Peertechz

Journal of Civil Engineering and Environmental Sciences
civilengineering@peertechz.us
ENGINEERING GROUP

Journal of Civil Engineering and Environmental Sciences
OPEN ACCESS JOURNAL

ISSN: 2455-488X   DOI: https://dx.doi.org/10.17352/jcees

Research Article

# Landscape metrics to analyze the forest fragmentation of Chitteri Hills in Eastern Ghats, Tamil Nadu

**Narmada K[1]*, Dipjyoti Gogoi[2], Dhanusree[2] and Bhaskaran G[3]**

[1]Post-Doctoral Fellow (ICSSR), Resource Management (CWRM), University of Madras, Guindy, 600025, Chennai, India

[2]Research Scholars, Resource Management (CWRM), University of Madras, Guindy, 600025, Chennai, India

[3]Professor and Head i/c Centre for Water, Resource Management (CWRM), University of Madras, Guindy, 600025, Chennai, Indi

**Received:** 23 February, 2021
**Accepted:** 19 March, 2021
**Published:** 22 March, 2021

***Corresponding author:** Narmada K, Post-Doctoral Fellow (ICSSR), Resource Management (CWRM), University of Madras, Guindy, 600025, Chennai, India, E-mail: narmadakm@yahoo.com

https://www.peertechzpublications.com

Check for updates

## Abstract

Chitteri Hills of Eastern Ghats is primarily covered by evergreen forests and deciduous forests. Forest Management, change in landuse and rapid economic development has caused a minor change in the landscape of Chitteri. In the current study the forest fragmentation was assessed using the Fragstat 4.0 software for different classes using specific metrics. Fragstats 4.0 spatial pattern analysis was applied for different landuse classes that was derived from landuse and landcover maps prepared using the Landsat 8 digital data. The results from the above analysis have shown that there was more fragmentation in the Chitteri Hills. Class Area (CA), Percentage of Landscape (PLAND), Largest Patch Index (LPI), Number of Patches (NP), Patch Density (PD), Area Weighted Mean Shape Index (AWMSI) at the class level was quantified in the present study. These spatial metrics were found to be very simple and helpful in quantification of the complex spatial processes and can be used as an effective means for monitoring the Chitteri Landscape.

## Introduction

Loss of biodiversity has resulted in habitat loss and fragmentation. Human interference on the environment have altered natural ecosystem due to increase in human settlements and fragmented agricultural land [1,2]. Many natural reserves are enclosed by altered environment and later get functional as a separate natural ecosystem. Fragmentation is a changing phenomenon which leads to change in the habitat in the landscape over a period of time. The term “Fragmentation” has been defined as simultaneous reduction of forest area, increase in forest edge and subdivision of large forest areas into smaller non-contagious fragments [3]. The consequences of fragmentation include habitat loss for some plant and animal species, habitat creation for others, decreased connectivity of the remaining vegetation, decreased patch size, increased distance between patches, and an increase in edge at the expense of interior habitat [4]. The degree of fragmentation has been described as a function of the varying size, shape, spatial distribution, and density of patches [5]. Scientists have been using metrics for assessing fragmentation and its impact [4,6]. The ecological consequences of forest fragmentation may depend on the spatial configuration of the fragments within the landscape and how the configuration changes both temporally and spatially. Three spatial attributes of fragmentation may be particularly important: core area, shape, and isolation of forest fragments [7]. While field ecologists routinely measure the abundance of species or the structure of biological communities at point locations within fragmented landscapes and then relate these measures to metrics of habitat fragmentation, such studies typically focus on biological responses to one or a few attributes of the fragments



**Citation:** Narmada K, Gogoi D, Dhanusree, Bhaskaran G (2021) Landscape metrics to analyze the forest fragmentation of Chitteri Hills in Eastern Ghats, Tamil Nadu. J Civil Eng Environ Sci 7(1): 001-007.DOI: https://dx.doi.org/10.17352/2455-488X.000038

or landscape such as area, edge-effect, shape, isolation, landscape forest cover, or matrix quality [7]. The term "spatial metrics" can be defined as measurements derived from the digital analysis of thematic-categorical maps exhibiting spatial heterogeneity at a specific scale and resolution [8]. Fragstat landscape metrics are algorithmic program that quantify specific spatial characteristics of patches, classes of patches, or entire landscape mosaics. Fragstat metrics has been developed to quantify landscape structure and spatial heterogeneity based on landscape composition and configuration. As the present study is specifically aimed to understand and compare the magnitude of forest fragmentation in Chitteri landscape due to the influence of forest management and changes in land use, Fragstat has been used in this Figure 1.

