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URBAN GREEN COVER ASSESSMENT AND SITE ANALYSIS IN CHENNAI, TAMIL NADU - A REMOTE SENSING AND GIS APPROACH

Meera Gandhi. G, Nagaraj Thummala and Christy. A
Faculty of Computing, Centre for Remote Sensing and Geo informatics, Sathyabama University, Rajiv Gandhi Road, Jeppiaar Nagar, Chennai, India
E-Mail: professorgandhi29@gmail.com

ABSTRACT

Green space distribution plays a imperative role in urban planning since they contribute significantly in enhancing ecological quality of metropolitan areas. It improves air quality, urban health, conserving biodiversity, reducing noise, etc. Removal of vegetation cover can be identified as one of the poorest effects of urbanization. Proper distribution of green spaces in urban environments is consequently more inevitable for the sustainable development and healthy living. Hence, it is necessary to identify the green space requirement quantitatively and spatially. To achieve the goal, high resolution Cartosat-1 satellite data, were used to analyse the spatial pattern. Spatial features like Point feature and polygon features were demarcated from imagery. Individual trees, group of trees, bushes, building area (covering both residential/industrial area), water bodies (lakes, ponds, reservoir, streams, rivers etc.), parks and temples has been considered. The tree cover area covers 72.82Sqkm, Buildings covers 241Sqkm, Parks covers 9.28Sqkm, Water bodies covers 35.73 Sq.km and other area 104.40Sqkm out of 464sq.km area coverage of Chennai municipality. Subsequently, green spaces required to be created are calculated with respect to WHO standards of green spaces per capita for healthy living (9.5 m^2/ person) and a methodology is developed to spatially define appropriate areas to establish them.

Keywords: green pace, Chennai Corporation, tree area, crown area, remote sensing, GIS.

1. INTRODUCTION

Tree cover in urban areas around the world, is declining and inflexible cover is increasing due to the demand of the land for development Forest Survey of India (FSI) has been assessing country's forest cover since the 1980's using data from remote sensing satellites on a two-year cycle. Due to a substantial number of trees tree cover is not captured by the Satellite data and reported as tree cover for the first time in 2001 assessment. The planned development of Chennai city present a clean and green with trees, plants, lakes and parks and towns in Chennai. It is growing at fast pace in terms of urbanization, technology, infrastructure, and environment. The pace of urbanization is harmfully affecting the green cover in the urban areas. Trees provide numerous Environmental, Social and Economic benefits to people and their services in maintaining environment are been universally accepted. The tree canopies shows moderate temperature, provide shade to building, area of sidewalk, streets and reduce pollution. Urban areas Kuhelmeister, G., 1998 can comprises large variety of green spaces, such as Parks/ gardens green space near institution, Industrial area green spaces (Heinze, J., 2011), and private green spaces (Boone *et al*, 2010). It includes woodlands, farm lands, public gardens and play areas. Green spaces play a major role in urban areas through their environmental, aesthetic, social and economic contributions to residents' health and wellbeing (Cavanagh *et al*. 2009). (e.g. Faryadi and Taheri, 2009).

In order to design an appropriate urban green cover assessment I.P. Senanayake 2014, spatial features must be evaluated. An attempt is carried out in this study to map the status of green coverage land use and land cover of the Chennai city area using high resolution Cartosat-1 satellite data. In order to achieve the goal, high resolution Cartosat-1 satellite data, were used to analyse the spatial pattern of land cover change in the area and the future growth was modelled by applying CA-Markov model described in Shikhar deep 2014. Spatial features like Point feature and polygon features were demarcated from imagery. Individual trees, group of trees, bushes, building area (covering both residential/industrial area), water bodies (lakes, ponds, reservoir, streams, rivers etc. parks and temples has been considered detect the land consumption rate and the changes that have taken place particularly in their built-up area.

2. STUDY AREA AND DATASET

Chennai District is bounded by Northern Latitudes of 12° 59' 10" and 13° 08' 50" and eastern Longitudes of 80° 12' 10" and 80° 18' 20" according to Survey of India Topographical Maps Nos. 66 C / 4 and and 66 D 1 and 5. (*Santhiya et al 2010*). The North East monsoon during the months of October, November and December essentially contributes the rainfall for the district. The average annual rainfall of the district is in the range of 1285.6 to 1232.7mm. Location map of the Chennai Corporation Study Area is shown in Figure-1.

