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MULTISPECTRAL MONITORING OF VEGETATION COVER OF BANGALORE METROPOLITAN AREA

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ABSTRACT
Urban vegetation plays significant role in one's judgment for quality of place in a neighborhood, which is one of the important implication areas of urban image classification technique. In the present study Quick Bird and LISS III imageries of 2005 are used for comparative study of NDVI and TNDVI indices for estimating vegetation cover in Greater Bangalore also called Bruhat Bangalore Mahanagara Palike (BBMP) which is administratively divided into 8 zones. Both NDVI and TNDVI showed highly significant variation in their values between LISS III and Quick Bird imageries. The NDVI values range between -0.2 and 0.31797 in LISS III and –0.99595 and 0.92857 in Quick Bird. In case of TNDVI the variation is between 0 and 1.01145 for Quick Bird and 0 and 0.90442 for LISS III. A strong linear relationship was observed between NDVI and TNDVI of both imagery data set. The validation of results according to ground truth revealed that NDVI is much better tool for monitoring vegetation cover in urban environment in LISS III and Quick Bird data set. This study helps to demonstrate the difference between two imageries in depiction of the vegetation distribution across greater Bangalore. It also show the multipurpose utility of RS data for many application like land cover change, vegetation cover, planning and policy making, which are of particular importance in a large rapidly growing urban area with complex pattern of land use and many diverse environment.

KEY WORDS: Satellite Imagery, NDVI, TNDVI, BBMP, Classes

INTRODUCTION

Urbanization is an inevitable consequence of human social development occurring rapidly and is global in scope. One of the glaring problem that urbanization causes worldwide is the destruction of natural ecosystem and segregating people from nature. Urban vegetation is one of the major land use category which plays a significant role in one's judgment for urban Quality of Place (QOP) and is one of the important implication areas of urban image classification techniques. Satellite derived vegetation indices (VIs) are valuable tool to evaluate the role of vegetation in the exchange of radiation, momentum and heat during atmosphere-biosphere interactions (Kasturirangan, 1996). In the last decade, over forty vegetation indices are introduced in the remote sensing literature to measure the vegetation cover for different applications. Among the different VIs studied, TNDVI and NDVI seems to provide best results for vegetation analysis in urban environment. Tucker (1979) presented a transformed normalized difference vegetation index (TNDVI) by adding a constant 0.5 to NDVI and taking the square root, which always has positive values and the variances of the ratio are proportional to mean values. TNDVI indicates a slight better correlation between the amount of green biomass and that is found in a pixel (Senseman *et al.* 1996). Mohd, *et al*., (1992) evaluated LANDSAT-5 vegetation indices for detecting forest areas and crops and achieved better classification accuracies by using perpendicular vegetation index (PVI). Price, *et al*. (2002) investigated how to find optimal Landsat TM band combinations and vegetation indices for discrimination of six grassland types. In the present study, Quick Bird and LISS III imageries of 2004 are used for comparative study of NDVI and TNDVI indices for estimating vegetation cover in Bangalore metropolitan area.

MATERIALS AND METHODS

Study Area

The study area Bruhat Bangalore Mahanagara Palike (BBMP- Figure 1) 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. Administratively BBMP is divided into 8 Zones (Byatarayanapura, Mahadevapura, Bommanahalli, R.R nagar, Dasarahalli, West, South and East zone) supports 80 lakh population. The summer temperature ranges from 18° C – 38° C, while the winter temperature ranges from 12° C – 25° C.

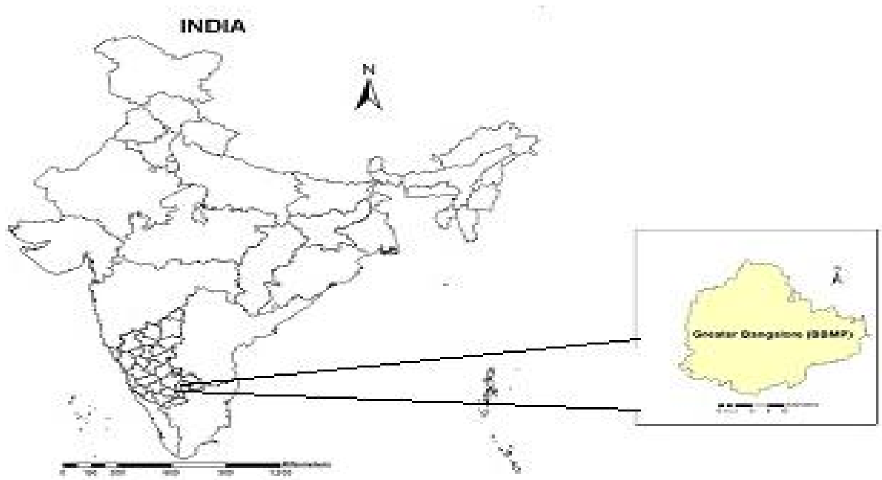


FIGURE 1. Study area_Greater Bangalore

Data products

The 2005 satellite imagery of Quick Bird and IRS LISS III and Pan merged data are used for the present study.

