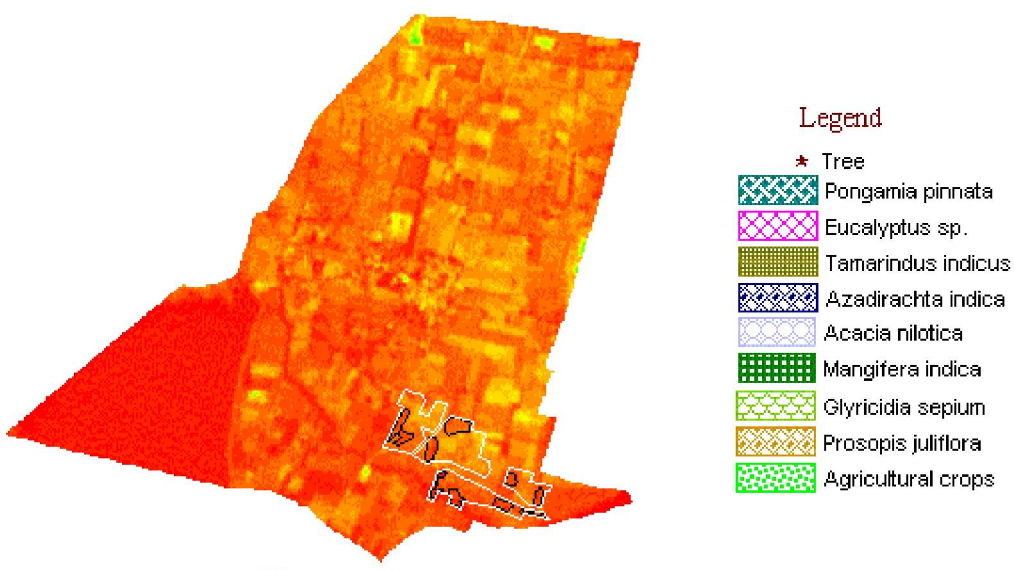


Figure - 4.2

Huthur village map with vegetative cover

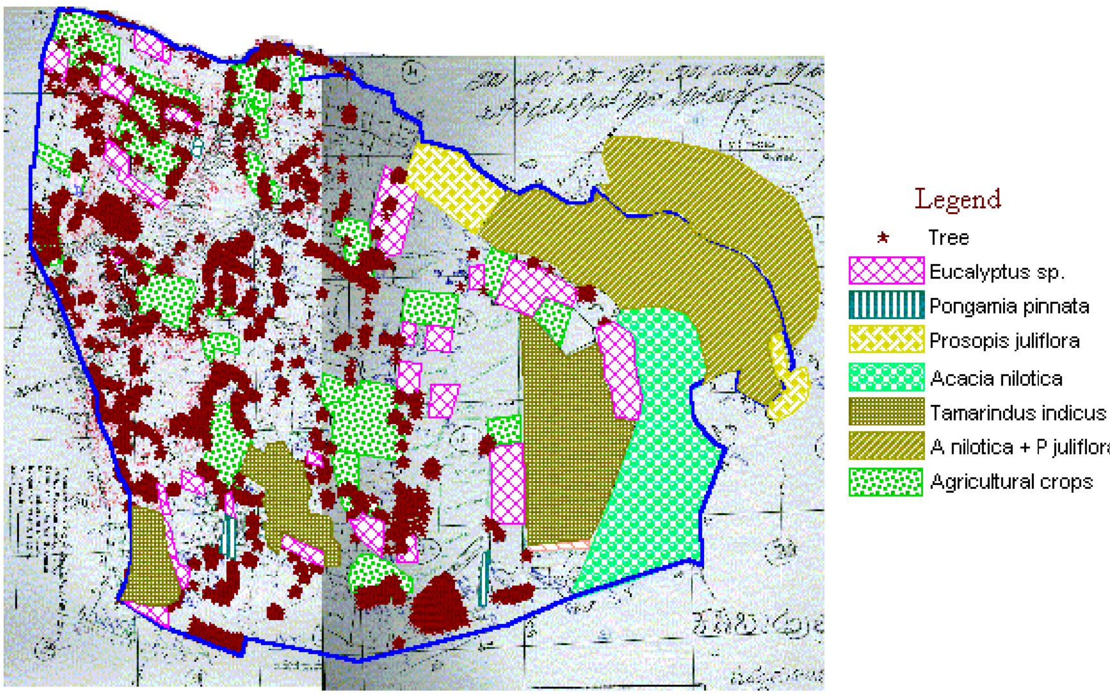


Figure - 5.1

PAN image of Huthur Village with Prosopis juliflora polygons

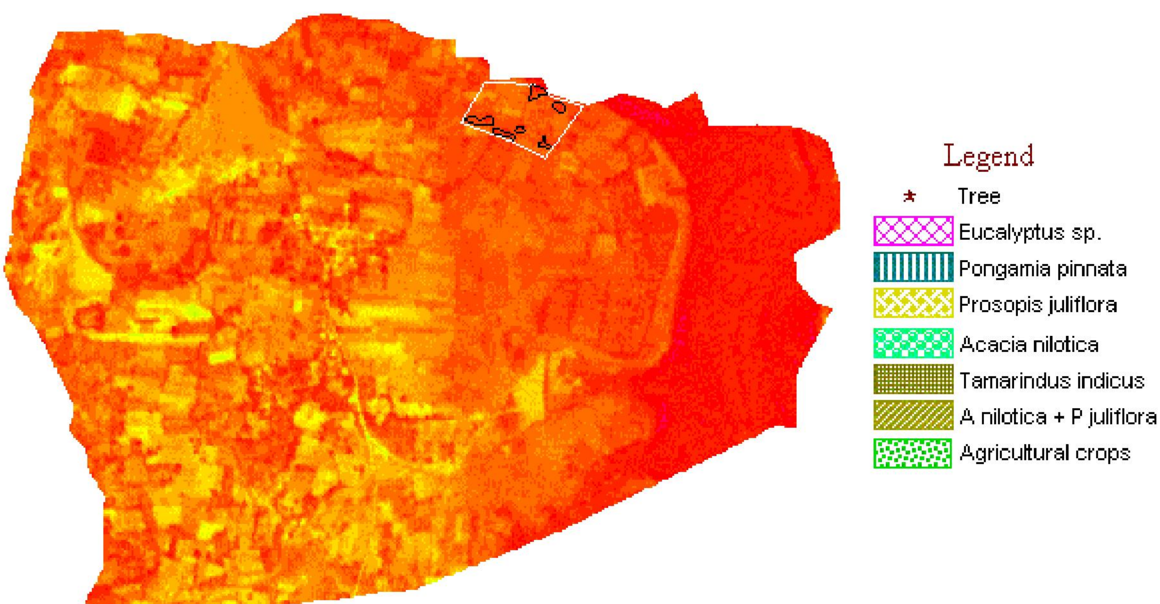