### Study area

Chitteri Hills in Eastern Ghats is located in Pappireddipatti taluk, Dharmapuri District, Tamil Nadu. It is situated towards North East of Salem district within the geographical limit of 78°51'10" - 78°32'40" E, longitude and 11°55'14" – 12 °4'48" N latitude and covers an area of about 654 km$^2$. The hills form a compact block consisting of several hill ranges and contain tangled ridges and ravines running in the North East and South West directions, enclosing many narrow valleys, rivers viz., Kallar, Varattar, Kambalai and Anaimaduvu (Harur Forest office Report, 2007). In the western region, Thottilmadu rivulet join with Varattar rivulet and reach Varattar dam or Vallimadurai dam located in the foot hills of Chitteri near Vallimadurai village. Kalmaduvu rivulet flows towards southern region and reach Puluthikuttai dam of Salem district. The Kottar rivulet flows towards Eastern region and joins with Kottapatti rivulet and reach Sattanur dam of Tiruvannamalai district.

## Materials and methods

### Data acquisition

Satellite images are used as a source for the study. Images of three different years were acquired for the study from USGS Earth Explorer. The study has been carried for a period of 20 years. Hence the images were acquired for 2000, 2008 and 2019. The images downloaded were as follows Table 1.

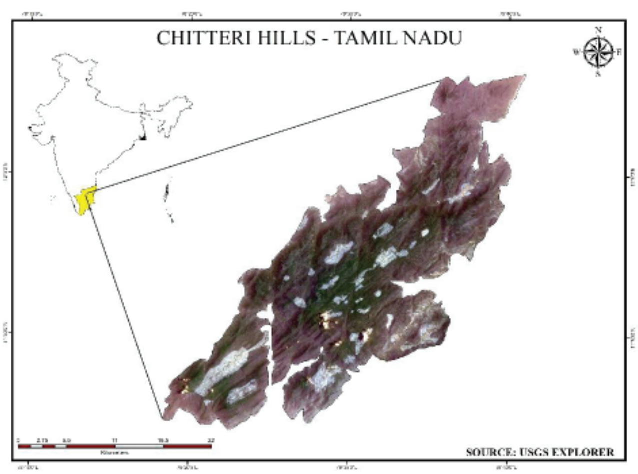


**Figure 1:** Study area, Chitteri Hills.

**Table 1:** Data acquired.

| S.No | Sensor Details | Date/ Month/ Year | Resolution |
|---|---|---|---|
| 1 | Landsat TM | 10th April 2000 | 30m |
| 2. | Landsat TM | 08th April 2008 | 30m |
| 3. | Landsat TM | 07th April 2019 | 30m |

### Image pre-processing

The satellite data from the sensors will have geometric errors and radiometric errors. The primary importance in image enhancement is Histogram. It reflects the characteristic of image which can then be studied and modified by changing the histogram. Histogram Equalisation is a non-linear stretch that redistributes the pixel values so that there is approximately the same number of pixels with each value within a range. The results approximate a flat histogram. Hence Histogram Equalisation is done in order to modify the intensity distribution of the histogram [9].

### Image classification

Image Classification is the process of labelling a pixel or a group of pixels based on its grey value. The images acquired are classified into various classes depending on their spectral signatures. The study area that was delineated from the 3-satellite image for 3 different years was classified using unsupervised classification method using ERDAS Imagine Ver. 2014. A modified version of Anderson scheme of land use [10], was utilized in this study. Unsupervised classification was carried to classify the image. In this classification method the spectral classes are defined according to some statistically determined data. The image was classified into four major categories in the current study. 1. Evergreen forests 2. Deciduous Forests 3. Degraded forests 4. Scrub land and 5. Others (settlements, water body, barren land and Agriculture). As the focus was mainly on the forest fragmentation, effort was taken more to classify the forest region and not in classifying the other categories. Image classification was done for 3 different years. The classification was done to understand the change of the different land use pattern over the years.

### Accuracy assessment

The accuracy assessment of spatial data has been defined by the United States Geological Survey USGS, 1990 as: "Accuracy assessment or validation is an important step in the processing of remote sensing data. It determines the information value of the resulting data to a user." The accuracy of any map may be tested by comparing the positions of points whose locations or with corresponding positions ground data that was captured at 100 ground points. The result of the assessment is derived as follows. The classification accuracy was found to be satisfactory. The Kappa statistics of around 0.9 was derived from all the classified images as shown in the Table 2.

