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Assessment of Vegetation Cover Through NDVI, Bangalore India

KEYWORDS: BBMP, Satellite Imagery, NDVI, vegetation cover

Malini A Shetty
Research Associate, Department of Environmental Science, Bangalore University, Bangalore-56.

R.K. Somashekar
Professor, Department of Environmental Science, Bangalore University, Bangalore -56

ABSTRACT *This paper assesses the distribution of vegetation in eight zones of BBMP also called Bruhat Bangalore Mahanagar Palike, and compares their condition with indicators of vegetative health for the city as a whole. The evaluation is based on use of the normalized difference vegetation index (NDVI) deliberated from 2004 Quick Bird satellite imagery. In our application, we examine spatial variation and mean NDVI for each zones. We then compare these results to the mean NDVI for different zones and discuss implications for use of the NDVI in Vegetation assessment of BBMP. Our results indicate that significant differences of mean NDVI values between the zones. Among eight zones high mean NDVI value was observed in Byatarayanpura and Dasarahalli zone showed lowest. In the current study vegetation assessment across the zones can epitomize how urban vegetation cover and its associated benefits vary across the BBMP and this data can be used to compare urban vegetation cover between the zones.*

Urban forest is unique and diverse, often depicts greater heterogeneity in green spaces including parks, botanical gardens, home gardens, office complexes, avenue trees, wetlands, plantations and forests. This spatio-temporal distribution of vegetation is a fundamental component of the urban environment that can be quantified using multispectral imagery.

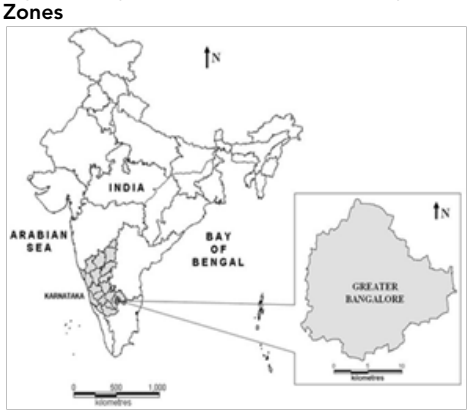
Vegetation indices are widely used for monitoring, analyzing and mapping temporal and spatial variations in vegetation structure. Among the different VIs studied, NDVI seems to provide best results for vegetation analysis in urban environment. The Normalized Difference Vegetation Index (NDVI) is used to transform multi-spectral data into a single image band which represents vegetation distribution was computed for Quickbird imageries using standard algorithm in present study.

Bangalore is experiencing pioneering urbanization in recent times due to congregated developmental activity effected in the increased population and subsequent pressure on infrastructure and natural resources, which ultimately give rise to plethora of serious challenges like climate change, green house effect and frequent flooding of low lying areas. In the current study vegetation dissemination across 8 zones of Bangalore is assessed by NDVI transformed 2004 Quick Bird imagery. Amidst eight zones high NDVI value was observed in Byatarayanpura followed by "South" and "West" zone. The vegetation distribution is largest in Byatarayanapura followed by Mahadevapura. The zones in central metro area once famous for parks, gardens and plenty of avenue trees mainly responsible for calling Bangalore as "garden city" is transfigured into concrete jungle. The zones in outskirts of the metro area categorized by thick plantation and forest cover now shows exceptional decrease in vegetation. Urbanization is happening at a very fast rate and at the cost of agricultural land and plantation in the outskirts of metro, which is described as National Natural Resource Census (NRC) hot spot areas for further studies and monitoring. Urban sprawl is observed as 9% and around 177 km^2 of agricultural land has been converted into built up area in the last 5 to 6 years. The Zone wise assessment of vegetation distribution using high resolution satellite imagery can exemplify how urban vegetation cover and its associated benefits vary across the BBMP and this data can be used to compare urban vegetation cover estimates among zones.

Study Area

The study area Bruhat Bangalore Mahanagara Palike (BBMP) is situated in the heart of Deccan plateau in peninsular India to the South-Eastern corner of Karnataka State between latitude parallels of 12°39'00" N & 13°1'00" N and longitude meridians of 77°22'00" E and 77°52'00" E at an average elevation of 900 mts above mean sea level and has an area of 800 Km^2, supports 80 lakh population.

Fig 1. Study area_BBMP (Greater Bangalore) and BBMP Zones



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MATERIALS AND METHODS

Data products

`The present study is carried out using the 2004 Quick Bird imagery. Base layers of the eight zones of BBMP was created using survey of India Toposheets of scale 1:50000; Erdas 9.2 and ArcGis 9.2 were used for image processing and further analysis.

Methods: Methodology is based on the combination of techniques to extract information from remotely sensed data.

