CHAPTER 5
TREE COVER AND ENVIRONMENTAL PERFORMANCE OF
THE CHENNAI CITY

5.1 INTRODUCTION

The amount of the green-cover greatly affects the components of the city’s physical environment. It specifically influences the air quality, water quantity and quality and micro-climate; these three in turn affect the environmental performance of the cities. During the urbanization process, most of the natural features in the cities are getting modified; mainly the green-covers are replaced by impervious surfaces like buildings, pavements, and roads etc. The subsequent lose in the green-cover services affects the health of individuals (refer Chapter 2). In short, the amount of green-cover (in terms of green-cover services) will reveal the spatial scenario of the quality of life. Therefore, it has been suggested that monitoring the vegetation covered area is one way to check such threat in general. Understanding the spatial scenario of the green-cover services is imperative to identify appropriate green-cover improvement activity. This chapter is evolving methodology to comprehend the spatial scenario of the green-cover services, through appraising the environmental performance using the Chennai city as the case study area.

5.2 CHENNAI CITY PROFILE

The city of Chennai, popularly known as Madras, one among the four major metropolitan cities of India, located in the southern India lies
between 12° 09′, 80° 12 NE and 13° 09′, 80° 19′NE. It is having population of 6.04 million in an area of 170.47 Sq.km. It is growing at an average of 25% per decade. The population growth of the Chennai city is given in the Table A3.3- Appendix 3. The city is situated in a hot climate zone, experiencing tropical maritime monsoons. The minimum temperature ranges from 21° C to 24° C in the month of December to February and the average daily maximum temperature is 37° C during the month of May. The minimum monthly rainfall ranges from 6mm to 10mm in the month of February and maximum rainfall of 320mm has been recorded during the month of November. Chennai city does not have much of green space, except the Guindy National Park with an area of 270.57 hectares, which is under reserve forest category. This area has sparse vegetative cover. Due to population growth the per capita vegetative area of the city declined to 0.00007 hectare from 0.00021 hectare between the years 1951-1991 (office of the Chennai wildlife warden).

The Chennai city’s terrain is more or less a flat plain with scattered hillocks, gently sloping towards Bay of Bengal in the east. The city has two kinds of metamorphic rocks, namely, the rocks consisting mainly of gneiss and rocks consisting mostly of laterite in various stages of formation. The Chennai city’s soils type is broadly classified into red loamy soil (in the inland), sandy soil (along the coastal belt), clayey soil (along low lying areas) and lateritic soil (on some barren lands). The city is traversed by two streams, the Cooum and the Adyar. The two rivers are flowing west to east, among the Cooum river, divides the city into halves. Kortalayar is another stream defines the northern boundary of the metropolitan area. Buckingham canal once navigable passes right through the metropolitan area, parallel to the sea coast. The red hills lake
and Cholavaram lake are located in the north-west from which the city gets its water supply.

Chennai has two administrative boundary, the outer boundary is Chennai metropolitan boundary – encompass the suburban areas; the inner one is the corporation boundary, which include only the urban area. This research has taken the corporation boundary as the study area as shown in the Figure 5.1. For administrative purpose the corporation area is divided into 16 planning units, which further divided into 155 wards.

Figure 5.1 Administrative Boundaries of Chennai city.
(Source: CMDA)
5.3 ENVIRONMENTAL PERFORMANCE ASSESSMENT

Among various land-cover types, the green-cover provide many life supporting services (refer Chapter 2). The availability of these services is influenced by the modification in the green-cover. Therefore, based on the green-cover change, this chapter appraises the available green-cover services in the Chennai city. This is carried out for the following reasons. 1. To get the better insight of the spatial phenomena of the Chennai’s environmental quality. 2 To identify the spatial hot-spots that has poor environmental quality. 3. Above all, with relation to the topic of this research, it becomes more critical to identify the appropriate spatial strategies for the Chennai city’s green-cover improvement. The appraisal is done using the three services of the green-cover namely, amelioration of air quality, amelioration of hydrological process, and amelioration of micro-climate. Using the tree’s three services as parameters, a model has been developed to evaluate the environmental performance of the Chennai city. Entire processes can be divided into three major steps, they are

a. Acquiring the Chennai city’s land-cover information.
b. Assessing the Chennai city’s land-cover change.
c. Appraising the Chennai city’s Environmental performance.