### Temporal change detection of Chitteri Hills

Change detection is the method or way to analyse the differences in the condition of a feature in different time periods [10]. The change detection analysis comprises of a



**Citation:** Narmada K, Gogoi D, Dhanusree, Bhaskaran G (2021) Landscape metrics to analyze the forest fragmentation of Chitteri Hills in Eastern Ghats, Tamil Nadu. J Civil Eng Environ Sci 7(1): 001-007.DOI: https://dx.doi.org/10.17352/2455-488X.000038

**Table 2:** Error Matrix 2000, 2008 & 2019.

| Class Name | 2000 | | 2008 | | 2019 | |
|---|---|---|---|---|---|---|
| | Producers Accuracy | User Accuracy | Producers Accuracy | User Accuracy | Producers Accuracy | User Accuracy |
| Evergreen Forests | 93.33% | 93.33% | 75% | 85.5% | 98% | 88% |
| Deciduous Forests | 95% | 95% | 78% | 79% | 82% | 86% |
| Degraded Forests | 96.83% | 95.31% | 91.25% | 94.2% | 93.8% | 96.5% |
| Scrub Land | 91.5% | 92.5% | 88.52% | 81.4% | 86.25% | 88.12% |
| Others | 98.4% | 95.6% | 91.25% | 87.25% | 84.35% | 85.63% |
| Overall Classification Accuracy | 97.25% | | 85.5% | | 90.25% | |
| Kappa Statistics | 0.9562 | | 0.812 | | 0.805 | |

wide range of methods used in order to identify, describe and quantify differences between images of some scene at different times or different conditions. The changes between land use and land cover of the study area were studied and this change is quantified. The land use maps of study area were prepared for the year 2000, 2008 and 2019.

The five land use classes identified in the 3 images were looked up for changes for the past 20 years. The change detection was done for 2000-2008, 2008-2019 and finally 2019 - 2000 (Figure).

## Analysis of habitat fragmentation of Chitteri Hills using Fragstat spatial metrics

Different types of landscapes have an impact on different types of biological processes which involves biotic and abiotic environment. Hence, when that natural link is disturbed, it has an impact on multiple ecological processes and there is a break in the link. This process is called Fragmentation. The major reason for this fragmentation is human interference. This may further lead to disruption and degradation of ecosystem. The whole process of the disruption process can be summarized as perforation, dissection, dissipation and shrinkage. Landscape metrics is used here to understand the level of disruption. Hence the study of spatial metrics to study the extent of landscape fragmentation has become an important area of research. The availability of satellite data at different resolutions the study of fragmentation metrics has become important and comparison between images has become significant.

## Selection and calculation of spatial metrics

The landscape metrics is often called as spatial metrics is used for other environments like urban areas. The term "spatial metrics" can be defined as measurements derived from the digital analysis of thematic-categorical maps exhibiting spatial heterogeneity at a specific scale and resolution [11]. Landscape metrics are algorithmic program that quantify specific spatial characteristics of patches, classes of patches, or entire landscape mosaics. Many landscape metrics have been developed to quantify landscape structure and spatial heterogeneity based on landscape composition and configuration.

Seven class-level parameters quantifying the urban footprint at each time are calculated using Fragstat tool:

1. CA: absolute forest area

2. PLAND: Percentage of Landscape

3. NP: number of patches

4. PD: Patch density

5. LPI: Largest patch Index

6. AWMSI: Area-Weighted Mean Shape Index

## Class Area (CA)

CA is a simple metrics used to describe the pattern of urban growth in spatial metrics computation which also known as total area implying the total area covered by a land cover class in hectares [12]. This indicates how much of the landscape is comprised of a particular patch type. In addition to its direct It indicates the sum of the areas ($m^2$) of all the patches of the corresponding patch type, divided by 10000(to convert to hectares), i.e., total class area

$CA = \sum aij$ [ 1 1000] $n$ $J$=1 (1) 3.2

## Percentage of Landscape (PLAND)

PLAND quantifies the proportional ratio of each patch type in the landscape. It equals the sum of the area ($m^2$) of all patches of the corresponding patch type, divided by the total landscape area ($m^2$), and multiplied by 100 (to convert to percentage) [8].

PLAND= Pi= $\sum$ $aij$ $n$ $J$=1 $A$ (100) (2)

## The Number of Patches (NP)

It is the measure of discontinuous urban areas or individual units in the landscape (Gezahegn Awake Abebe, 2013). Due to the rapid core development, the number of patches is expected to increase due to the emergence of new fragmented patches around the cores. Number of patches indicates the diversity or richness of the landscape. In other word it gives a simple measure of the extent of subdivision or fragmentation of the patch type [8].

$NP = ni$ (3)

Where $ni$= number of patches in the landscape of patch type NP≥, without limit NP=1 when the landscape contains only one patch of the corresponding patch type;

## Patch Density (PD)

It is one more measure of landscape fragmentation of the patches of a land cover class which specifies the density of the fragmented urban units within a quantified area. Values of this indicator are affected by the size of the pixel and also the



**Citation:** Narmada K, Gogoi D, Dhanusree, Bhaskaran G (2021) Landscape metrics to analyze the forest fragmentation of Chitteri Hills in Eastern Ghats, Tamil Nadu. J Civil Eng Environ Sci 7(1): 001-007.DOI: https://dx.doi.org/10.17352/2455-488X.000038

minimum mapping unit since this is the significant factor for describing individual patches. This usually expresses number of patches on a per unit area basis that facilitates comparisons among landscapes of the varying size [8].

