Journal of Agroecology and Natural Resource Management
p-ISSN: 2394-0786, e-ISSN: 2394-0794, Volume 3, Issue 2; July-September 2016 pp. 188-191

http://www.krishisanskriti.org/Publication.html

A Study in Change in Vegetation Cover in an Urban Environment: A Multi-spectral, Multi-Temporal analysis of Mumbai Suburban District using Remote Sensing

Hamish Dsouza[1] **and Sudha Gupta**[2]

[1,2]*Department of Electronics Engineering, K.J. Somaiya College of Engineering, Mumbai*
E-mail: [1]hamish.d@somaiya.edu, [2]sudhagupta@somaiya.edu

Abstract—*The earth surface is under constant change due to natural or artificial causes. The growing population and urbanization in Mumbai has led to deforestation to accommodate urban growth. This loss of green cover poses serious environmental issues such as increase in air pollution, increase in surface temperature and risks of coastal floods. This study aims to study and present the change in vegetation cover in Mumbai using satellite remote sensing. Multi-spectral Landsat images acquired in the months of March 1990, November 2013 and November 2014 were studied. Different vegetation indices have been obtained to identify vegetated areas. From the analysis, it is seen that Normalized Differential Vegetation Index (NDVI), Simple Ratio and Green Chlorophyll Index (GCI) are excellent for detecting vegetation. Multi-temporal images were analyzed to understand the temporal changes. The results of such analysis will help take steps towards environment conservation.*

Keywords: *remote sensing, NDVI, GCI, Landsat, change detection*

1. INTRODUCTION

Vegetation is one of the most important components of terrestrial ecosystem. It plays an important role in regional ecosystem, environment and optimization of human habitation.

Mumbai is one of the most populated cities of India owing to the vast employment opportunities it offers as the commercial capital of India and administrative capital of Maharashtra. The population of Mumbai is continuously increasing and this increases the need for accommodation. The increased areas under habitation come at a cost of loss of forest areas, mangroves and vegetation cover in the city. This poses a threat to the ecological balance of the city and hence it is necessary to monitor the change in vegetation cover for sustainable development.

Remote sensing has proved to be an excellent tool in studying vegetation. It offers a synoptic view of the study area and is cheaper and faster compared to manual methods of surveying. The potential of using Normalized Differential Vegetation Index (NDVI) from multi spectral satellite images has been studied by Goward et.al [1]. Peijen Du gave a comparison of four approaches to study vegetation based on remotely sensed data using NDVI, KT Transform, Spectral mixture analysis and decision tree for vegetation classification. Each of these approaches gave a slightly different vegetation coverage ratio. It was proposed that a combination of different approaches could give a more accurate estimate of the vegetation [2]. Multi-temporal satellite data was used to study vegetation dynamics in Grasslands National Park, Canada [3].

Various studies in recent years have tried to use multi-spectral and multi-temporal data for vegetation analysis. Many vegetation indices have been developed to study vegetation. In this study, we have combined the results of different vegetation indices to detect vegetation. Data from different years has been used to monitor the vegetation dynamics. QGIS software was used to extract the study area. The data pre-processing and image processing was implemented in MATLAB 2013a.

2. STUDY AREA AND DATA

2.1 Study Area

Mumbai is the commercial capital of India and houses many businesses. It is also the administrative capital of Maharashtra.

Mumbai Suburban District is located in Konkan Division in Maharashtra on the western coast of India. It encompasses a geographical area of 446 sq.km [4]. It lies between 18°53' N and 19°19' N; and 72°45' E and 73° E. The location of the study area is shown in Fig. 1.

The study area contains Sanjay Gandhi National Park which contributes to a large share of the vegetated area. The coastal areas have mangrove forests which are dwindling due to land reclamation.