Figure - 5.2

PAN image of Gauribidanur taluk with Prosopis juliflora mapped

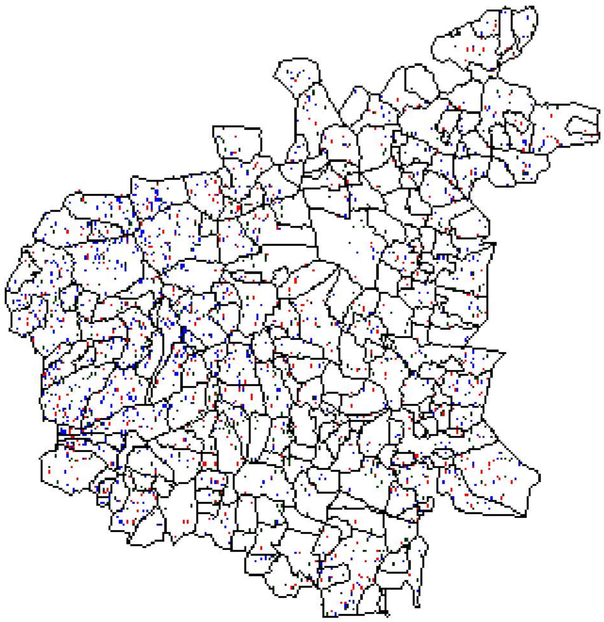


Figure - 6.1

PAN image of Gauribidanur taluk with Prosopis juliflora training sites