$D = ni\ A$ (10,000) (100)

### Largest Patch Index (LPI)

LPI equals the area (m²) of the largest patches of the corresponding patch type divided by the total landscape area (m²), multiplied by 100 (to convert to a percentage); i.e., LPI equals the percentage of the landscape comprised by the largest patch [8].

$LPI = maxn\ j{=}1\ aij\ A$ (100)

### AWMSI (Area – Weighted Mean Shape Index (AWMSI)

The AWMSI is equivalent to the sum, across all patches of the corresponding patch type, of each patch perimeter (m) divided by the square root of patch area (m²), adjusted by a constant to adjust for a circular standard (vector) multiplied by the patch area (m²) divided by the total class area (sum of patch area for each patch of the corresponding patch type). The AWMSI, in other words, is the average shape index of the corresponding patch type, weighted by size so that larger patches weigh more than smaller ones [8].

## Results and discussion

The images were classified and the area occupied by each class was computed. The evergreen forest was found to occupy an area of about 27296.6 hectares in the year 2000, 20994.3 hectares in the year 2008 and 17954.3 in the year 2019. The deciduous forests have also decreased in area from 20978.4 hectares in the year 2000 to 20037.9 in the year 2008 and 13411.5 hectares in the year 2019. The area of the degraded forests has also increased from 2947.41 in the year 2000 to 3513.78 hectares in the year 2008 and 6654.3 hectares in the year 2019. Others category which has settlements in it and water bodies has increased from 6187.14 hectares in the year 2000 to 8554.8 hectares in the year 2008 and 11563.5 hectares in the year 2019 Tables 3-6, Figures 2,3.

Change matrix was computed using ERDAS Imagine 14.0 user raster calculations of Matrix Union. The temporal change in the land use classes were identified. In the change matrix of 2000-2008 (Table 4), around 121.44 hec of evergreen forest has been converted to deciduous forest, 1134.95 hec of evergreen forest has been converted to degraded forests, 262.26 hec of evergreen forests was converted to scrub lands and finally 2629.35 hec of evergreen forests was converted to others category which includes settlements and water bodies. Around 607.41 hectares of deciduous forests was converted to degraded forests and 667.26 hec of deciduous forests was converted to scrub land and 4090.68 hec was converted to others category. Around 1303.29 hec of degraded land was converted to scrub land and 2289.82 hec of degraded land was converted to others category.

In the change matrix of the landuse and landcover classes of the year 2008-2019 (Table 5), 1953.18 hectares of the evergreen forests was converted to degraded forests, 295.38

**Table 3:** Land use and Landcover 2000, 2008 & 2019 (Area in hectares).

| LULC Classes | 2000 | 2008 | 2019 |
|---|---|---|---|
| Evergreen | 27296.6 | 20994.3 | 17954.3 |
| Deciduous | 20978.4 | 20037.9 | 13411.5 |
| Degraded | 2947.41 | 3513.78 | 6654.3 |
| Scrub | 7996.31 | 12303.8 | 15971.5 |
| Others (settlements, waterbodies. Barren land & agriculture) | 6187.14 | 8554.8 | 11563.5 |

**Table 4:** Change Matrix 2000 – 2008.

| Year | 2008 (Hectares) | | | | | |
|---|---|---|---|---|---|---|
| | Classes | Evergreen | Deciduous | Degraded | Scrub | Others (settlements, waterbodies. Barren land & agriculture) |
| 2000 | Evergreen | - | 121.44 | 1134.95 | 262.26 | 2629.35 |
| | Deciduous | 14.67 | - | 607.41 | 667.26 | 4090.68 |
| | Degraded | 0.45 | 147.92 | - | 1303.29 | 2289.82 |
| | Scrub | 5.04 | 264.55 | 3510.74 | - | 589.32 |
| | Others (settlements, waterbodies. Barren land & agriculture) | 0.18 | 129.06 | 464.67 | 279.09 | - |

**Table 5:** Change Matrix 2008 – 2019.

| Year | 2019 (Hectares) | | | | | |
|---|---|---|---|---|---|---|
| | Classes | Evergreen | Deciduous | Degraded | Scrub | Others (settlements, waterbodies. Barren land & agriculture) |
| 2008 | Evergreen | - | 125.1 | 1953.18 | 295.38 | 661.81 |
| | Deciduous | 15.3 | - | 1362.06 | 4596.57 | 1269.63 |
| | Degraded | 0.55 | 165.29 | - | 872.1 | 1096.42 |
| | Scrub | 11.2 | 69.56 | 806.76 | - | 1131.66 |
| | Others (settlements, waterbodies. Barren land & agriculture) | 0.81 | 102.66 | 76.32 | 297.63 | - |