GIS datasets are common data sources used for geo processing and are useful for automated data processing and GIS analysis. Datasets are used as inputs, and new datasets are derived as results for various geo processing tools. Geo processing helps you to automate many tasks as a series of operations so they can be run as a

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single step. This helps to create a repeatable, well-documented data processing workflow. Users also work with Arc GIS datasets to perform spatial analysis. Visual interpretation plays a major role in delineating spatial features of the earth by a geospatial expert. It can be concluded that, green space planning could be an essential component of any urban development.

3. METHODOLOGY - URBAN GREEN COVER MAPPING

Tree cover means the area covered by crown of trees that is too small to be delineated by digital interpretation of remote sensing data at 1:50,000 scales used for forest cover assessment. India's National Forest Policy aims at maintaining 33 percent of country's geographical area under forest and tree cover. (http://www.fsi.nic.in/sfr2003/treecover.pdf). The present assessment of forest cover, carried out by digital processing of satellite data at 1:50,000 scales, includes forests and tree crops having 10 percent or more canopy density and with an area of more than 1.0 ha. The tree cover comprises of small patches of trees (< 1.0 ha) in plantations and woodlots, or scattered trees on farms, homesteads and urban areas, or trees along linear features, such as roads, canals, bunds, etc. has been estimated by mainly using field inventory methods.

Boundary of the grouped trees was demarcated spatially and its spatial extension has been calculated. From Ground truth information, the tree diameter is identified. Number of trees within the spatial extent can be attained by aggregating the trees diameter to total demarcated area. Tree Cover in the urban areas should be treated as important and essential constituent of urban infrastructure. Estimation of tree population and tree cover in urban area and publication of a report on the status of tree cover in Municipal Corporations and municipalities shall be of immense use for developing appropriate action plan to improve tree cover for all urban areas.

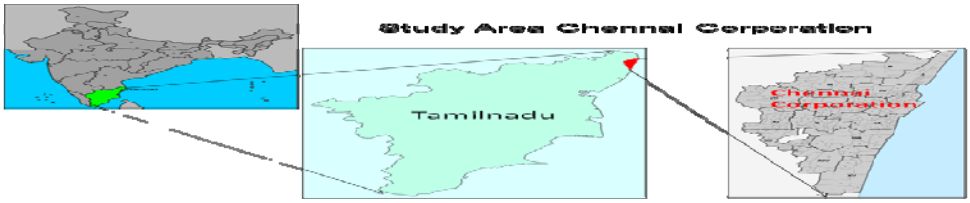

Figure-1. Location map of the Chennai corporation study area.

3.1 Crown area mapping

Crown area is the area covered by the living branches and foliage of trees. It is often expressed as a percentage of total land area. Crown area is estimated using Sky camera in the real field conditions. In our work, Cartosat 1 data helps to find the crown diameter of individual tree. It is well known fact the gaps of the trees will not counted as crown area, which is eliminated in the shape file. Average crown spread is one of the parameters commonly measured as part of various champion tree programs and documentation efforts. Other commonly used parameters, outlined in Tree measurement, include height, girth, and volume. Methodology of Tree height measurement, Tree girth measurement, and Tree volume measurement are presented in the links herein.

3.2 Water bodies and buildings coverage

Water bodies include tanks, ponds, lakes, rivers, streams and artificial storage structures that are spatially visible on the satellite images are identified. The size of the water bodies may increase in width and length depending on the seasonal inflow of water based on monsoon rains and may decrease in size during non monsoon seasons. Which are dynamic and temporal in nature. Whereas, Cartosat 1 data acquired during the non monsoon (with less per cent cloud cover) was adopted to extract the required information of spatial extent. It is a well known fact that all the major corporations in Tamil Nadu possess large number of concrete structure to accommodate all Government offices, residential complex and business centres. Such features are delineated based on reflectance properties of the satellite images that are represented by light tonal variation due to highest reflectance.

3.3 Delineating parks and temples

In Delineating spatial features such as parks and temples, every pattern should be in the form of rectangle or square. All these boundaries are delineated in shape file format. Features have a similar pattern are seen through Cartosat 1 Satellite imagery. Surface feature may be represented by the open spaces at the centre of parks and continuous plantation of trees at the boundaries as shown in the Figure-5 and Figure-6. Minimum concrete structure is available in the parks for recreation purpose.