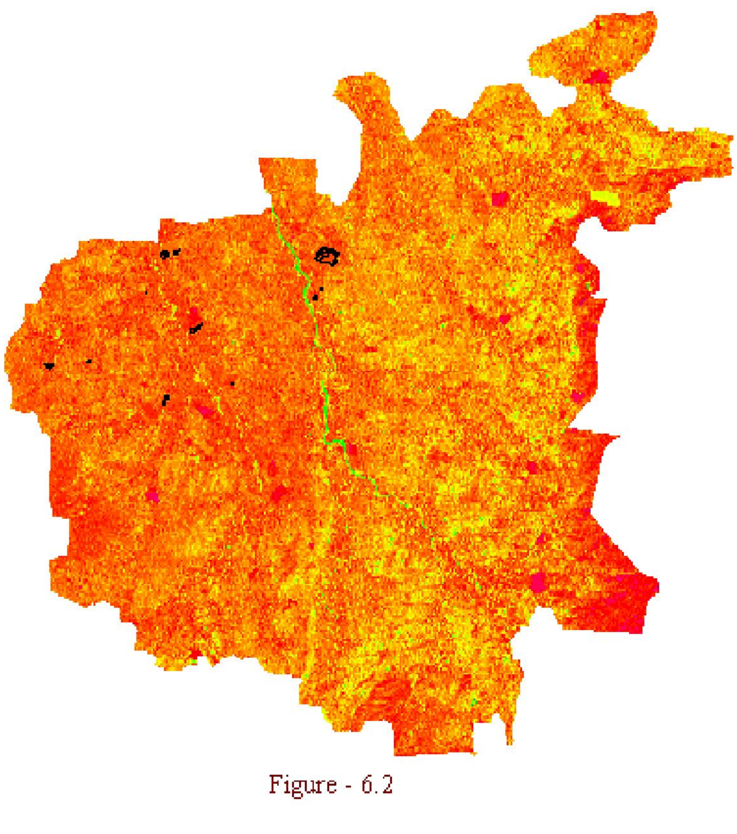


Figure - 6.2

PAN image - Gauribidanur Prosopis juliflora patches

Figure - 7.1

LISS-III band2 image - Gauribidanur Prosopis juliflora patches

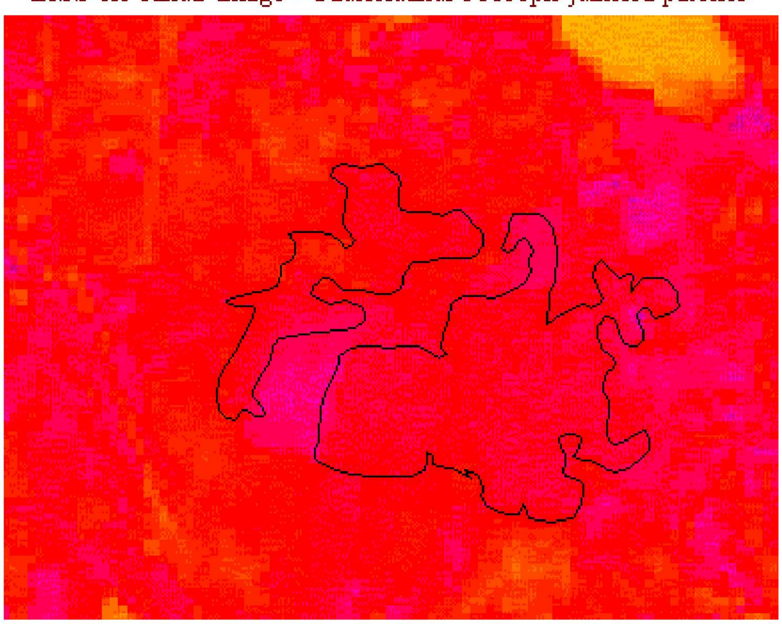


Figure - 7.2