**Table 6:** Change Matrix 2000 – 2019.

| Year | 2008 (Hectares) | | | | | |
|---|---|---|---|---|---|---|
| | Classes | Evergreen | cvDeciduous | Degraded | Scrub | Others (settlements, waterbodies. Barren land & agriculture) |
| 2000 | Evergreen | - | 134.95 | 121.44 | 2629.35 | 3262.26 |
| | Deciduous | 14.67 | - | 607.41 | 4090.68 | 5267.26 |
| | Degraded | 0.45 | 147.92 | - | 1303.29 | 1289.82 |
| | Scrub | 5.04 | 264.55 | 1510.74 | - | 1689.32 |
| | Others (settlements, waterbodies. Barren land & agriculture) | 0.18 | 129.06 | 464.67 | 279.09 | - |



**Citation:** Narmada K, Gogoi D, Dhanusree, Bhaskaran G (2021) Landscape metrics to analyze the forest fragmentation of Chitteri Hills in Eastern Ghats, Tamil Nadu. J Civil Eng Environ Sci 7(1): 001-007.DOI: https://dx.doi.org/10.17352/2455-488X.000038

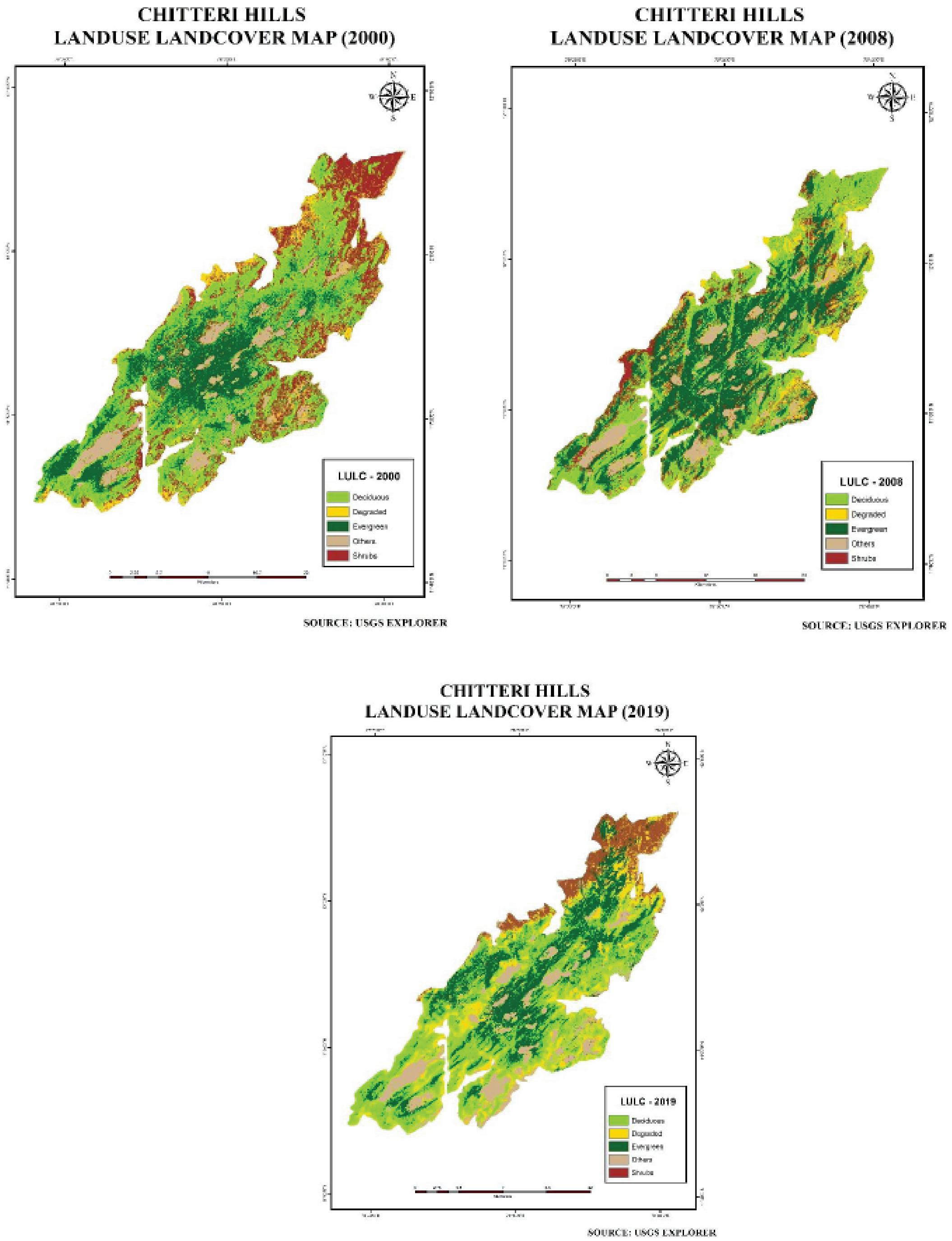


**Figure 2:** Landuse and Lancover Maps (2000, 2008 & 2019).

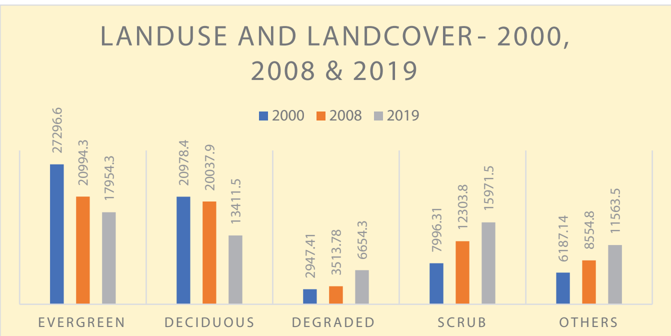


**Figure 3:** Landuse and Landcover – 2000, 2008 & 2019.

hec of evergreen forests was converted to scrub land and 661.81 hectares of evergreen forests was converted to others category. 1362.06 hec of deciduous forests was changed to degraded land, 4596.57 hec was converted to scrub land and 1269.63 hec was converted to others category. 872.1 hec of degraded land was converted to scrub land and 1096.42 hec of land was converted to others category. Around 806.76 hec of land was converted to degraded land and 1131.66 hec of scrub land was converted to others category.

Change matrix was finally computed for the year 2000 to 2019 (Table 6). From the analysis it was found out that 2696.35



**Citation:** Narmada K, Gogoi D, Dhanusree, Bhaskaran G (2021) Landscape metrics to analyze the forest fragmentation of Chitteri Hills in Eastern Ghats, Tamil Nadu. J Civil Eng Environ Sci 7(1): 001-007.DOI: https://dx.doi.org/10.17352/2455-488X.000038

hec of evergreen forests was converted to scrub land, 3262.26 hec of evergreen forests was changed to others category. Around 607.41 hec of deciduous forests was converted to 4090.68 hec of scrub land and 5267.26 hec was converted to others. 1303.29 hec of degraded forests was changed to scrub land and 1289.82 hec of degraded land was converted to others. 1510.74 hec of scrub land was changed to degraded land and 1689.32 hec was changed to others.