1. Geometric correction and pre-processing for enhancing imagery data: This includes geometric rectification to the UTM (WGS 84 datum) coordinate system by 10 ground control points for each image.

2. The Normalized Difference Vegetation Index (NDVI) : is used to transform multi-spectral data into a single image band which represents vegetation distribution was computed for quickbird imagery using standard algorithm

NDVI = (NIR – R) / (NIR + R).

3. One way anova: One way anova was applied to compare mean NDVI values of 8 zones of Bangalore Metro.

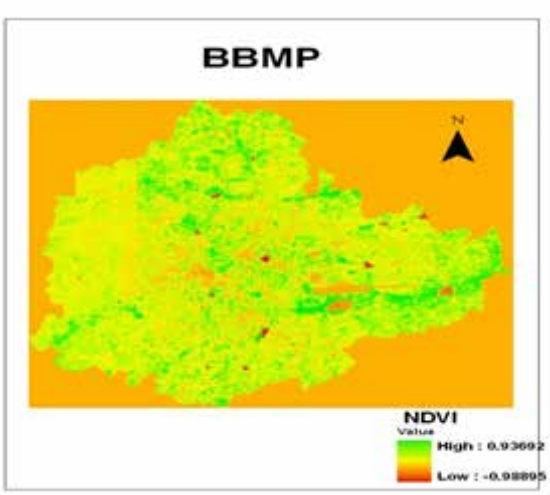
4. Scatter plot: was constructed to find the correlation between vegetation percentage, Built ups and population density of different zones of BBMP.

Results and discussion

The Quick Bird image of Bangalore Metro (2004) is considered for comparative vegetation assessment by NDVI indice. The FCC (False Color Composition) of the study area is structured with 4, 3, 2 bands of the Quick Bird.

Normalized Difference Vegetation Index (NDVI) has demonstrated to possess an extremely wide range of applications in measuring urban vegetation cover (Brown et al., 1993; Evans, Zhu, and Winterberger, 1993; Loveland et al., 1991; Townshend, Justice, and Skole, 1994). NDVI is a grey scale continuous data set where the vegetation cover is portrayed as varying level of brighter patches. The NDVI transformed image is classified into 4 different classes based on NDVI values, which varies between -1 and +1 and is given pseudo colour in varying shades of Green (vegetation) and Pink(water).

Fig 2. NDVI change image of BBMP. Red and green pixels indicate an decrease and increase in vegetative reflectance.



The NDVI transformed image is classified into 4 different classes based on NDVI values, which varies between -1 and +1 and is given pseudo colour in varying shades of Green (vegetation) and Pink(water). The four classes were identified as water, Built Ups, Vegetation and Others. Dense vegetation shows up very strongly in the imagery and areas with little or no vegetation can be clearly identified (Wilson, Brother and Marcano 2000).

Table I NDVI for various land uses in 8 zones of metro:

BBMP Zones	Water	Built ups	others	Vegetation
	NDVI Mean±SD	NDVI Mean±SD	NDVI Mean±SD	NDVI Mean±SD
BYATARAYANAPURA	-0.607± 0.226	-0.081± 0.080	0.110± 0.032	0.514± 0.199
BOMMANA HALLI	-0.609 0.228	-0.112± 0.073	0.065± 0.033	0.457± 0.195
DASARAHALLI	-0.573± 0.228	-0.111± 0.056	0.028± 0.022	0.383± 0.034
WEST	-0.707± 0.171	-0.222± 0.111	0.014± 0.027	0.507± 0.258
SOUTH	-0.637± 0.209	-0.155± 0.071	0.019± 0.032	0.531± 0.265
MAHADEVPUR	-0.637± 0.209	-0.132± 0.084	0.082± 0.041	0.395± 0.141
EAST	-0.667± 0.193	-0.136± 0.115	0.108± 0.028	0.505± 0.208
RR NAGAR	-0.605± 0.225	-0.111± 0.062	0.041± 0.027	0.396± 0.179

A closer look at the values of NDVI by land use classes(Table I) indicates continuous decrease from vegetation to non vegetation area as observed by Briggs et al., 1997. The vegetation class encompass mainly grass and trees (parks, forest and plantations) having mean NDVI values between 0.395 and 0.531. Water, a good absorber of near-infrared radiation shows the lowest NDVI mean.