LISS-III band3 image - Gauribidanur Prosopis juliflora patches

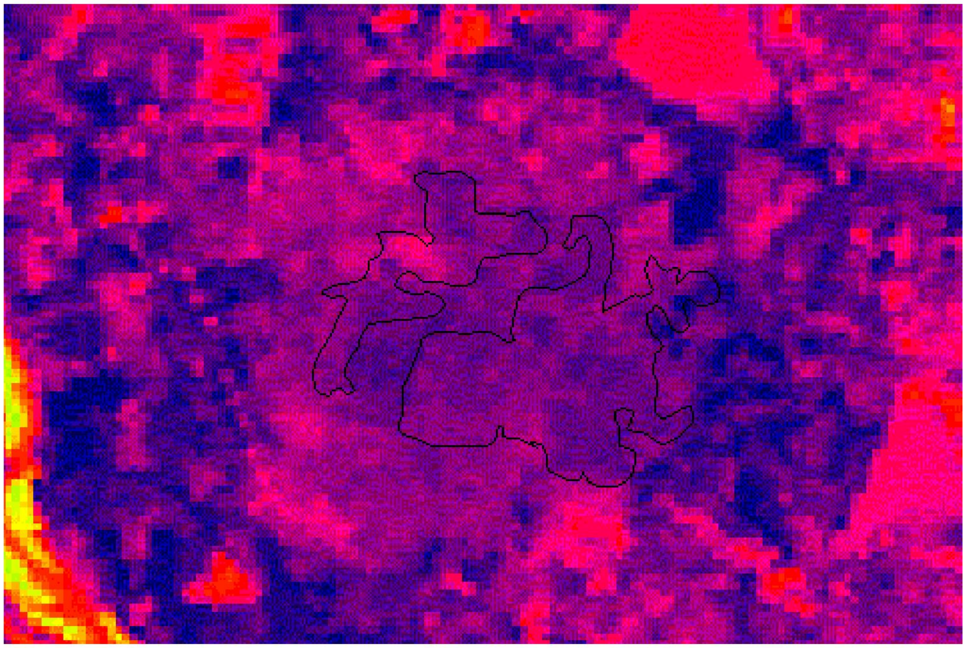


Figure - 7.3

LISS-III band4 image - Gauribidanur Prosopis juliflora patches

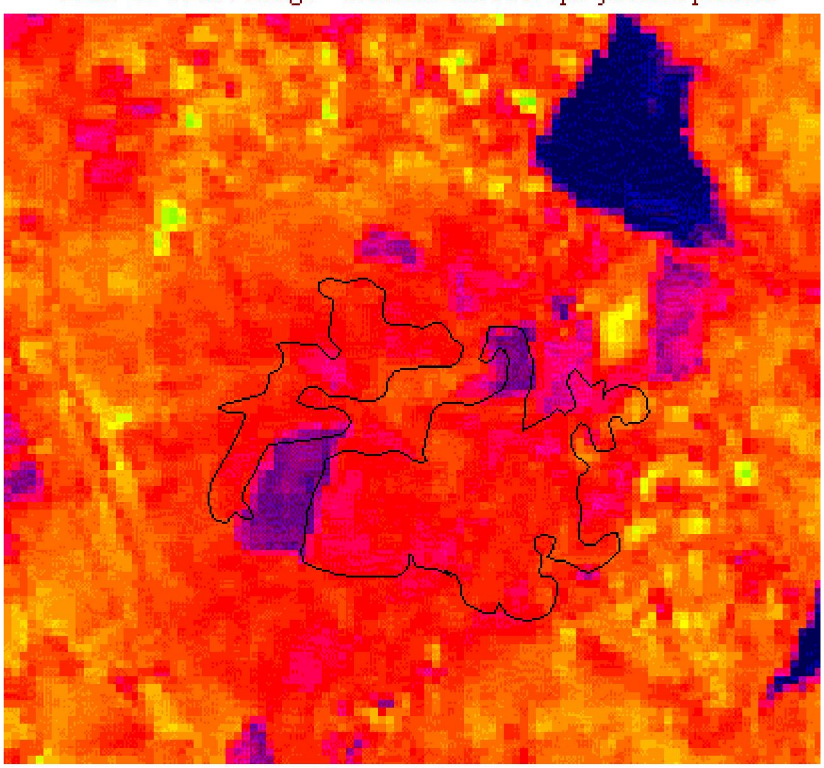


Figure - 7.4