Each of the above steps are elaborated below:

5.3.1 ACQUIRING CHENNAI CITY’S LAND-COVER INFORMATION USING REMOTE SENSING TOOLS

Chennai’s land-cover information for the year 1997 and 2001 is obtained from PAN plus LISS data of IRS 1C and IRS 1D respectively. The land-cover information is derived by means of digital image processing as shown in Figure 5.2.
Figure 5.2 Application of RS tools for Chennai’s land-cover derivation from the satellite images
The digital image processing is mainly based on the spectral band reflectance of objects on this earth. The processes of getting the land-cover information involve following steps:

a. Extracting the Chennai city’s image.

b. Correcting geometrical distortion of the Chennai city’s image.

c. Obtaining land-cover information of the Chennai city.

5.3.1 Extracting Chennai City’s image from RS data

Area within the metropolitan boundary of the Chennai city is taken as the area of study for this research. The process of extracting the study area from RS data involves two major steps, namely, geometric correction and subsetting the area of study.

5.3.1.2 Correcting geometrical distortion of the Chennai City’s RS image by means of RS tools

In general the satellite data has geometric distortion which is not suitable for obtaining the true information. Therefore, the geometrical distortion of IRS 1C and IRS 1D satellite data of Chennai city is corrected using ERDAS Image processing software. The image rectification is performed by means of registration with the plannimetric precision. The digitized Chennai city’s topographic map (source survey of India) is used as a reference map for the geometric rectification of IRS 1C and IRS 1D satellite data. The geometric correction is carried out in two steps. First, common identifiable and identical features are identified both in the IRS 1C, IRS 1D images as well as on the Chennai city’s topographic map. They are known as the Ground Control Point (GCP’s). Some of the selected GCPs are 1. Road junctions, 2. Intersections of road and railway track 3. Prominent building edges 4.
Bridges cutting across the river or streams etc. The coordinate of each GCP’s are obtained from the Chennai city’s topographic map. Then the coordinates of the GCPs are transferred to the corresponding GCPs of Chennai’s IRS images by means of the image registering using polynomial model. Then the geometric correction is done with the help of Geometric correction program of ERDAS Imagine software (Figure 5.3). Following that the study area is subsetted from the corrected image of the Chennai city.

### 5.3.1.3 Subsetting by means of RS tools

The geographical spatial limit of the study area (the metropolitan area of the Chennai city) falls within 13° 06’ latitude to 80° 21’ longitude. Through subsetting, the study area is clipped from the geometrically corrected IRS 1C and IRS 1D satellite data. The subsetting involves following steps, first, the spatially referenced vector grid that representing the size and shape of the metropolitan area of the Chennai city is created. And its topology is ensured using the ‘Clean Topology’ tool. Following that the AOI (AREA OF INTEREST) layer is developed in the ERDAS Imagine software from the vector layer. This newly created AOI layer is placed over the rectified IRS 1C and IRS 1D satellite data; subsequently the ‘Inquire Box’ is invoked from the ‘Utility Tool’. The inquire box is adjusted to fit to AOI. Then through clicking the ‘DATAPREP’ button, the subset of the image is clipped keeping the inquire box as reference.
Figure 5.3 Geometrical correction of the Chennai city’s image using RS tools
5.3.2 OBTAINING THE LAND-COVER INFORMATION OF THE CHENNAI CITY USING RS TOOLS

The land cover information of the Chennai city is derived by means of the supervised classification using Erdas Imagine 8.5 software. The land-cover classification is done in two steps - 1. Identifying the training sets. 2. Classifying the image.

5.3.2.1 Identifying the ‘Training sets’

The first and foremost step in the land-cover classification is selecting the sample pixels of different land-cover type, which is known as training set selection. Then, these training sets are used for generate the parametric signature to classify the satellite data into land-cover information. To identify the land-cover of the Chennai city, the training sets are selected in a supervised manner. That is, the training sets are identified based on the prior knowledge of the Chennai city’s land-cover and from the ground observation. The chosen training sets are added to the spectral signature editor of ERDAS. The training sets are selected by two methods, namely, the polygon method and the seed tool method. The polygon method is adopted to select the bigger feature, like water bodies; whereas the seed tool method is used to pick the dispersed smaller feature, like vacant lands. The training sets of the Chennai city are grouped into nine signature files. They are built and un-built lands, water bodies, forest areas, wetlands, road, beach etc. These training sets are created in the signature editor to classify the subset of IRS 1C and IRS 1D satellite images. Each one of the training site is verified with the ground truth before putting them as the representative key. Also trueness of each training set is evaluated by checking its brightness count.
histogram at each band. The training set that fails to meet the standards are replaced by reselection.