4. RESULTS AND DISCUSSIONS

It is clear from the visual interpretation that urban and built up has increased significantly based on the assessment. The accuracy assessment will help in validating green coverage area. The estimation of total number of trees in Chennai Corporation is shown in Table-1. The interpreted results of percentage of urban green area assessment is shown in Table-2. Chennai municipality boundary covers total area of 465 Sq.km in which minimum area is occupied with temple area and maximum area occupied with buildings. Spatial features like Point feature and polygon features were distinguished

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from imagery. Individual trees, group of trees, bushes, building area (covering both residential/industrial area), water bodies (lakes, ponds, reservoir, streams, rivers etc. parks and temples has been considered. The tree area covers 72.82Sq.km, Buildings covers 241Sq.km, Parks covers 9.28Sq.km, Water bodies covers 35.73 Sq.km and other area outlined as 104.40Sq.km out of 464 sq.km area coverage of Chennai municipality Trees will be a distinct feature that is visible in Cartosat satellite images. In general, trees on the road side are mentioned as avenue trees. These trees are seen as individual trees on the image as shown in the Figure-3. In the case of large grouping of trees, trees were grouped based on their shape and distribution density categorised as either sparse or high dense. In dense region, a composite map is shown with dense grouping of trees.

4.1 Crown area calculation

Crown spread is taken independent of trunk position. Spread should be measured to the tips of the limbs, not to "notches" in the crown shape, and at approximately right angles from each other according to equation (1)

Average crown spread = (longest spread + longest cross-spread)/2 (1)

With the increased availability of high resolution air photos, crowns of individual trees can be distinguished providing another option for measuring crown spread. The latitude and longitude of the tree can be read directly from Google Earth. Google Earth itself includes a ruler tool that can be used to measure diameters or spokes across the crown of the tree. Alternatively the crown area can be measured and crown spread calculated from that value. Easy Acreage V1.0 (demo version) http://www.wildsoft.org / 2013 is a Google Earth area measurement tool that calculates the area of any shape outlined on the Google Earth display. Outline the edge of the trees canopy, following the branches and hollows around the canopy perimeter, including any enclosed hollows within the canopy outline and read the area provided by Easy Acreage. Average crown spread can be determined with a simple formula in equation (2).

$$\text{Crown spread} = 2(\text{area}/\pi)^{1/2} \quad (2)$$

Here area is taken as the area of an equivalent circle.

$$TA = \frac{T_{CRA} - T_{NT}}{\prod \times R^2} \quad (3)$$

Where TA = Total tree area, T_{CRA} = Total crown area
NT = Number of trees.

The total area of Chennai municipality comprises of 464.65 Sq.km. Chennai Metropolitan Development Authority map has been used for deriving boundary considered as Greater Chennai (including Tambaram and Avadi municipality. Layers were derived from Cartosat 1 imagery based on themes. Buildings are much congregated at the central part of Chennai and therefore buildings were digitized from imagery.

Figure-2. Natural colour composite (Cartosat image) of Chennai municipal corporation boundary.

During the path of the mapping techniques, area of buildings as view from space a minimum size of 2m*2m size can be mapped. Larger buildings could be spatially mapped in a convenient manner. From the analysis, a strategy of an eight percent cover from the obtained cover is employed to get the actual crown cover from the total area. Each tree area is calculated, assuming area is the area of an equivalent circle (circle area= $\prod r^2$). Approximately Circle Radius value was taken as 3m and each tree area is (3.14*3*3) calculated by total number of trees from total crown area divided by each tree area is shown in equation (3).

Table-1. Estimation of number of trees in Chennai corporation crown area.

Corporation	Total tree cover area Sq.km	Gaps between tree area Sq.km	Crown area Sq.km	Number of trees
Chennai	72.82	5.83	66.99	23,70,504

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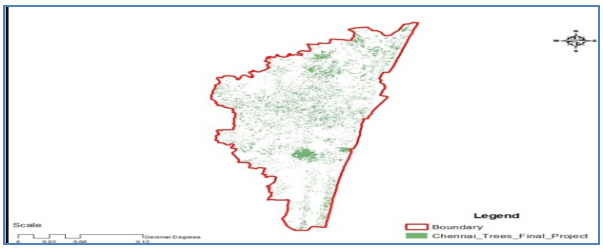

Figure-3. Tree cover area of Chennai municipality.