Geographical data: Topographical map: Scale: 1:50000; the co-ordinate system of the baseline data map is applied for geometric correction of 2 satellite images. Erdas 9.2 and ArcGis 9.2 were used for image processing and further analysis.

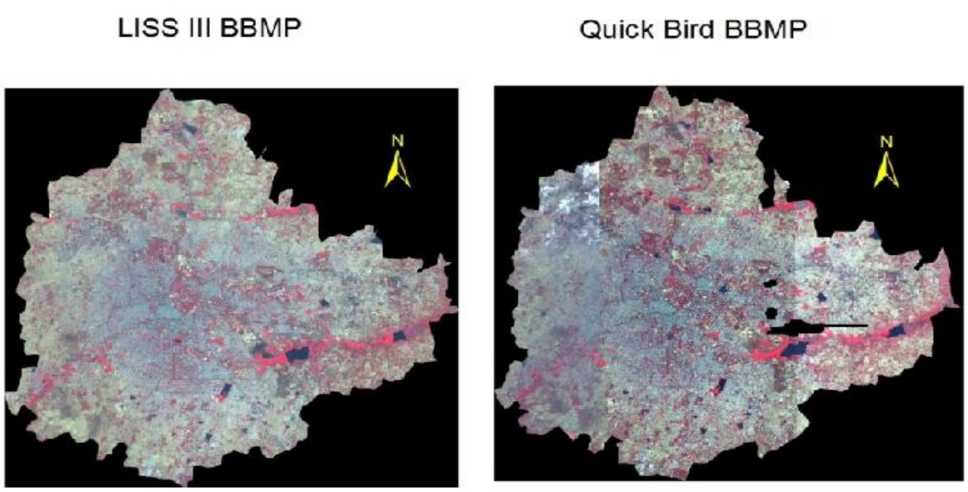
METHODS

A multi-spectral remote-sensing approach was utilized as the spatial basis for mapping the vegetation area in the BBMP. Methodology is based on the combination of techniques to extract information from remotely sensed data.

1. Geometric correction: Image preparation includes geometric rectification to the UTM (WGS 84 datum) coordinate system by 20 ground control points for each image. The geo corrected image is then used for further processing
2. The Normalized Difference Vegetation Index (NDVI) and Transformed Normal Difference vegetation index(TNDVI): is used to transform multi-spectral data into a single image band which represents vegetation distribution was computed for both Quickbird and LISS III imageries using standard algorithm
   NDVI = (NIR – R) / (NIR + R).
   TNDVI= Sqrt ((NIR-red/NIR+red) + 0.5).
3. NDVI- RGB false color composite of vegetation was developed to display and quantify vegetation change using IRS LISS III and Quick Bird.
4. One way anova was applied to find variation in NDVI and TNDVI values of two imagery.
5. Scatter plot was constructed to find the correlation between TNDVI and NDVI values of both LISS III and Quick Bird imageries.

RESULTS AND DISCUSSION

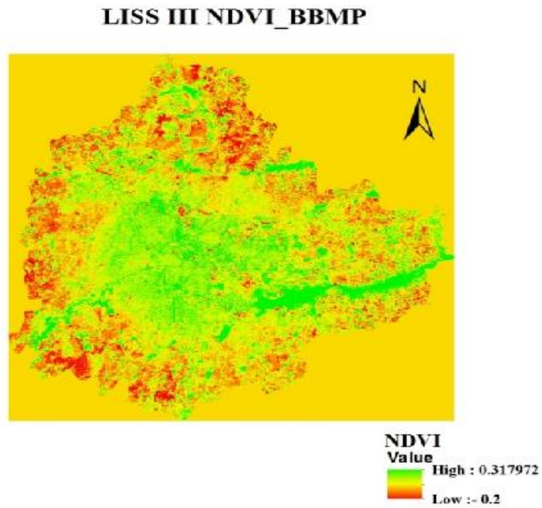
In the present study LISS III IRS and Quick Bird image of 2005 of Bangalore Metro is used for comparative study of NDVI and TNDVI. The FCC (False Color Composition) of the study area(Figure 2) is prepared using 4, 3, 2 bands of the Quick Bird and 1, 2, 3 bands of IRS LISS III.