LISS-III and PAN fused image - Gauribidanur Prosopis juliflora patches

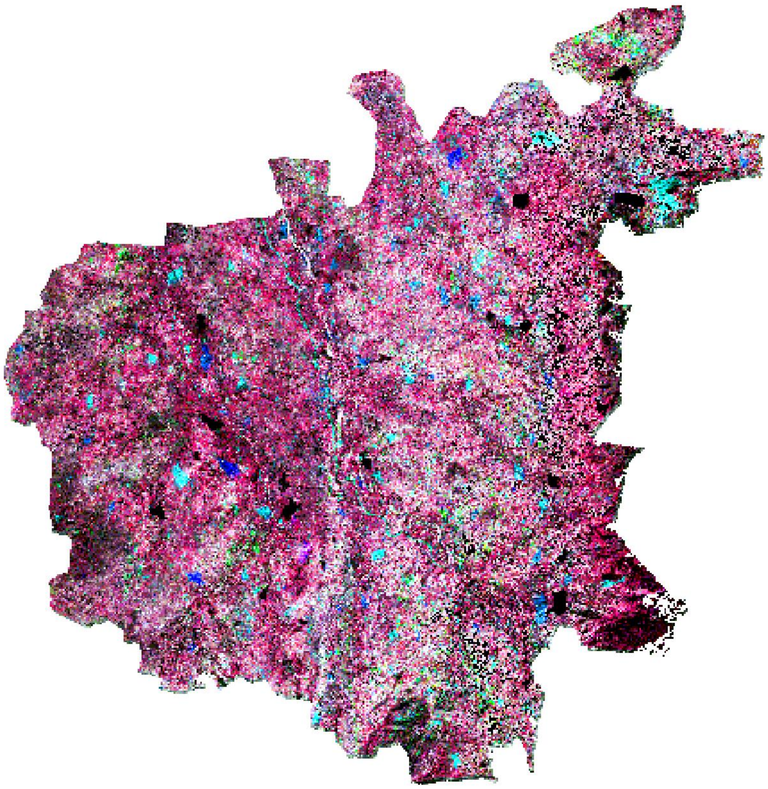


Figure - 8.1

LISS-III and PAN fused image - Gauribidanur Prosopis juliflora patch

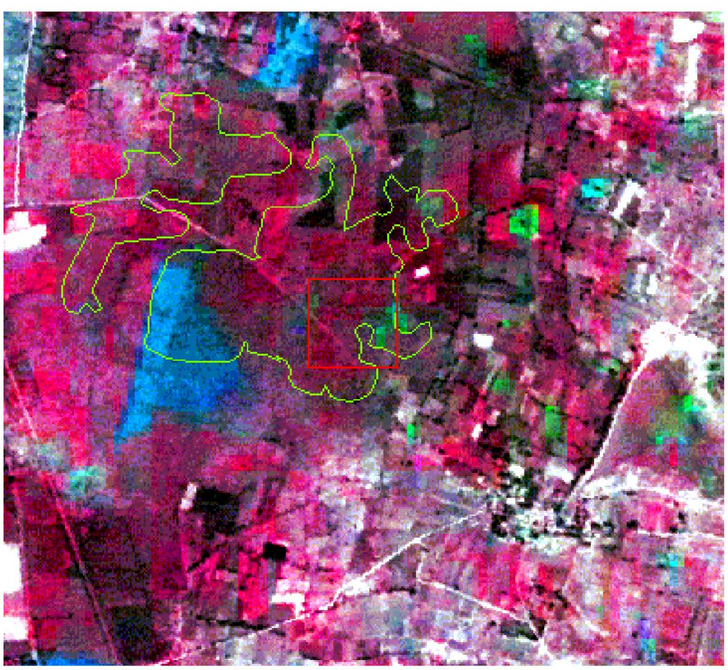


Figure - 8.2