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Quantification of Invasive Colonies of Prosopis Juliflora Using Remote Sensing and GIS Techniques

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***Abstract*— The invasion of alien species is singular threat to global biodiversity and a major threat to water level declination. The present study deals with the mapping and quantifying the distribution of Prosopis juliflora in Palayamkottai taluk using Geoinformatic technique. The invasive weed infestation was identified using remote sensing images. This study will handle multi-temporal LANDSAT images for the years 2007, 2008, 2009, 2010, 2011 and 2012 for evaluating the distribution of Prosopis juliflora. The normalized difference infrared index is derived from both Short wave IR and IR bands of LANDSAT images. The normalized difference infrared index is used to derive Prosopis juliflora leaves, based on the moisture content. The field survey is done to verify the locational information of Prosopis juliflora which is also useful to improve the accuracy of the analysis. This study proves that Geoinformatic technique is a useful tool in understanding the presence and distribution of Prosopis juliflora by reducing field visits.**

***Index Terms*— prosopis juliflora,invasion,NDII,spectral curve.**

I. INTRODUCTION

Over the last century forest plantation using exotic trees was developed as an integral and crucial part of many national economy and environmental programmes. Planted trees and woody shrubs have provided both economic and species invasive alien species (IAS), which is the second next to habitat distraction to biodiversity threat. Therefore countries should evaluate the ecological distribution and socio economic impact of these species to take appropriate management and control measure. Prosopis juliflora also known as "velikaruvelam" is a major threat to water conservation. The native species of West Africa and was introduced in Tamilnadu in 1960's as fuel wood. The seeds germinate easily. This tree has characteristic of high drought sufferance and very high water use efficiency. This tree is one of the phreatophytes, so making it difficult for any other crop to grow near by the tree. The harsh part is no other species could grow in place where karuvelam exists. It takes over the natural vegetation does not allow undergrowth and hence greatly reduces the grazing value of land. Prosopis juliflora invades land and even worse encroaches on river beds and canal beds blocking them and causing drainage patterns to uncontrollably shift. Prosopis juliflora has great opportunities to grow faster and better and makes it more adapted to drought conditions compared to other native species. The number of Prosopis juliflora seeds in the soil seed bank is greater than the seeds of native tree species. The plant accumulates long-lived dormant but viable seeds in the soil serving as a source of new prosopis juliflora plants in the event of disturbance that might eliminate the above ground stands. Under optimal condition only a portion of the seeds germinate at any one time. The seeds have high dormancy caused by the hard seed coat by the hard seed coat. This is particularly important for species survival in arid environments regardless of spatial and temporal rainfall distribution.

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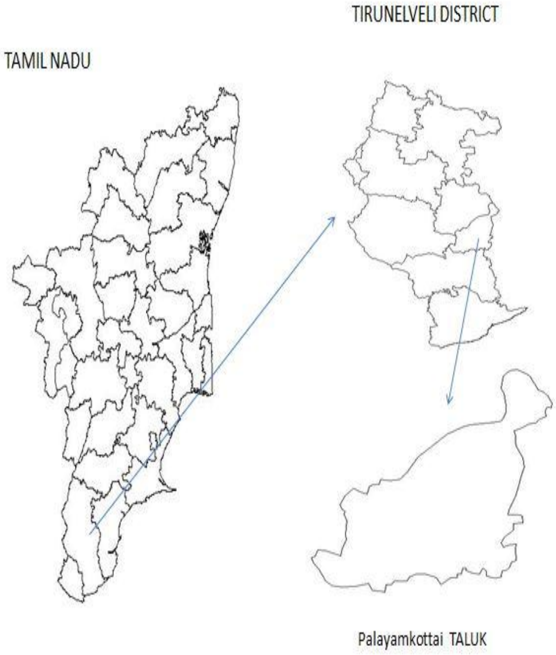
IUCN (international union for conservation) has rated Prosopis juliflora as one of the world's top 100 invasive alien species. It grows in varied types of soils from sandy to saline-alkaline soils. It has proved to be a versatile species for afforesting shifting sand dunes coastal dunes, riverbeds ,saline-alkaline land, eroded hill slopes, mine spoiled areas and other wastelands. Prosopis juliflora has more negative aspects than positive. People found its benefits such as selling Prosopis juliflora as fuel wood. The seed pod is used as a livestock feed and the wood is also used in charcoal making.