5.3.2.2 Image classification by means of RS tools.

In the last step the training sets are given as a representative key input for the supervised classification. Based on the training sites, the image analyst supervises the IRS 1C and IRS 1D satellite images pixel categorization process. The training-samples guide the classification algorithm to assign a specific value to each pixel and group them into unique classes. That is, each pixel in the images is compared numerically with each one of the training site and then labeled with the name of the category it looks most like. In this way, the IRS 1C and IRS 1D satellite data are classified into nine major categories of land covers (Figure 5.4). They are dense built-up areas, sparse built-up areas with vegetations, dense vegetations, inland water body, shrubs, ground covers, barren lands, marshy area and sandy area. Figure 5.5 and Figure 5.6 shows the land cover character of 1997 and 2001. However it is difficult to test every pixel of a classified image by ground truth, therefore certain features like ‘Roads’ are hided within the other classes (Congalton 1991)

5.3.2.3 Identifying Land-Cover Change Using GIS tools

Changes in the Chennai city’s land-cover between the year 1997 and 2001 is assessed with the help of the spatial analyst of ArcGIS 9.0. First, the land cover data of the Chennai city for the year 1997 and 2001 is reclassified into uniform pixel size that is at 5m X 5m. Next, the changes in the Chennai city’s land-cover are evaluated location-wise, by comparing the images with one another on a pixel-by-pixel basis.
Figure 5.4 Land Cover classification of Chennai city by means of RS tools
Figure 5.5 Chennai’s 1997 land-cover derived from IRS 1C using RS tools
Figure 5.6 Chennai’s 2001 land-cover derived from IRS 1D using RS tools
The location specific changes are mapped by means of subtracting the images from one another in the raster calculator. The subtraction is done at the micro-level, that is, at the cell level in order to capture the finer details. Subsequently, through summing up the cell values the quantifications are done at the macro level that is at the ward level (the smallest administrative unit).

5.3.3. APPRAISING THE CHENNAI CITY’S ENVIRONMENTAL PERFORMANCE USING GIS TOOLS.

The methodology to appraise the Chennai city’s environmental performance is shown in the Figure 5.7. The entire analysis is intended to carryout based on the Map Algebra concept (Tomlin1994), which enables the Geographical Analysis, at finer level at cell by cell basis. This type of analysis in GIS utilizes the raster data, generally known as raster analysis. It provides better results to analyze the phenomena that are spatially continuous rather than discrete in nature. Since the urban environmental issues are continuous in spatial manner, the raster analysis is selected for this study. Each cell represents a location and value of the cell gives the phenomena of that location. This feature enables us to do the location specific analysis more accurately. Three types of raster analysis are used for the environmental performance analysis. They are the local function, the focal function and the zonal function. The basic raster layers used in this analysis are land cover, pollution layers, soil, slope, population density, administrative layers and layers that derived from the above.
Figure 5.7 Assessment of environmental performance using GIS tools
The methodology consists of the following steps. Firstly, change in the available tree’s services between the study periods is assessed by comparing the three green-cover services of the year 1997 with 2001. Secondly, the Chennai city’s environmental performance is assessed based on the green-cover service change. Simultaneously, change in the per-capita green-covered area between the year 1997 – 2001, is computed according to the population density. Finally, it evaluates the correlation between the per-capita green-cover change and the environmental performance change. While performing the environmental performance analysis, following frame works are followed:

1. The cell size of all the input raster layers are fixed as 5m x 5m.
2. The analyses are carried out at micro level i.e. cell by cell basis in order to capture the finer details. That is green-covers three services, air quality amelioration, regulating the hydrological processes, and micro-climatic balance are computed at cell level.
3. Then the quantifications are done at the macro-level, that is at ward level (the smallest administrative unit), through summing up the cell values.
4. For comparative purpose, all these value changes at the macro level are converted into uniform relative scale.
5. The city’s environmental performance is calculated by finding the net change in the three green-cover services.
6. The per-capita green-cover change is calculated at the ward level, by dividing the ward level green-covered area by the population density.
7. Finally, the correlation between the per-capita green-cover change and the environmental performance has been evaluated using the correlation factors \( r \) (Gujarati 1988). That is, 

\[
5.1 \quad r = \frac{SS_{xy}}{\sqrt{SS_{xx}SS_{yy}}}
\]

Where, \( r \) is a measure of the strength of the linear relationship between two variables \( x \) (per capita green cover) and \( y \) (environmental performance). Value of \( r \) near or equal to 0 implies little or no linear relationship between \( x \) and \( y \). The closer the \( r \) value to 1 or to \(-1\), is stronger the linear relationship between \( x \) and \( y \).