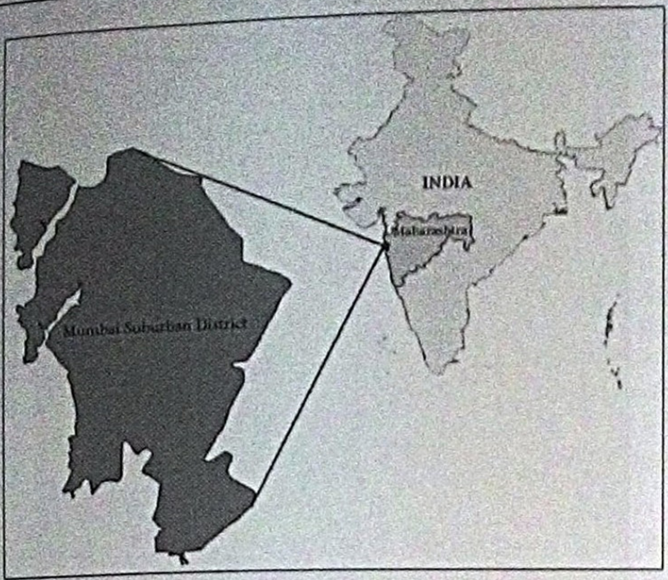


Fig. 1: Study Area

2.2 Data

Multi spectral remote sensing data from Landsat 8 OLI for November 2013 and November 2014 was acquired. Data from Landsat 5 was obtained for March 1990. The images obtained were Level 1 products.. The remote sensing data was obtained from the archives of United States Geological Survey. The shape files of Mumbai Suburban District were obtained from Global Administrative Areas (GADM) [5]. A brief account of the satellite data used is given in table 1.

Table 1: Details of the satellite data

Date	Satellite/Sensor
9 March 1990	Landsat 5 TM
19 November 2013	Landsat 8 OLI
6 November 2014	Landsat 8 OLI

3. DATA PRE-PROCESSING

3.1 Extraction of Study Area

The obtained satellite images were processed and the area of Mumbai Suburban District was extracted using the Clipper tool of QGIS. The shape file of Mumbai Suburban District obtained from GADM was used to extract the study area.

3.2 Conversion of DN to Physical Units

The satellite images were encoded in 16 bit integral digital numbers(DN). These digital numbers were converted to Top Of Atmosphere Reflectance using equation 1 [6].

$$toa\_ref\_u = Mp * DN + Ap \quad (1)$$

where toa_ref_u = uncorrected TOA reflectance

Mp = reflectance multiplicative scaling factor

Ap = reflectance additive scaling factor

DN = Level 1 pixel value

The uncorrected TOA reflectance was corrected for the solar elevation angle using equation 2 [6].

$$toa\_ref = toa\_ref\_u/\sin(se) \quad (2)$$

where toa_ref_u = Uncorrected TOA reflectance

se = Solar Elevation angle

3.3 Generation of Color Composites

The multi-spectral image bands were combined in different combinations for visual interpretation of the land use. True Color Composites and False Color Composites are shown below. Since vegetation strongly reflects energy in the near infra red band, vegetation can be easily detected when the Near Infra Red (nir) band is displayed in red channel. Standard False Color composite was created using Bands 5,4,3 of Landsat 8 and Bands 4,3,2 of Landsat 5 data.

Fig. 2: Standard False Color Composite

(Image acquired from Landsat 8 on 19th November 2013)

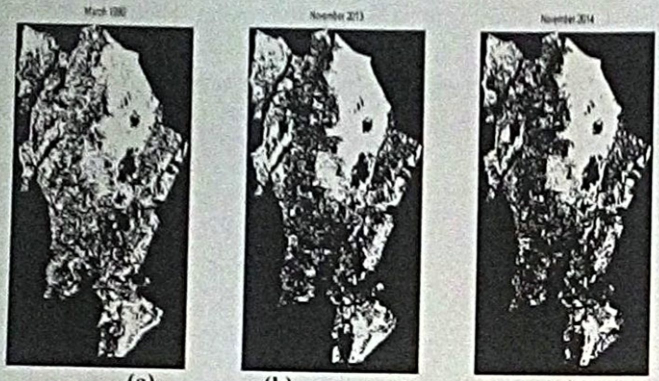
4. VEGETATION DETECTION METHODS

Every object has a specific spectral reflectance pattern by which it can be identified. The main characteristic of the spectral signature of vegetation is its high reflectance in near infra red region and absorption in the red band.

A vegetation index (VI) is an algorithm for detecting vegetation using the various bands of a multispectral data. Many vegetation indices have been designed and tested in the past few years. In this study, we use a combination of Normalized Differential Vegetation Index (NDVI), Simple Ratio (SR) and Green Chlorophyll Index (GCI) to identify vegetation. Vegetation indices were calculated and individual Vegetation Index maps were obtained. A threshold was set for each VI to detect vegetation. The obtained vegetation maps were compared. Pixels satisfying the threshold conditions of all the evaluated vegetation indices were mapped as vegetation in the final map. Vegetation maps were obtained for different dates and used for temporal comparison. The vegetation maps are shown in Fig. 3.