II. STUDY AREA AND DATA

A. Study Area

Tirunelveli and Palayamkottai together called as Twin city. Palayamkottai is situated on the eastern bank of the perennial Thamirabarani river(figure-1). It lies between the latitude 77°45' E to 77˚55'E and 8˚39' N to 8˚48'N longitude. The region is very fertile and supports a thriving agrarian community in the midst of many urbanized areas. Regular monsoon rains coupled with the Thamirabarani water, support the purely agricultural villages around the city. Palayamkottai contain 60 revenue village. Palayamkottai is located on the National Highway in close proximity to many bigger cities (international

seaport: Tuticorin - 45 km; Madurai -150km,Tuticorin - 25 km)hence supporting trade and commerce. The district is located in the southern part of Tamil Nadu. It is surrounded by Virudhunagar district in the north, the Ghats in the west, Kanyakumari district and Thoothukudi district in the east. The headquarters of the taluk is the town of Palayamkottai. The total region of Palayamkottai taluk covers 300km2.



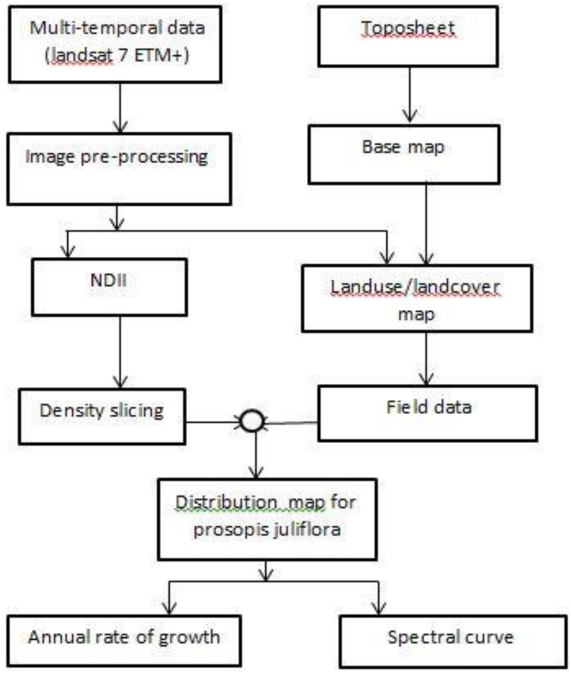
A. Fig1 study Area

B. Data and Softwares

Landsat 7 ETM+ collected for the following years 2007, 2008, 2009, 2010, 2011, 2012, data were analyzed. The information collected from the field was entered into a Geographic Information system. After 2003 Landsat 7 ETM+ SLC-OFF , there is a gap in the images. ENVI 4.8 and ARCGIS 9.3 software were used for image processing and GIS respectively.

III. METHODOLOGY

Remote sensing techniques have a greater potential to derive information above the ground surface. The analysis can be efficiently made through GIS. Data sets, such as GIS coverage and satellite image data are used. The GIS coverage consists of topographic data sets that have been converted to a digital format compatible with Arc GIS. The satellite image of the multi spectral bands is rectified from the geometric and radiometric error using image processing software ENVI. After 2003 Landsat7 ETM+ SLC-OFF, there is gap in the images, So landsat gap fill tool are used in the ENVI software to fill the gap in Landsat 7 ETM+. To reduce the error due to various atmospheric conditions top-of-Atmosphere reflectance was performed on multi-temporal remote sensing datasets [3]. The information collected from the field was entered into a Geographic Information System. The on-screen visual interpretation technique was used to map land use/land cover types on multi-temporal satellite data. In the study area Prosopis juliflora remained evergreen throughout the year, while grasslands and thorn scrub vegetation types showed senescence/deciduousness. Prosopis cover have dark red colour, brownish red colour and dark pink tone in the standard false colour composite images depending on the date of acquisition.



C. data pre-processing

The multi spectral band of the satellite image is rectified for geometric and radiometric errors using image preprocessing.