**5.4 GIS MODEL FOR ENVIRONMENTAL PERFORMANCE ASSESSMENT**

The environmental performance assessment involves the complex analysis. In addition to identifying the change in the green-cover services, it has to be repeated for two years (1997 and 2001). Hence to simplify and manage the entire process, the model is built in the model builder of Arc GIS 9.0. In the model builder, the interactions among the green-cover and environmental components are modeled using the spatial analysis tools. This GIS model will enable us to run the analysis many times without much effort.

Typically, this model also contains several processes, which are chained together in such a way that output from one process becomes input at next level. Building and operating the environmental performance model in the model builder involves four steps 1. First, the model has been constructed based on the functional relationship that has been defined in the aforesaid methodology 2. Next, the initial input variable and the intermediate variables to assess the three green-cover services are individually identified. 3. Following that, the spatial analyst
tools such as reclassification, zonal functions and math functions are identified to build the relationship between the variables. Such as, change in the air quality amelioration of tree-cover, change in the hydrological processes due to land-cover change and change in the net all wave radiation from the urban land-covers 4. Finally, through linking all the intermediate processes, the environmental performance of the Chennai city is assessed. The outcomes of this appraisal are explained at the intermediate processes level as in the same sequence of methodology that is explained above. This has been elaborated below.

5.4.1 Appraising the Change in the tree-cover’s air quality amelioration service using GIS tools.

The functional relationship between the green-cover and the air quality amelioration (Figure 5.8) is derived from the literatures (refer Chapter 2). For analysis purpose this is reconstructed in the model builder as shown in the Figure 5.9. The major input variables are the land-cover, the air pollution data, the published meteorological data such as wind velocity, temperature etc (Table A3.4- Table A3.3-Appendice 3). SO2, NO2, SPM are the three pollutants taken for the analysis. They are major pollutants of the Chennai city, mainly caused by intensifying the urbanization coupled with increasing the industrial activities and vehicular traffics. The pollution level at various locations of the Chennai city is taken from the National Ambient Air Quality Monitoring Series (NAAQMS, the annual report of the Central Pollution Control Board (CPCB) India) from the year 1992 -2002.
Figure 5.8 Appraising the functional relationships between Land Cover and urban air quality using GIS tools.
Figure 5.9 GIS model to assess the air quality amelioration by tree-cover
The sample locations and mean pollution are given in the Table A3.1-
Table A3.3- Appendix 3. The point pollution data has been converted
to pollution concentration (C) surfaces (Figure 5.10, Figure 5.11 and
Figure 5.12) using ArcGIS Spatial Analyst.

Rough-length, displacement height, Monin-obuhkov stability length,
stability functions, von-karman constant, prandtl number, Schmidt
number, wind speed, mesophyll resistance, stomatal resistance, and
cuticular resistance are the other statistical inputs required for this
model. They are either collected from the secondary sources or
calculated using the formula that is already established (refer Chapter 2).
The sub-intermediate variables are aerodynamic resistance (Ra),
boundary layer resistance (Rb) and canopy resistance (Rc). All those
sub-intermediate variables are derived individually for each of the above
mentioned three pollutants SO2, NO2 and SPM. The pollutant flux of
SO2, NO2 and SPM for the two years 1997 and 2001 is calculated as
shown in the Figure 5.13 to Figure 5.18. Combining the above sub-
intermediate variables i.e. SO2, NO2 and SPM flux, average flux of the
pollution for the years 1997, 2001 is derived as shown in the Figure 5.19
and Figure 5.20. Finally, the amount of pollution removed by the green-
cover for a particular period is quantified by multiplying the green
covered area with the net average hourly pollutant flux of that period
across the city. The amount of pollutant removed for the year 1997 and
2001 is calculated separately at the micro-level and then summed up at
the ward level as shown in the Figure 5.21, Figure 5.22.
Figure 5.10 So2 Pollutant concentrations.

Figure 5.11 No2 Pollutant concentrations.