Table 2: Vegetation indices used in the study

VI	Formula
NDVI	(nir - red)/(nir + red)
SR	nir/red
GCI	Nir/green



(a) (b) (c)

Fig. 3: Vegetation maps (a) 9 March 1990 (b) 19 November 2013 (c) 6 November 2014

5. COMPARISON AND ANALYSIS

5.1 Comparison

The multi- temporal vegetation maps prepared after combining the results of evaluated vegetation indices were compared visually. The results of multi-temporal analysis were mapped in a single image using the three color bands – red, green and blue. Different pixel colors obtained in the resultant map shown in Fig. 5 helped identify changes in the vegetation cover. The channel assignment is listed in table 3.

Table 3: Channel assignment for composite result

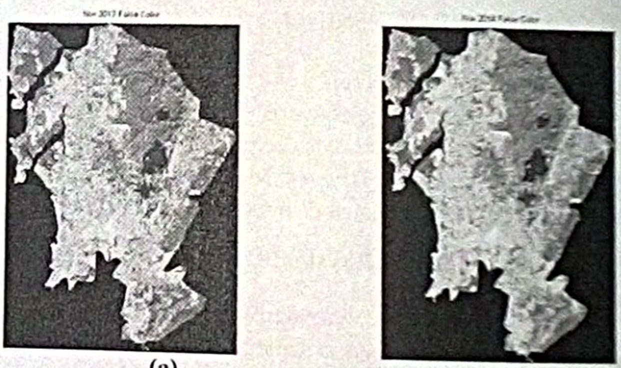
Channel	Date
Red	9 March 1990
Green	19 November 2013
Blue	6 November 2014

Fig. 4: Results of change analysis

March 1990 data is displayed in red, November 2013 data is displayed in green and November 2014 data is displayed in blue

5.2 Change Detection

Visual interpretation was used for qualitative analysis of change. The False Color Composites of November 2013 and November 2014 are shown in Fig. 5.



(a) (b)

Fig. 5: False color composites
(a) 19 November 2013 (b) 6 November 2014

Image correlation gave a measure of the similarity between 2 vegetation maps. As the image cover the same areas and the pixel size is constant, a lower value of correlation indicated more change.

5.3 Analysis

A comparison showed a steady decline in vegetation cover in the years from 2013 to 2014. Comparisons with data from 1990 showed a great of loss in vegetation cover. The correlation between vegetation maps of march 1990 and November 2013 showed a correlation factor of 0.5113. The correlation between vegetation maps of November 2013 and November 2014 had a correlation factor of 0.98. Thus, there was a big change in the vegetation maps from March 1990 to November 2013.

In the composite result map shown in Fig. 4, red pixels denote the areas where vegetation was present in 1990 but absent in 2013 and 2014. The loss is distributed along the western suburbs. This can be credited to large residential complexes that have come up in the western suburbs.

6. CONCLUSION

The change in vegetation cover of Mumbai Suburban District was compared using remote sensing and image processing. The vegetation was detected using unsupervised classification technique. Three different vegetation indices were combined for better results. The study showed a decreasing trend in the vegetation cover in Mumbai Suburban District. The presence of Sanjay Gandhi National Park has protected vast area of vegetation cover. However the decline in overall vegetation cover is contributed by loss in Mangrove forests and smaller vegetation patches in the city. Appropriate measures should be taken by the government agencies to preserve the environment in Mumbai and not let it be sacrificed at the expense of urban sprawl.

7. ACKNOWLEDGEMENTS

This work was supported by the Department of Electronics, K.J.Somaiya College of Engineering, Mumbai.

REFERENCES

[1] B. D. W. J. S.N.Goward, "Normalised differential vegetation index measurements from the Advanced very high resolution radiometer," *Remote Sensing of Environment*, vol. 35, no. 2, pp. 257-277, 1991.

[2] P. Du, "A comparison and evaluation of four vegetation analysis approaches based on remote sensing imagery," in *2008 International Workshop on Earth Observation and Remote Sensing Applications*, 2008.

[3] J. J.Henderson, "Analysis of changes in vegetation condition in Grasslands National Park using Remote Sensing," in *IEEE International Symposium on Geoscience and Remote Sensing*, 2006.

[4] "Mumbai Suburban District," [Online]. Available: http://mumbaisuburban.gov.in/html/indexenglish.htm. [Accessed 20 June 2016].

[5] "Global Administrative Areas," [Online]. Available: ww.gadm.org. [Accessed 20 June 2016].

[6] Landsat 8 (L8) Data Users handbook, United States Geological Survey, 2016.