1. Conversion to TOA (top-of-atmosphere) radiance using the radiance rescalling factor.

$$L\lambda = bias + (gain * DN) \quad (1)$$

Bias= Lmin : Gain = (Lmax/255-Lmin/255)

2. Conversion to TOA reflectance using the reflectance rescalling coefficients.

$$\rho = (\pi L\, D^2)/(Esun * \cos(sz)) \quad (2)$$

D=earth-sun distance in astronomical units :

E sun=solar exoatmosphere: SZ= sun zenith angle

3. TOA reflectance with a correction for the sun angle and removal of pixel atmospheric correction.

$$\text{Correction sun angle} = \frac{(\text{TOA reflectance})}{\sin(\text{sun elevation})} \quad (3)$$

D. Image processing techniques

- Visual interpretation is a process whereby a digital image is studied by eye with reference to field data or aerial photographs and a decision on different feature categories reached without any further computational effort or statistical processing.
- land use/land cover map defined as "the arrangements, activities and inputs people undertake in a certain land to produce, change or to maintain it.

- A band ratio is the result of dividing one band by another, researchers have developed many different band ratios over the years that exploit the specific reflectance properties of the materials the sensor were designed to detect.

E. NDII

Normalized Difference Infrared Index (NDII), which is defined as the ratio of actual to foliar water content. The foliar water content is often divided by the density of liquid water to derive the equivalent water thickness (EWT). EWT is useful because the canopy EWT is equal to the leaf EWT multiplied by the leaf area index (LAI). Leaf reflectance at short wave infrared (SWIR) wavelength increases linearly with respect to leaf reflectance at NIR for a decrease in leaf EWT. The measurement can be calculated from remotely sensed data (NIR and SWIR)in field measurement and result of NDII(NDII>0.1)show that the mesquite trees expansion Hardisky et al. (1983)[4] defined the Normalized Difference Infrared Index (NDII) as:

$$NDII = (SWIR-NIR)/ (SWIR+NIR) \quad (4)$$

Where, NIR is reflectance of near Infrared and SWIR is reflectance of short wave infrared.

F. Density slicing

Density slicing, also known as double threshold, is a classification technique using computer processing of digital data. Density slicing allows the user to define sub-intervals for characterizing the data. The advantage of density slicing is that it allows one to gain a greater degree of variability of brightness within the remotely sensed image compared to the original image (e.g. black and white imagery). The method works best if the range of brightness values covers a single band of frequencies. Each interval is then assigned a color value. The intervals may be defined based on the application. The range of input pixel values is assigned a single output pixel value in a density sliced image. The range of pixel values may be defined by the user. Density slicing is most effective when the value of particular pixel have significance to a physical variable.

IV. RESULT AND CONCLUSION

G. Base map

It is very useful for identifying structure of water body, settlement, transport line etc. The base map will be useful when considering design changes to the landscape. Identify all the existing prominent objects in your landscape. Base map is essential to understand the physical attributes of the place. The base map is shown in fig 2..

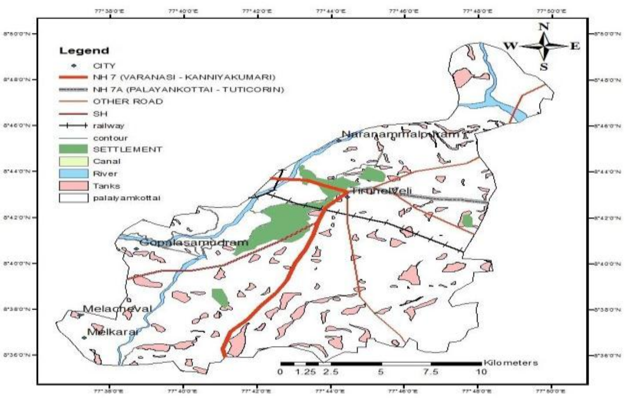


Fig. 2: Base map

H. Land Use/Land Cover

The prepared map consists of the land use/land cover classes that are agriculture, built-up, waste land, water bodies and forest. The temporal land use changes which are accruing in the area are identified based on prepared land use map, for the different years. The land use map /land cover map is show in fig.3.