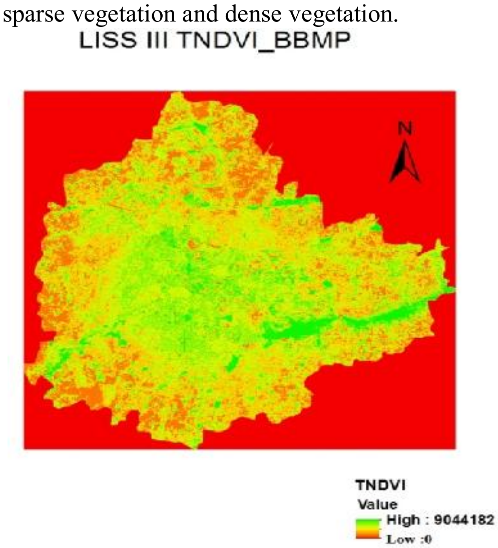
2a **2b**

FIGURE 2. FCC of Study area_BBMP

The Normalized Difference Vegetation Index (NDVI) and Transformed Normal Difference vegetation index(TNDVI) has proven to have an extremely wide range of applications in measuring urban vegetation cover. The efficiency of NDVI in detecting the changes was proven by many earlier researchers (Lyon *et al.* 1998; Ross and Christopher 1999). The NDVI/TNDVI transformed image is sliced into 5 classes for ease of analysis and is given pseudo color in varying shades of green (vegetation) and Red(water). The five classes were identified as water, very poor vegetation, poor vegetation, sparse vegetation and dense vegetation.



3a

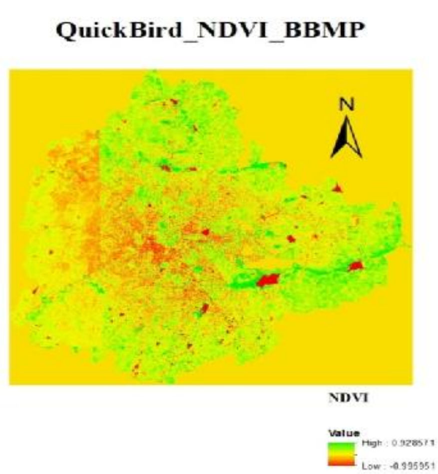


3b

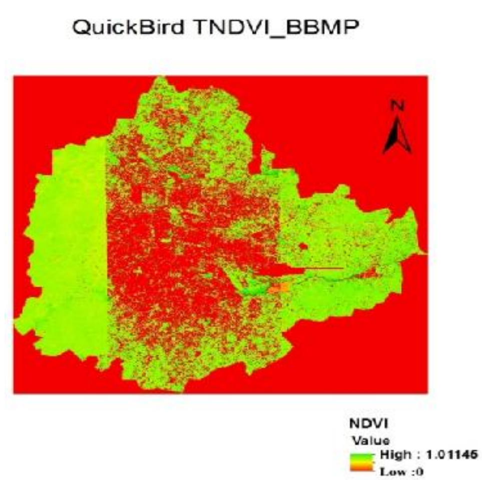
Fig. 3 (a & b). NDVI and TNDVI image of LISS III. Red colored pixels indicate a reduction in vegetative reflectance, while green colored pixels indicate an increase.

The five classes of the LISS III NDVI transformed study area image (Figure 3a) had values ranging from -0.2 (the minimum NDVI value in this dataset) to 0.31816 (the maximum NDVI value in this dataset). The majority of forest, plantations and grass areas which comes under class dense vegetation had NDVI values ranging between 0.19624 and 0.31561, Sparse vegetation showing mainly scrubs had values between 0.13321 to 0.19502, the values vary between 0.01071 to 0.13041 for poor vegetation class comprising mainly fallow lands and bare soil. Built up areas and impermeable surfaces which comes under very poor vegetation category had values less than 0.01009. Water areas have the lowest NDVI values as water is a good absorber of near-infrared radiation. This is not true in every case but serves the intended purpose here.

The LISS III TNDVI transformed image (Figure 3b) had values from 0.0035 to 0.8092. The forest, plantations and grass areas which comes under class dense vegetation had TNDVI values between 0.7321 and 0.8092. For Sparse vegetation values vary between 0.6182 and 0.7302, fallow lands and bare soil under poor vegetation class had values between 0.5021 to 0.6174. The values were less than 0.5011 for very poor vegetation category. The lowest TNDVI values is observed in Water areas.