Among the eight zones, "Byatarayanapura" zone showed very high NDVI mean value followed by "South" and "West" zone. The lowest NDVI value observed in "Dasarahalli" is mainly because of high percentage of built up areas and prevailing of large scale industries. The high NDVI value in "Byatarayanapura" zone can be mainly attributed to the state forest and Eucalyptus and Sandal wood plantation areas. The scrub forest with intermittent plantations is more frequent in "RR Nagar" zone . "Mahadevapura" zone is categorized by agricultural fields with scrub vegetation. Parks, Gardens and Avenue trees are predominant in zones of central metro. Water bodies are very prominent in outskirts zones like Bommanahalli and Byatarayanpura while central zones are represented by very few water bodies. Most of them are either encroached or converted into parks and gardens. Spatial variation of NDVI is not only influenced by the vegetation amount but also the topography, slope, solar radiation availability and other factors (Walsh et al., 1997).

Table II Anova depicting difference in NDVI among eight zones of metro at 95 % (p<0.05)

	DF	F-value	p-value(<0.05)
Variance in NDVI between Zones	7	3.55	0.0008
Variance in NDVI Within Zones	2040		
Total	2047		

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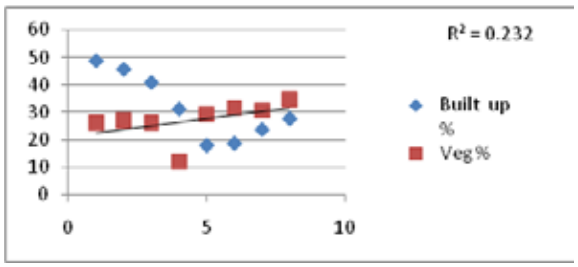
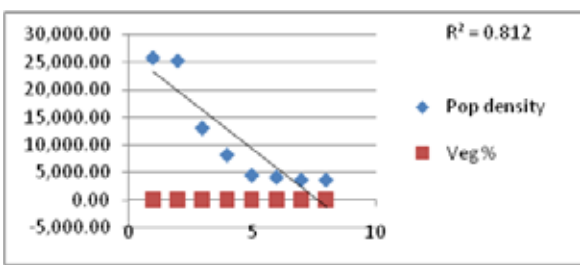
Single factor anova was employed to compare NDVI means of 8 zones of metro (TableII) showed statistically significant difference between zones.

Fig 3. Scatterplots of Vegetation % vs. Built Ups and Pop Density for Eight zones of Bangalore.

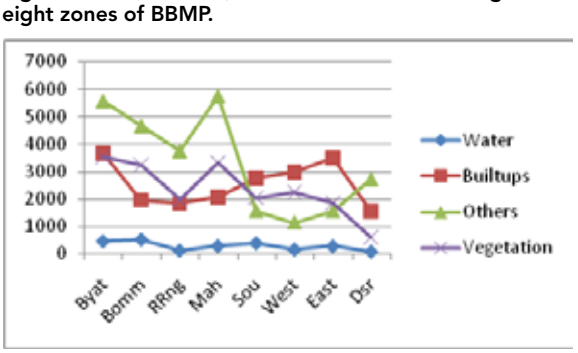




In scatter plots (Fig. 3) a significant linear relationship was observed on correlation between the percentage of vegetation, pop density and built ups of eight zones of BBMP. A negative correlation between vegetation percentage and built ups and a positive correlation between % built ups and population density was observed. This clearly shows that increasing urbanization has negative effect on vegetation of the area which is showing marked decrease, especially in the outskirts of the city.

In the NDVI image, Percentage Vegetation cover across different zones vary from 35 % in "Bommanahalli" followed by 30.2 % in "Mahadevapura". The lowest Vegetation Percentage (12 %) is found in Dasarahalli followed by East. The Vegetation cover is comparatively high in South zone and West zone because of presence of large green areas in the form of parks, avenue trees, trees in residential areas and a famous Lalbagh Botanical Garden in "South zone" and Golf Course and Indian Institute of Science campus in West zone comprising mainly old big trees. Large number of developmental works like ring roads, Road widening, and Construction of Sub-ways have taken heavy toll on vegetation in these areas (about 300 old big trees, which once used to line streets of Bangalore are cut for these projects-BBMP Report on Urban forestry).

Fig 4. Area (hectares) in different land use categories in eight zones of BBMP.



As seen from graph (Fig. 4) in terms of area, vegetation and Built up is parallel in RR Nagara and Byatarayanapura zone while in East zone the difference between vegetation and built up is very large where built up area shows twofold increase over vegetation. Among the zones Bommanahalli and Mahadevapura shows very high vegetation area. West, East and South zones in the central metro have large built up areas, vegetation and Open scrub is dominant in Bommanahalli, Byatarayanapura and Mahadevpura Zones. The Urbanisation process increased in 2000 to 2006 indicating higher entropy value, as the distribution of built up during 2000-2006 was more dispered than in 1973 or 1992 (Ramachandra and Uttam Kumar 2009).