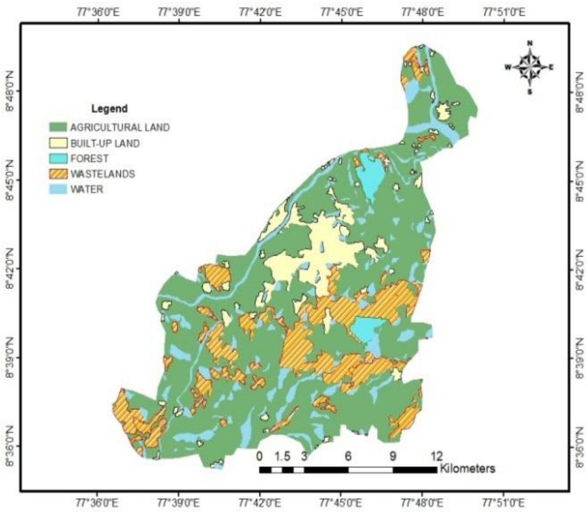


Fig. 3: land use/land cover

I. Vegetation Indices map

Classified maps of vegetation indices of Palayamkottai for the year 2004, 2008, 2011and 2015 are presented in Fig. 4, Fig. 5, Fig. 6, Fig. 7. The sites with vegetation index value > 0.1 were mostly found with Prosopis juliflora tree. (Table 1) Percentage area under different vegetation indices classes. This indicates an increase in permanent vegetation in the form of trees as most of the annual herbs and shrubs mostly remains dry during hot summer season. The difficient parameters namely soil moisture and rainfall affect the vegetation the invasive species. Major reason urbanization and agricultural activities reducing the prosopis juliflora cover. The spatial extent of prosopis juliflora map prepared from the NDII map was displayed in fig.10, fig.11, fig.12, fig.13, fig.14 and fig.15.