## Analysis of habitat fragmentation of Chitteri Hills using Fragstat spatial metrics

The below table was obtained by running the unsupervised classified image in Fragstat 4.2 software. The area occupied by each class in the study area were computed, along with the percentage of landscape it occupies and the Largest Patch Index (LPI) was also identified. From the result it is evident that there is a drastic decrease in the class area of evergreen forest and deciduous forest in the last 20 years Table 7.

The area covered by the evergreen forest in the year 2000 is 27056 hectares and it has reduced to 21174.21 hectares in the year 2008 and 17257.87 hectares in the year 2019. The deciduous forests covered an area of about 21546.3 hectares in the year 2000 and had reduced to 20309.92 hectares in the year 2008 and 17573.5 hectares in the year 2019. But the degraded land has increased from 3051.8 hectares in the year 2000 to 5699.35 hectares in the year 2008 and 8710.53 hectares in the year 2019. Scrub land has also decreased from 8014.2 hectares in the year 2000 to 10655.37 hectares in the 2008 and 128288.85 hectares in the year 2019. The others category which includes built up area, water bodies and others has increased from 5879.5 hectares in the year 2000 to 7554.88 hectares in the year 2008 and 9622.98 hectares in the year 2019. The percentage of landscape coverage of each category was computed which showed a drastic reduction of evergreen forest and scrub land and decrease in the degraded land and others category. The largest patch coverage was computed using the Fragstat. This shows a drastic reduction of the patch size of evergreen forests and deciduous forests has reduced and the patch size of the others category and degraded land has increased very well.