Figure 5.12 SPM Pollutant concentrations.
Figure 5.17 No$_2$ Pollutant Flux in 2001

Figure 5.18 No$_2$ Pollutant Flux in 1997

Figure 5.19 Average Pollutant Flux in 1997

Figure 5.20 Average Pollutant Flux in 2001
The net change between the two periods has been computed at the ward level through subtracting. The final result (Figure 5.23) shows that the pollution removal capacity by natural means has gone down considerably across the city. At some wards to the extent of 68% reduced along with changes in the built-up area (Figure 5.26, Figure 5.27).

5.4.2 Appraising change in tree-cover’s micro-climatic amelioration service using GIS tools

The energy exchange between the earth surface and atmosphere determines the micro-climate. This is greatly influenced by the land cover characteristic, mainly the amount of green-cover. The functional relationship between the green-cover and the surface energy flux is constructed (Figure 5.28) based on the ‘Net All Wave Parameterization’ (NARP) of Offerle et al 2003 (refer Chapter 2). This is reconstructed in the model-builder (Figure 5.29), to appraise the influence of the green-cover change in Chennai city’s micro-climate. The primary raster inputs are land-cover, land-use; the numerical inputs are incoming long-wave radiation,
Figure 5.23 Ward wise Pollution removal reductions by tree-cover change.
Figure 5.24 Albedo of Land-cover 1997

Figure 5.25 Albedo of Land-cover 2001

Figure 5.26 Built-up Area 1997

Figure 5.27 Built-up Area 2001
Figure 5.28 Appraising functional relationships between Land Cover and surface radiation using GIS tools
Figure 5.29 GIS model to assess the surface radiation
incoming shortwave radiation, Steffen’s constant. The sub-intermediate raster variables are albedo-cover, radiation absorbed by each land-cover, land-cover emissivity and longwave radiation from the surfaces. Each of these is obtained from the established previous research. The sub intermediate raster layer ‘albedo-cover’ is obtained for the two years 1997 and 2001, by reclassifying their land-cover as shown in the Figure 5.24 and Figure 5.25. The emissivity of each land-cover for different land-uses is obtained from Oke (1987) (Table A3.2- Appendix 3). By reclassifying the land-cover data of the year 1997 and 2001, the emissivity cover is derived. Then radiation absorption of each land-cover is calculated from the albedo cover for each of the study period. The out going long-wave radiation is obtained using the emissivity cover and radiation absorption cover. All the above assessments are carried out at cell level. Finally, ‘net radiation’ for the land-cover 1997 and 2001 is calculated at the micro-level as shown in the Figure 5.30 and Figure 5.31.

The analysis shows that between the years 1997-2001, the city lost a considerable amount of the green cover. The non vegetative land cover increased as much as 88 % in some of the wards (Figure 5.26, Figure 5.27). Consequently, the Chennai city experienced higher temperature than it’s surroundings. Within the Chennai city itself, the vegetated areas are experiencing 2° C to 4° C less temperature than the densely built up areas (Sundrsingh 1990). The change in the net all wave radiation between the study periods, are calculated by simply subtracting the net wave radiation of the year 1997 from the year 2001. That has been summed up at the ward level using the zonal functions.
Figure 5.30 Surface radiations 1997

Figure 5.31 Surface radiations 2001
Figure 5.32 Ward wise surface radiation increase between the years 1997-2001
The result of the comparison (Figure 5.32) shows that the net surface radiation is increased considerably throughout the city and at some wards up to 22% increased (refer Table A5.1)

5.4.3 Appraising the influence of the tree-cover change on the hydrological processes using GIS tools.

The association between the green-cover and urban hydrological processes is obtained (Figure 5.33) from TR 55 (Chapter 2). Based on this, a GIS sub-model is built in the model-builder to appraise the Chennai city’s hydrological process change associated with green-cover change (Figure 5.34). The soil-cover and land-cover is the initial input raster layers and the rainfall data is the initial statistical data. The curve number, runoff and the actual retention raster are the sub intermediate variables. The curve number for different land uses are obtained from the SCS, 1986. Accordingly the land-use is reclassified to obtain the curve number for the land-covers of 1997 and 2001 as shown in the Figure 5.35 and Figure 5.36. Then the ‘potential maximum retention after runoff begins’ (S-raster) are computed separately for the study year 1997 and 2001 using the curve numbers. Following this, using the S-raster, and 24-hr maximum rainfall intensity, Chennai city’s runoff for the year 1997 and 2001 is derived as shown in the Figure 5.37 and Figure 5.38. The green covers reduced rapidly across the city between the year 1997 to 2001 (Figure 5.39, Figure 5.40), at some ward’s almost 99 % of the green covers replaced by the non vegetative developments. As a result, the water holding capacity of the city’s surface gone down drastically (Figure5.41).
Figure 5.33 Appraising the functional relationships between Land Cover and urban hydrological process using GIS tools.
Figure 5.34 GIS model to assess the urban hydrological process
Figure 5.35 Curve numbers for Land cover 1997