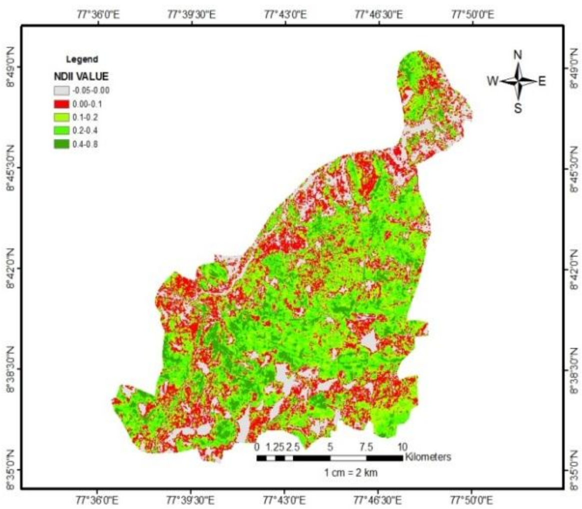


Fig. 4: NDII map for the year 2007

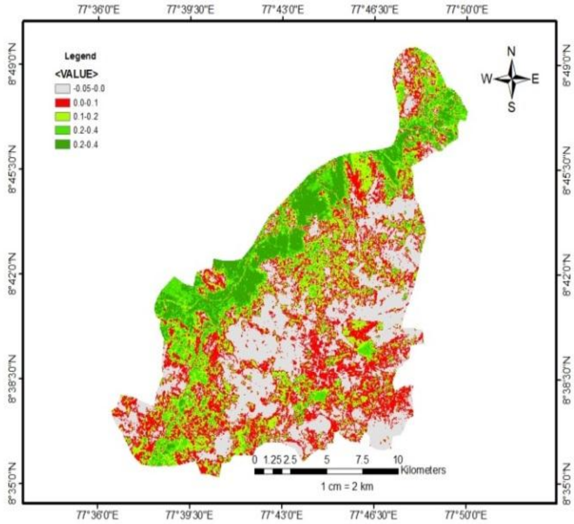


Fig. 5: NDII map for the year 2008

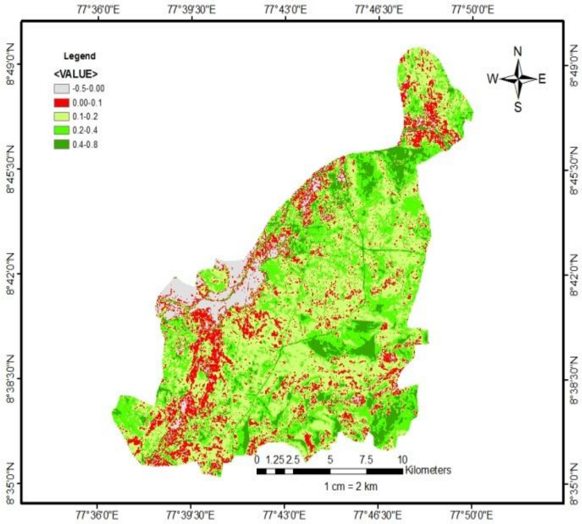
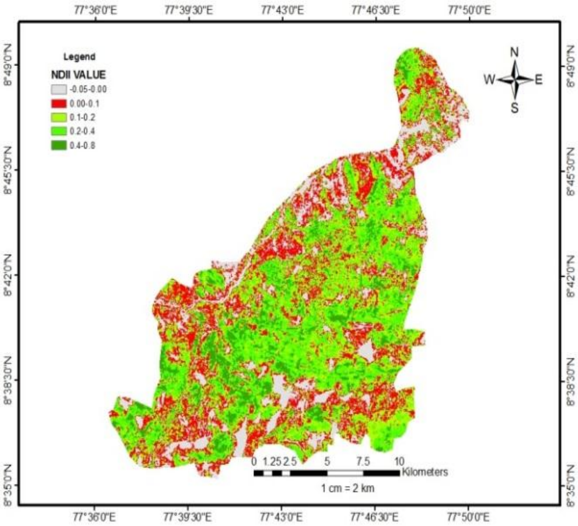


Fig. 8: NDII map for the year 2011



A. Fig. 6: NDII map for the year 2009

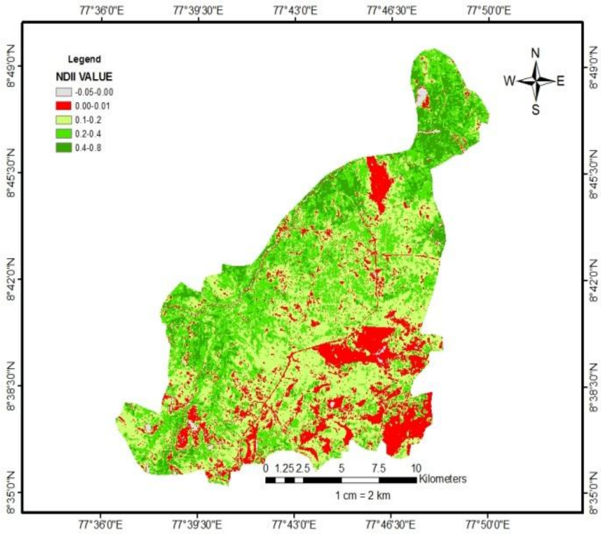
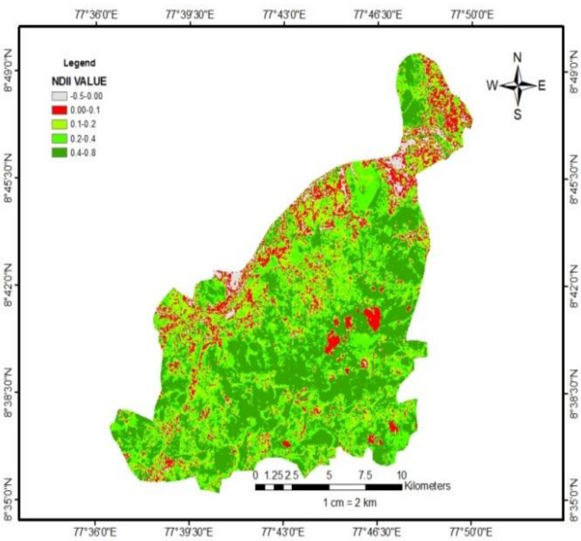