As an overall change, there was a net increase of 1675.38 hectares of non-forested areas in the last 20 years. The observed trends of decreasing forest and increasing non forest areas in the Hills could be explained by the following four reasons. First, among the general and main causes of deforestation are human population pressure and an increasing demand of land for living and agriculture and timber products from forests [13,14]. In Chitteri Hills, human population increased to nearly 5.6% in the period of 2001 to 2011. However, there is no important change in population in the last 11 years. It is important to note that there is a gradual decrease in the rural population which can be explained by the fact that demographic movement of rural areas which concentrated in the neighbouring towns of Dharmapuri and Salem. Many villages were abandoned and more people left the rural areas to become resident in the urban centres for their livelihood. Abandoned areas were covered with young plants and trees. These areas are categorised as degraded forests as these don’t have any crown culture. This is the reason of increasing degraded forest area. This situation is the reason of increasing degraded forest area. In Chitteri, besides inequity in land ownership, low productivity in agriculture and the domestic net income per person was far below the threshold to keep the rural communities in their homeland, allowing the urban population to increase. The quantitative evidences of forest cover patterns showed that human activities have affected the forest cover type changes. Second, plantation by the forest department has contributed to the increase in plantation area. Third, Insects that primarily attack individual species have an effect similar to selective cutting on a multi-species stand within a forest. Insect infestation may or may not cause significant change in species composition (i.e., associated plant and animal species) and forest-stand structure. A lot depends on the diversity, site conditions and overall health of the original stand [15]. The major reason for the loss of biodiversity is the change in forest cover [16,17] which in turn is due to forest fragmentation, habitat loss and urbanisation. The fragmentation of the forest is shown by the increase in the number of patches and increase in the number of smaller patches [15]. This in turn affects the species richness, habitat isolation and many more. There is decrease in the evergreen cover and deciduous forest in the last 20 years and from the result it shows there is increase in the number of smaller patches. Patchiness is an important indicator of natural habitat fragmentation [3]. The evergreen forest in the study area has fragmented and is indicated by the

**Table 7:** Values of spatial metrics obtained from standard analysis in Fragstat 4.2.

| CLASSES | CLASS AREA (CA) (in hectares) | | | PERCENTAGE OF LANDSCAPE (PLAND) | | | LARGEST PATCH INDEX(LPI) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2008 | 2019 | 2000 | 2008 | 2019 | 2000 | 2008 | 2019 |
| Evergreen | 27056.4 | 21174.21 | 17257.87 | 41.27711 | 32.37957 | 26.39071 | 31.13 | 27.69 | 18.45 |
| Deciduous | 21546.3 | 20309.92 | 17513.5 | 32.87093 | 31.0579 | 26.78162 | 23.45 | 20.52 | 17.89 |
| Degraded | 3051.8 | 5699.35 | 8710.53 | 4.655811 | 8.715438 | 13.32013 | 1.88 | 2.15 | 3.25 |
| Shrub | 8014.2 | 10655.37 | 12288.85 | 12.22642 | 16.29418 | 18.79209 | 7.35 | 12.35 | 11.52 |
| Others | 5879.5 | 7554.88 | 9622.98 | 8.969735 | 11.55291 | 14.71545 | 0.45 | 0.98 | 2.25 |

| CLASSES | NP (Number of Patches) | | | PD (Patch Density) | | | AWMSI (Area weighted shape Index) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2008 | 2019 | 2000 | 2008 | 2019 | 2000 | 2008 | 2019 |
| Evergreen | 3344 | 2914 | 1716 | 3.3 | 2.9 | 1.7 | 5.6 | 4.9 | 3.8 |
| Deciduous | 2936 | 2284 | 1632 | 1.6 | 1.9 | 2.2 | 3.0 | 2.6 | 2.1 |
| Degraded | 3812 | 7638 | 7818 | 3.5 | 7.5 | 7.7 | 4.9 | 5.8 | 6.2 |
| Shrub | 6733 | 7832 | 16886 | 10.5 | 12 | 16.6 | 2.6 | 3.6 | 5.6 |
| Others | 6443 | 12185 | 12679 | 6.8 | 8.4 | 11.4 | 20.2 | 26.2 | 32.6 |



**Citation:** Narmada K, Gogoi D, Dhanusree, Bhaskaran G (2021) Landscape metrics to analyze the forest fragmentation of Chitteri Hills in Eastern Ghats, Tamil Nadu. J Civil Eng Environ Sci 7(1): 001-007.DOI: https://dx.doi.org/10.17352/2455-488X.000038

increase in the number of patches from 1716 in the year 2000 to 3344 in the year 2019. Same is seen with the deciduous forest which shows increase on the number of patches from 1632 in the year 2000 to 2936 in the year 2019. The degraded forests have also shown increase in the number of patches from 3812 in the year 2000 to 7818 in the year 2019.

## Conclusion

From the analysis it is found that there is increase in number of fragments, leading to isolation of patches and there was further decrease in mean patch size. The increase in the number of patches could be attributed to conversion of the forest to other categories, road construction. Urban population has also increased in the last 20 years. The forest landscape was found to be altered due to this increasing fragmentation. The overall change in the structure of the natural habitat has led to the degradation of the forest. The forest landscape has deteriorated or fragmented due to increase in the number of patches, mean patch size and patch density. Forest degradation in this area is mainly due to mismanagement, heavy grazing of pasture land adjacent to forest areas. People using the forest resources illegally for their livelihood is also one of the reasons. The major impact of this change is that the people concentrating more on the improvement of the products that are useful for them, thereby disturbing the natural habitats and further leading to soil erosion and carbon emission into the atmosphere. To conclude, monitoring the spatial metrics for these forest ecosystems help us to analyse the change in composition and configuration of the ecosystem. This can be used as a major tool in forest management for biodiversity conservation and sustainable forest management.