Figure 5.36 Curve numbers for Land cover 2001

Figure 5.37 Runoff at Micro level in 1997

Figure 5.38 Runoff at Micro level in 2001
The reduced city’s surface water holding capacity combine with the augmented impermeable surface increased the peak flow (Figure 5.42), up to 89% from the year 1997 to 2001 at some of the wards. Increased surface runoff and reduced retention capacity of the land cover almost stopped the ground water recharging processes in the city. The ground water level came down up to 10m (Figure 5.44) from the year 1997 to 2001 (Source: CMWSSB).

The analysis shows that the green cover reduction and the increased impermeable surfaces lowered the ground water level to the extent of 33% at some part of the city between the year 1997-2001 (Figure 5.45). This eventually reduced the ground water quality, which has been proved by the study on the Total dissolved solids in the Chennai ground water Figure 5.43 published in the daily Indian National news paper the Hindu dated 28/02/2004 (The Hindu 2004)
Figure 5.41 Ward wise retention capacity reduction between the years 1997 - 2001
Figure 5.42 Ward wise increase in the peak flow between the years 1997-2001
Figure 5.43 Chennai city Ground water quality total dissolved solids (source: The Hindu 28/02/2004)

Figure 5.44 Water table level in 1997 and 2001
Figure 5.45 Ward wise water table level fall between the years 1997 - 2001
5.4.4 Appraising Chennai’s net environmental performance change using GIS tools

Combining the above results Chennai city’s environmental performance is evaluated. The environmental performance of a city is broadly defined as its capacity to support human health, through providing fresh air, water and livable climatic conditions, etc. For that a GIS model has been built in the model builder using the three services of the green-cover as shown in the Figure 5.46. Before calculating the environmental performance change, all the three results are converted into uniform scale. Then, the ward-wise net environmental performance change of the Chennai city are worked out through calculating the mean percent change of all the three critical environmental services, that is air quality amelioration (Figure 5.23), micro-climatic amelioration (Figure 5.32) and the amelioration of hydrological process (Figure 5.41, Figure 5.45). The result from this analysis in Figure 5.47 impeccably reveals the changes in the net environmental performance across the city and at some parts to the degree of 38\% reduced. The city’s current environmental problems like the scarcity of water, dried ground water table, flood during the monsoon and the increased local temperature prove this.

5.4.5 Evaluation

Even though each problem is triggered by numerous urban factors, the reduction of the green cover affects fundamentally the urban system’s self rejuvenating capacities in large extent. The degree of association between Chennai’s green cover change and its net environmental performance changes are evaluated using the coefficient of correlation (r) method described above using GIS tools.
Figure 5.46 GIS model in the model builder to assess the environmental performance of the city
Figure 5.47 Ward wise Net Environmental performance change between the years 1997 -2001
Figure 5.48 Percapita Vegetative Cover change between the years 1997-2001
Figure 5.49 Correlation between Per capita Green cover change and Environmental Performance change
The population of the Chennai city has been increased from 4.94 million to 6.04 million from the census year 1991 to 2001. Since city’s environmental quality is more influenced by its population density, per capita vegetative cover has been taken for the correlation assessment. The correlation between the two factors in each ward, that is, the per capita green cover (Figure 5.48) and the environmental performance change (Figure 5.47) is evaluated in the ArcGIS raster analysis. The outcome from this analysis (Figure 5.49) shows the positive relationship in most of the wards, that confirms the relationship between the per capita green cover and the environmental performance of the city. The correlation assessment has been carried out using the relative scale in order to prove the relationships, rather than quantifying the change.

5.5. CONCLUSION

This study shows the significant relationship between tree cover change and the environmental performance change of the Chennai city. Also it demonstrates that the green cover is one of the prominent indicators to monitor the ecological services as well the environmental performance of the city. Emphasis of this analysis is that the role of the urban green cover is just not an end in the improvement of the physical environment; rather answer to the human well beings in the city and its future sustainability. Therefore, the urban green cover can be the solution for most of the current urban environmental problems.