Fig. 9: NDII map for the year 2012



B. Fig. 7: NDII map for the year 2010

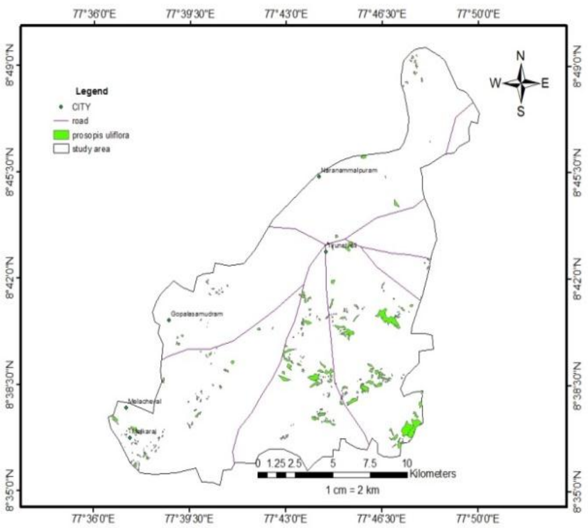


Fig. 10: spatial extent of prosopis juliflora in 2007

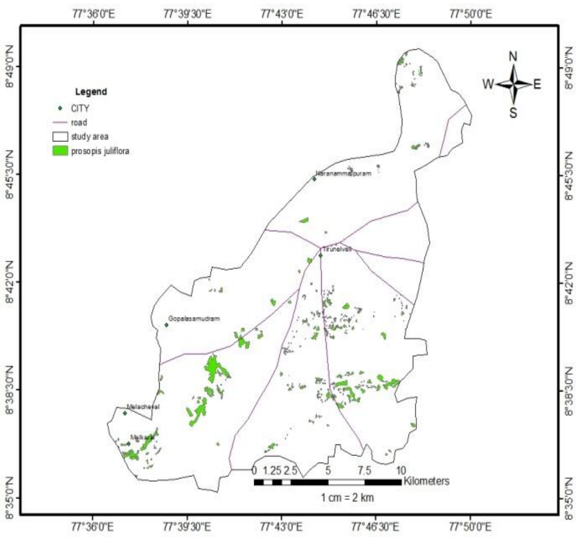


Fig. 11: spatial extent of prosopis juliflora in 2008

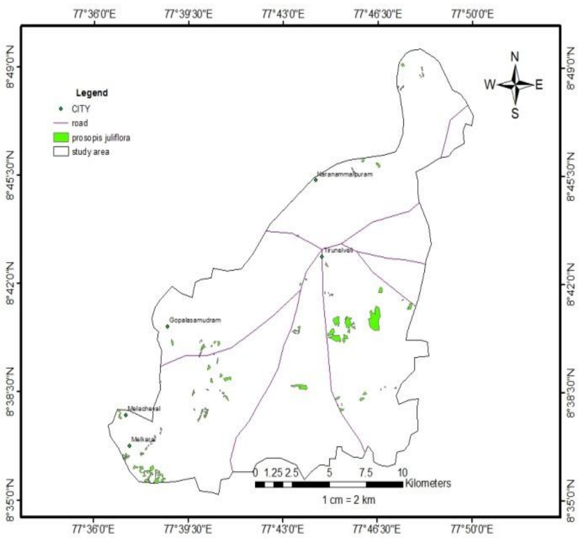


Fig. 14: spatial extent of prosopis juliflora in 2011

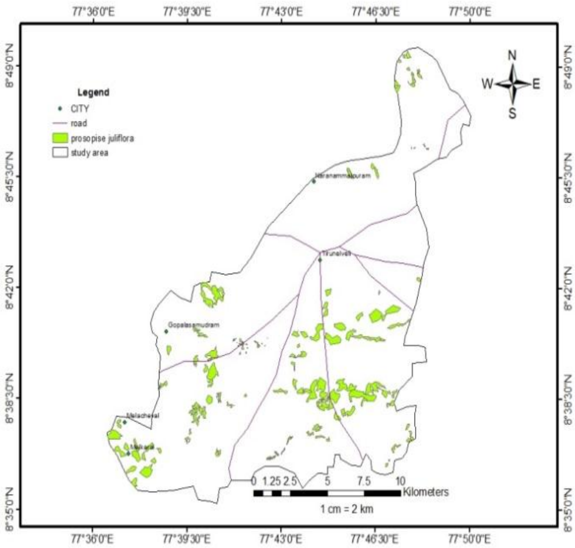


Fig. 12: spatial extent of prosopis juliflora in 2009

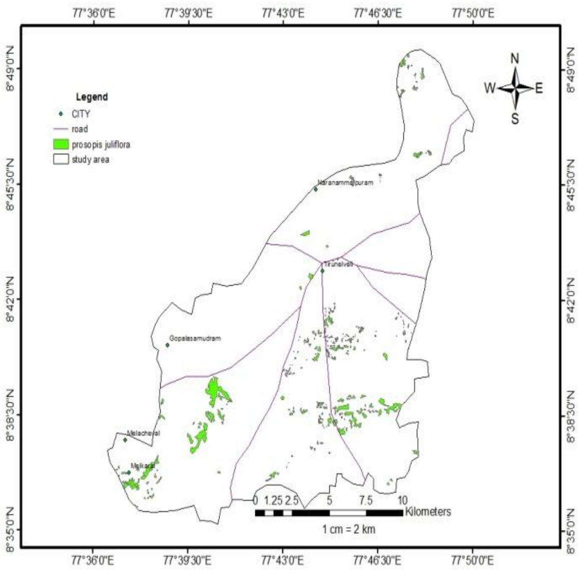


Fig. 15: spatial extent of prosopis juliflora in 2012