The existing study comprising different zones facilitate the zonal disparity in vegetation picture of the Bangalore extensively, which can be adopted to evaluate vegetation cover assessment among zones. Vegetation cover can serve as an indicator of the extent to which trees and forests are accommodating critical services to the residents. The percentage vegetation cover shows increasing trend from inner boundary to outskirts of the city. In appreciation of the importance of urban forestry, the U.S. Conference of Mayors lately conducted an urban forestry survey of 135 U.S. cities with populations of 30,000 or more. Their final report (City Policy Associates 2008) recognizes "the invaluable role of urban forests in the protection of public health and the reduction of harmful greenhouse gases".

The substantiation of results, shows that vegetation cover is depicted in a succinct way in the NDVI imagery. Besides NDVI can be used as an ecological indicator to successfully monitor temporal and spatial variation in vegetation density as well as the health and viability of plant cover (Fung and Siu, 2000; Jiang et al., 2008; Wang, Price, and Rich, 2001; Weng, Lu, and Schubring, 2004). A comprehensive study on urban forests of Bangalore was made by Sudha and Ravindranath (2000) found 374 species in the different land-use categories. Similar study carried out by Nagendra and Gopal (2010) showed that density of street trees in Bangalore is lower than many other Asian cities, but the species diversity is high. There is a greater need to improve documentation and amalgamate available information on Urban Forestry of Bangalore as the literature is very meagre and limited. Present study depicts the importance of satellite imagery in pronouncement of the green open space, supporting urban vegetation cover inventories and in manifesting regular systems for inventory updates as well as vegetation monitoring in large metropolitan city like Bangalore where the inventory has to cover several hundred square kilometers.

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REFERENCE

Brown, J.F., Loveland T.R., Merchant J.W., Reed B.C., Ohlen D.O., (1993). "Using multisource data in global land-cover characterization: concepts, requirements, and methods." Photogrammetric Engineering and Remote Sensing, 59, 977–987. | Evans D.L., Zhu Z., Winterberger K., (1993). "Mapping forest distributions with AVHRR data. " World Resource Review 5, 66–71. | | Fung T., Siu, W., (2000). "Environmental quality and its changes, an analysis using NDVI." International Journal of Remote Sensing, 215, 1011–1024. | Jiang, X., Wan, L., Du, Q., Hu BX., (2008). "Estimation of NDVI images using geostatistical methods." Earth Science Frontiers, 15(4), 71–80. | Loveland T.R.., Merchant, J.W., Ohlen, D.O., and Brown, J.F., (1991). "Development of a land-cover characteristics database for the conterminous U.S." Photogrammetric Engineering and Remote Sensing, 57(11), 1453–1463. | Lyon, J.G . , Yuan, D., Lunetta, R.S., and Elvidge, C.D., (1998). "A change detection experiment using vegetation indices." American Society of Photogrammetry 6(2), 143-150. | Nagendra, H., Gopal, D., (2010). "Street trees in Bangalore: Density, diversity, composition and distribution." Urban Forestry and Urban Greening, doi:10.1016/j.ufug.2009.12.005 | Ramachandra, T.V. and Uttam Kumar (2009). " Geo informatics for urbanization and urban sprawl pattern analysis." In: Joshi P. K. (Eds). Geoinformatics for Natural Resource Management, Nova Science Publishers, Chap 19. | Ross, S.L. and Christopher, D.E.,(1999). "Remote sensing change detection" Environmental Monitoring Methods and Applications." Taylor and Francis Ltd., Gun Powder Square, London. | Sudha P., Ravindranath N.H., (2000). "A study of Bangalore urban forest." Land Scape and Urban Planning 47,47-63. | Townshend, J.R.G.; Justice, C.O., and Skole, D., (1994). "The 1 km resolution global data set: needs of the International Geosphere Biosphere Programme." International Journal of Remote Sensing 15, 3417–3441. | Walsh, S.J., Moody, A., Allen, T.R. and Brown, D.G., (1997). "Scale dependence of NDVI and its relationship to mountainous terrain. In D.A. Quattrochi and M.F. Goodchild(Eds.), Scaling in remote sensing and GIS." FL:Lewis Publishers, Boca Raton, pp.27-55. | Wang, J., Price, K.P., and Rich, P.M., (2001). "Spatial patterns of NDVI in response to precipitation and temperature in the central Great Plains." International Journal of Remote Sensing, 22(18), 3827–3844. | Weng, Q. Lu, D., and Schubring, J., (2004). "Estimation of land surface temperature–vegetation abundance relationship for urban heat island studies." Remote Sensing of Environment 89, 467–483. | Wilson J.S., Brothers T.S., Marcano E., (2000). " Remote sensing of spatial and temporal vegetation dynamics in Hispaniola: A comparison of Haiti and the Dominican Republic." Geocarto International 15(2), 5-17. |