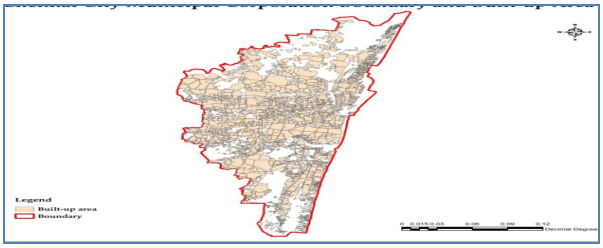

Figure-4. Built up area of Chennai municipality.

The map scale has been fixed to 1:10000 scales in order to obtain maximum features with precise accuracy. Mapping of individual buildings have been shown in the Figure-4.

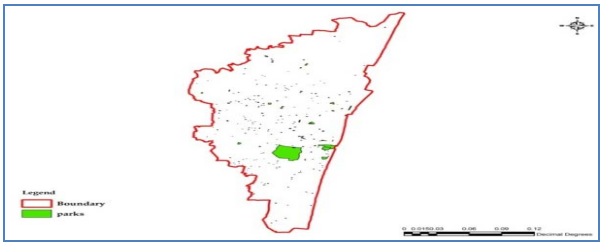

Figure-5. Parks area coverage of Chennai municipal.

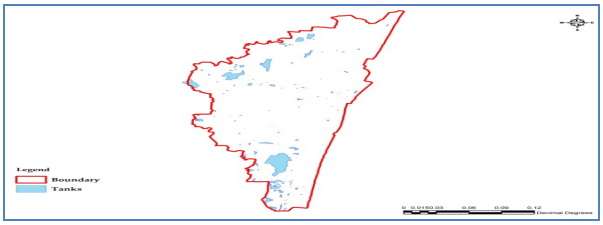

Figure-6. Tanks area coverage of Chennai municipal.

Table-2. Interpreted results of Chennai municipal corporation.

Chennai municipal corporation		
Name	**Area Sqkm**	**% of area coverage**
Buildings	241.5794	19.23%
Parks	9.2899	0.50%
Tanks	35.7288	0.13%
Temples	0.8449	5.49%
Trees	72.8157	0.06%
Others	104.394	0.04%

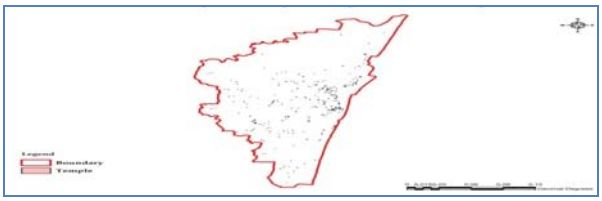

Figure-7. Temple area Chennai city municipality.

Every individual shape file of buildings was merged as a single polygon. Total area of the Chennai buildings (241.57 Sq.km) is calculated using Arc GIS software. Tanks possess uniform shape either as rectangle or square or circle as viewed through Satellite data. Chembarambakkam, puzhal, porur, Karanodai, are some of the larger lake that supplies drinking water to Chennai City. Boundary of tanks was digitized as area of the tank as shown in the Figure-6. Water level of the tank may not be considered as tank boundary, as water level of the tank varies according to the monsoon rainfall. Table-2 depicts the Chennai Municipal boundary percentage of urban area assessment in which buildings occupy the highest percentage of 19.23%. Park area of Chennai Municipal Corporation that accounted for 9.29 Sq.km Cartosat 1 Satellite image outlines the area of feature that is greater than 3m*3m with square or rectangular pattern as temple boundary. Temples are widely distributed within the Chennai Municipal Corporation. Old temples can be derived from satellite imagery which acquire larger boundary with more open spaces and small number of trees. New temples look smaller in size having less open spaces and greenery. Figure-7 depicts how every temple feature is derived from satellite imagery in shape file format in turn merged to a single layer.

CONCLUSIONS

A Green space assessment study has been carried out to measure the existing green spaces in Chennai City of Tamil Nadu quantitatively and to identify sites to create new green spaces in order to upraise the green spaces for the minimum required value recommended by WHO (i.e. 9.5 m2/ person). The methodology adopted in this study can be utilized effectively in other urban centres to

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calculate the required amount of green spaces and to identify the sites to create green spaces, in order to enhance the environmental quality of the city based on WHO standards.

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