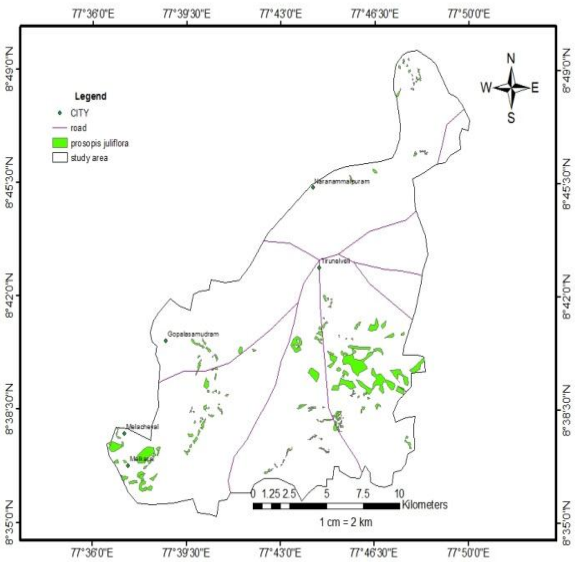


Fig. 13: spatial extent of prosopis juliflora in 2010

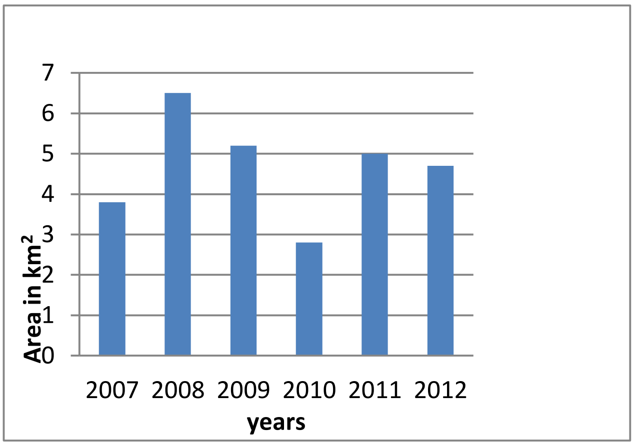


Fig. 16: spatial extent area of prosopis juliflora

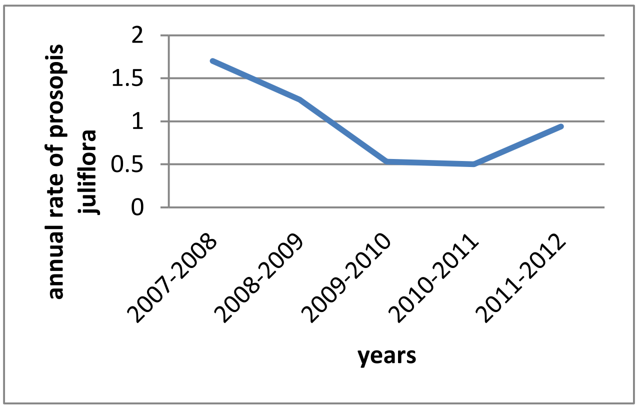


Fig. 17 annual rate of prosopis juliflora spread: 2007-2012

Fig. 16 shows the spatial extent area of prosopis juliflora. Spatial analysis indicates highly occupancy of prosopis juliflora cover is 6.5% in the year of 2008and low occupancy of prosopis juliflora is 2.8% in the year of 2010, The main reason for the reducing in prosopis cover area is real estate activities.