## Acknowledgement

I would like to thank ICSSR (Indian Council for Social Sciences Research) for funding this research work, which has helped me to carry with my work in an effective way.

## References

1. Abdullah SA, Nakagoshi N (2007) Forest fragmentation and its correlation to human land use change in the state of Selangor, peninsular Malaysia. Forest Ecology and Management 241: 39-48. Link: https://goo.gl/b0NZSm
2. ADB (2010) Key indicator for Asia and the Pacific (1-312). Mandaluyong City, Philippines: Asian Development bank. Link: https://goo.gl/jEQq1C
3. Laurance WF, Camargo JLC, Luizão RCC, Laurance SG, Pimm SL, et al. (2011) The fate of Amazonian forest fragments: A 32-year investigation. Biological Conservation 144: 56-67. Link: https://goo.gl/qLUw7p
4. Reed RA, Johnson-Barnard J, Baker WL (1996) Fragmentation of a forested rocky mountain landscape, 1950-1993. Biological Conservation 75: 267-277.
5. Mladenoff DJ, White MA, Pastor J, Crow TR (1993) Comparing spatial pattern in unaltered oldgrowth and disturbed forest landscapes. Ecological Application 3: 294-306.Link: https://bit.ly/30U2rtG
6. Jorge LAB, Garcia GJ (1997) A study of habitat fragmentation in Southeastern Brazil using remote sensing and geographic information systems (GIS). Forest Ecology Management 98: 35-47. Link: http://bit.ly/3eMWmrt
7. BIP (2010) Forest Fragmentation: Identifying a biodiversity-relevant indicator. Cambridge, UK: Biodiversity Indicators Partnership. Link: https://goo.gl/Oxq43x
8. Herold M, Couclelis H, Clarke KC (2005) The role of spatial metrics in the analysis and modeling of urban land use change. Computers, Environment and Urban Systems 29: 369-399. Link: http://bit.ly/2Q2hxLB
9. Rao DV, Jenab SA, Clapp DA (1989) Rainfall Analysis of Northeast Florida. Part III: Seasonal Rainfall Data [Report]. St. Johns River Water Management District (SJRWMD).
10. Anderson JR, Hardy EE, Roach JT, Witmer RE (1976) A Land Use and Land Cover Classification System for Use with Remote Sensor Data. Geological Survey Professional Paper No. 964, U.S. Government Printing Office, Washington DC, 28. Link: http://bit.ly/3eK4vgh
11. Singh A (1989) Digital Change Detection Techniques Using Remotely-Sensed Data. International Journal of Remote Sensing 10: 989-1003. Link: https://bit.ly/2OwF33b
12. Holdt BM, Civco DL, Hurd JD (2004) Forest fragmentation due to land parcelization and subdivision: a remote sensing and GIS analysis. In Proceedings of the 2004 ASPRS Annual Convention, Denver, Colourado. Citeseer. Link: https://goo.gl/pgHP6h
13. Bennett AF (2003) Linkages in the landscape. The role of corridors and connectivity in wildlife conservation. IUCN Forest Conservation Programme, Conserving Forest Ecosystem Series No.1. Link: https://bit.ly/3bV8ogt
14. Bennett AF, Saunders DA (2010) Habitat fragmentation and landscape change. Conservation Biology for All 93: 1544-1550. Link: https://goo.gl/px2xsh
15. Botequilha LA, Ahern J (2002) Applying landscape ecological concepts and metrics in sustainable landscape planning. Landscape and Urban Planning 59: 65-93. Link: http://bit.ly/3cA6lgY
16. Corry RC, Nassauer JI (2005) Limitations of using landscape pattern indices to evaluate the ecological consequences of alternative plans and designs. Landscape and Urban Planning 72: 265-280. Link: http://bit.ly/3lmOrlG
17. Haddad NM, Brudvig LA, Clobert J, Davies KF, Gonzalez A, et al. (2015) Habitat fragmentation and its lasting impact on Earth's ecosystems. Science Advances 1: e1500052–e1500052. Link: https://goo.gl/cs4iWB







**Citation:** Narmada K, Gogoi D, Dhanusree, Bhaskaran G (2021) Landscape metrics to analyze the forest fragmentation of Chitteri Hills in Eastern Ghats, Tamil Nadu. J Civil Eng Environ Sci 7(1): 001-007.DOI: https://dx.doi.org/10.17352/2455-488X.000038