4a



4b

Figure 4 (a & b). NDVI and TNDVI image of Quick Bird. Red colored pixels indicate a reduction in vegetative reflectance, while green colored pixels indicate an increase.

The NDVI transformed Quick Bird image (Figure 4a) had values ranging from -0.9959 to 0.9211. The forest, plantations and grass areas which comes under class dense vegetation had NDVI values between 0.3121 and 0.9211, Sparse vegetation comprising mainly scrubs showed values between 0.2143 and 0.3109, fallow lands and bare soil had values between 0.1091 to 0.2068. Built up areas and impermeable surfaces which comes under very poor vegetation category had values less than 0.1016. The values range between -0. 9959 and -0.2953 for Water bodies. The NDVI was strongly correlated with chlorophyll content and crop characteristics such as green biomass and leaf water content (Tucker 1979).

The values range between 0.0039 to 0.9995 for five classes of the Quickbird TNDVI transformed image (Figure 4b). The forest, plantations and grass areas had values between 0.8059 and 0.9995, Sparse vegetation comprising mainly scrubs showed values between 0.7082 to 0.8033, fallow lands and bare soil had values between 0.6441 to 0.7113. The lowest TNDVI values were observed for Built up areas and water bodies.

One way anova was applied to compare NDVI values (Table Ia) and TNDVI values (Table Ib) of Quick Bird and LISS III. Results shows that NDVI showed highly significant variation between two satellite imagery and significant level is very high at $p<0.05$.

TABLE IA. Anova depicting variation in NDVI values between LISS III and QuickBird at 95 % ($p<0.05$)

	DF	F-value	p-value(<0.05)
Variance in NDVI between Zones	1	7.453587	0.00655
Variance in NDVI Within zones	508		
Total	509		

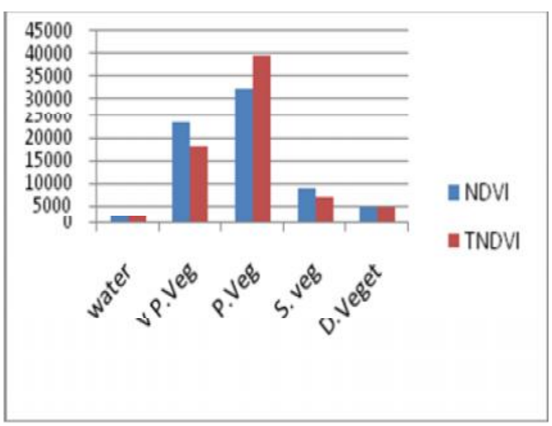
TABLE IB. Anova depicting variation in TNDVI values between LISS III and Quick Bird at 95 % ($p<0.05$)

	DF	F-value	p-value(<0.05)
Variance in TNDVI between Zones	1	4.72303	0.03022
Variance in TNDVI Within zones	510		
Total	511		

The significance level was much lower for TNDVI (Table 1b) in Quick Bird and LISS III than for NDVI in same image data at $p< 0.05$.

The areas for different classes of NDVI and TNDVI of Quick Bird(Figure 5a) and LISS III (Figure 5a) is depicted in Histogram.

5a



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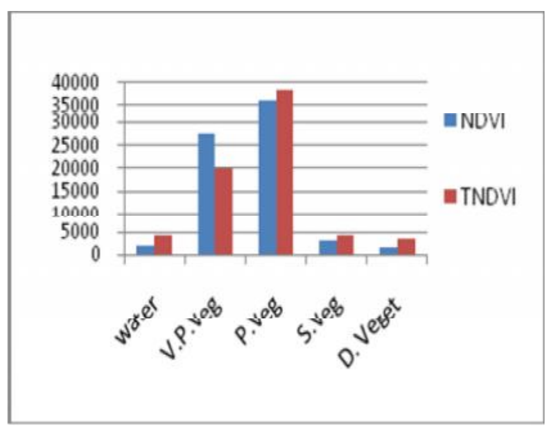
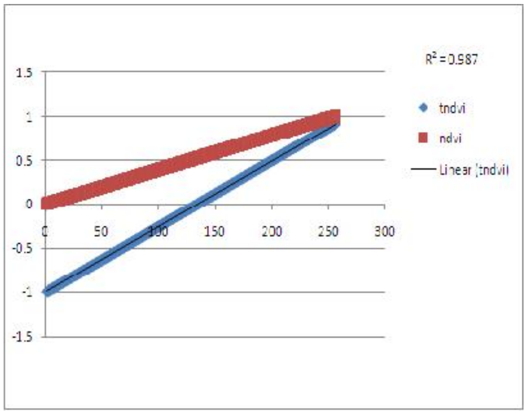
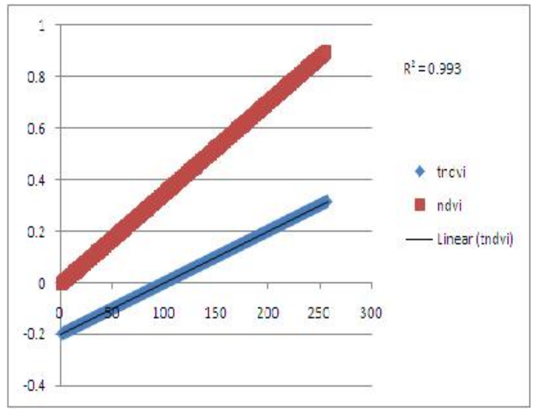