J. Spectral Curve

Remote sensing is based on the measurement of reflected or emitted radiation from different bodies. These differences make it possible to identify different earth surface features or materials by analyzing their spectral reflectance patterns or spectral signatures. These signatures can be visualized in curve called as spectral curve. Fig .19, represent the spectral curve of Prosopis juliflora, water, wetland ,cropland. Prosopis juliflora has low red-light reflectance and high near-infrared reflectance. Wetland has small red-light reflectance and high near-infrared reflectance. Cropland has high red-light reflectance and very less near-infrared reflectance. Water has small red-light reflectance and very less near-infrared reflectance.

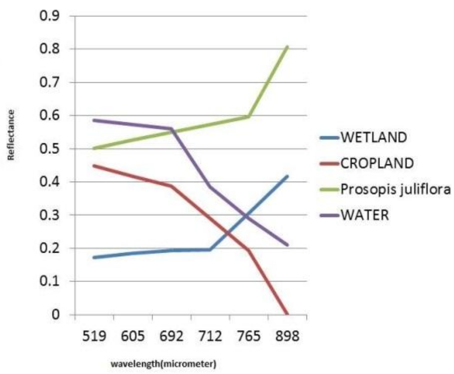


Fig. 18: Spectral curve

V. CONCLUSION

The present study has quantified invasion of prosopis juliflora in the Palayamkottai taluk during the year 2007 and 2012. The Study has found variation in spatial extent of prosopis cover and annual growth rate in study area. The spatial database generated will be helpful in planning management and to control rapid invasion of prosopis juliflora in Palayamkottai. The technique used and the methodology developed can be applied to other area in the country to track and model to the some species and other species .

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REFERENCES

[1] Robinson TP, Klinken RDV and Metternicht G 2008 Spatial and temporal rates and patterns of mesquite (Prosopis species) invasion in Western Australia. J Arid Environ 72:175–188.
[2] Saxena SK and Venkateshwarlu 1991 Mesquite an ideal tree for desert reclamation and fuel wood production. Indian Farming 41: 15-21.
[3] chavec PS 1996 image-based atmosphericcorrectionrevisited and imporoved photogrammetric engineering and Remote sensing 62(9):pp.1025-1036.
[4] HardiskyM.A.,klemas v.,smart R.M.(1983):The influence of soil salinity,growth from,and leaf moisture on the spectral reflectance of spartina alteriflora canopies photogramm.eng.remote sens.49:77-83
[5] Joshi C, Leeuw JD and Duren ICV 2004 Remote sensing and GIS applications for mapping and spatial modelling of invasive species. Proceedings of ISPRS 35: 669-677.
[6] Anderson GL, Everitt JH, Richardson AJ and Escobar DE 1993 Using satellite data to map false broom weed (Ericamera austrotexana) infestations on south Texas rangelands. Weed Technology,7:865-871.
[7] Reddy CS, Pattanaik C and Murthy MSR 2007 Assessment and Monitoring of Mangroves of Bhitarkanika Wildlife Sanctuary, Orissa, India using Remote Sensing & GIS. Current Science92(10): 1409-1415.
[8] Wittenberg R and Cock MJW 2001 Invasive alien species: a toolkit of best prevention and management practices: CAB International, Wallingford, U.K.
[9] VazeedPasha.S.Satish.KC.SudhakarReddy,P.V.V.Prasada Rao & C.S.Jha,(2012) Satellite Image ased Quantification of Invasion and Patch dynamics of Mesquite in Great Rann of Kachchh,Kactchh Biosphere Reserve, Gujarat,India.NRSC ,ISRO.Vol-17,No.5,PP 129-123.
[10] Saad and Alshammary, (2013),saline irrigation on growth and mineral composition of prosopise juliflora and Acacia Arabica in Saudi Arabia. The bioscience biotechology research,Asia.vol-10,No-2.PP 583-590.
[11] Joshi c,Leeuw JD and Duren ICV2004 remote sensing and gis applications for mapping and spatial modeling of invasive species.proceeding of ISPRS 35:669-677.
[12]puyravaud JP2003 standarding the calculation of the annual rate of deforestation.For,Ecological management.
[14] Moran M.S., Pinter P.J., Clothier B.E., Allen S.G. (1989): Effects of water stress on the canopy architecture and spectral indices of irrigated alfalfa. Remote Sensing of Environment, 29: 251-261.
[15] Peterson, E.B. 2005. Estimating cover of an invasive grass(Bromus tectorum) using tobit regression and phenologyderived from two dates of Landsat ETM+ data. InternationalJournal of Remote Sensing, 26, pp. 2491-2507.

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