FIGURE 5(a & b) Graph depicting areas of different classes of NDVI and TNDVI in Quick Bird (5a) and LISS III imagery (5b)

Forest, plantation and grasses in the Vegetation category were much more elaborated in both TNDVI and NDVI. TNDVI imageries gives higher values for vegetation than NDVI which is visible in terms of increased values for dense vegtation. However some water bodies are more obscured and are depicted under dense vegetation category in TNDVI transformed imageries.Visual analysis of the scatter plots was used to determine the correlation between the TNDV and NDVI of Quick bird (Figure 6a) and LISS III (Figure 6b) imageries. Scatter plots of NDVI versus TNDVI are effective at illustrating the varying effects of NDVI and TNDVI. Both LISS III and Quick bird imageries showed highly significant linear relationship with r value 0.987 for Quick bird and 0.993 for LISS III



6a



6b

FIGURE 6 (a & b). Scatter plot for correlation between NDVI and TNDVI of Quick Bird (a) and LISS III(b) imagery

In both LISS III and Quick Bird imagery very poor vegetation class comprising built up is restricted to central part of metro. The forests and plantations under dense vegetation class is prominent in outskirts and dense vegetation can also be seen in few parks and Lal Bagh botanical garden in the city centre. Poor vegetation class comprising open fields and agriculture areas were more in outskirts of city. Water bodies are equitably distributed throughout metro area. The above observation is in conformity with the findings of Zhengwi *et al* 2008, where they appropriately used vegetation indices and image ratios to potentially improve crop classification accuracy. Water bodies are depicted more lucidly in NDVI imageries than in TNDVI imageries of both Quick Bird and LISS III.

The intense urbanization observed in Central, North and South East of the metro is mainly due to setting up of IT corridors and Peenya Industrial units. The southern part of the city is showing new residential and commercial layouts. The rapid increase in built up areas has detrimental effect on overall ecology of the city particularly vegetation which is showing 32% decrease from 1972 to 1992 and 38% from 1992 to 2002 and 63% from 2002 to 2006 (Ramachandra and Uttam Kumar 2009).

There are 2 state forest called Kalkerei State forest in southern tip with only top portion of forest is in metro area and another in north-western side which shows very thick vegetation cover and Turahalli Gudda minor forest on south – western part. There are two Reserve forest on north eastern side with intact boundaries. All the forest areas except state forest on north western side showed large scale depletion in vegetation cover which is clearly observed in NDVI and TNDVI transformed image of both LISS III and Quick Bird. Ozbakir and Bannari (2008) carried out a similar comparative study between TNDVI, NDVI and SAVI transformed imageries for IRS-1D image of Montreal, where TNDVI seems to perform better than other two indices. The validation of results in the present study according to ground truth revealed that NDVI is much better tool for monitoring vegetation cover in urban environment in both LISS III and Quickbird data set. Lillesand and Kiefer (2000) and Quackenbush *et al*., (1999) observed that NDVI helps in compensating for image variations caused by changing illumination conditions and surface slope and therefore could be used to mitigate the shadow effect of high-spatial resolution imagery and to improve the classification of vegetated areas. In TNDVI imagery, water areas are obscured and are depicted as vegetation areas. This study helps to demonstrate multipurpose utility of RS data for many application like land cover change and vegetation cover which are of particular importance in a large rapidly growing urban areas with complex pattern of land use and many diverse environment. Further it shows that the satellite imagery could play an important role in supporting urban vegetation cover inventories and in establishing automatic systems for inventory updates as well as vegetation monitoring. This role is especially important in metropolitan areas where the inventory has to cover thousands of square kilometers.

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