

# Forest Change Detection of Bangalore Metropolitan Region with NDVI Technology

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## ABSTRACT:

GIS can be define as the systematic description of geospatial data and statistical data for various projects into many different disciplinary works and analysis of data is doing by using raster and vector data with GIS software's. This analysis is very helpful in the detection of various changes in environment of different regions, observation of component processes, based on current practices and management plans. The space generator sensors in the satellites helps to take information of the different parts of the earth by multispectral spatial and temporal data, this process is define the Remote sensing definition that what exactly it is. The remote sensing data, which helps to analyze the Earth's resources like changes occur dynamically in related to land and water, which known as image processing technology. Basically the various types of analysis techniques are helpful in generating technically statistical geospatial data to better know about the mobility of land and biodiversity ecosystem. Remote sensing data is basically used to detect Land cover and land use changes remotely and carefully selection of appropriate data sets is required for this. The change detection measurement is define as a differences occur in the data frameworks of different time period or scenario including the thematic information, which basically defines the readings of in sighted things in relation to land use and land cover changes of an area or region and it also provides information the changes occurred in that specific area from past times to the present time continuously due various root causes. This research examines the use of GIS and Remote Sensing technology in the detection of changes occurs in the forest area in **Bangalore Metropolitan Region between 1999, 2009 and 2018 years**. In this the changes has been detected which take place in the forest or vegetation in different time periods. In this the final readings of the analysis of satellite data is to be shown digitally with the help of software Normalize differential vegetation index (NDVI) is the GIS technique which helps in the digital transformation of satellite data of different bands, which is useful in findings various changes in land use and land cover properties of a specific area in form of remote sensing data. This GIS technique basically helps to identify the changes of two (or more) different dates, which have their general difference in their properties. The different techniques have their different applications in research areas such as land use / land cover change, geological changes, specific changes in deforestation / forestry, changes in coastal areas and changes in glaciers etc. There is the principle behind these all change detection technologies, in which the DN value (Digital number value) of a data is different from the DN value of another data with separate dates and timings. In this paper the NDVI technology of GIS is used for forest change detection of Bangalore Metropolitan Region.

**Keywords:** Remote Sensing; NDVI; change; directional analysis;

## 1.0 BACKGROUND

Due to continue migration of the population from rural areas to urban areas for getting better opportunities and jobs facilities, the urban areas/cities were started expanding in India since from the 1980s. there are some of the important cities where the urban expansion is occurring with surprising rates such as Delhi NCT, Bangalore, Calcutta and Bombay (Howe 2006). From 1986, Bangalore is the fastest growing city of India because of IT Hub or technology hub of Bangalore, where the technical youth finds their jobs easily in the multinational companies or firms.

"Bangalore is the capital of Karnataka state and due to its hub of IT industries, Bangalore is also known by the name of "Silicon City" of India. "Bangalore is now known as Bruhat Bangalore Mahanagara Palike (BBMP, Bruhal Bengaluru City Corporation), the biggest urban area with an extent of 850 sq. km. Bangalore also join with Mumbai, Delhi and Kolkatta as a mega city in India" (Taubenböck et al. 2009).

According to the News in Times of India on Jun 21, 2011, "Depleting forest cover could have grave impact on Bangalore: What might seem tiny could actually mean a lot, especially if it's to do with a huge carbon sink like the Western Ghats. Steady degradation of forest cover here is no surprise though central government remote-sensing figures show little loss. But this loss will mean grave danger in the years to come". Prof N H Ravindranath of the Indian Institute of Science, has done an assessment of deforestation in the ghats, found that in Uttara Kannada district, the area under forest cover was 7,84,000 hectares in 2001 but that got reduced to 7,82,000 ha in 2007. In Shimoga, 4,44,000 ha of forestland was reduced to 4,40,000 over the same period.

### 1.1 NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

Mainly in GIS technology, the technique of NDVI is using by the researchers and scientists to determine vegetation indices in any region or state (Di et al., 1994; John et al., 1998; Malingreau and Belward, 1992; Marsh et al., 1992; Reed et al., 1994). As according to the approach of vegetation indices in analysis study through satellite imagery or remote sensing data, the healthy vegetation has a low reflectance in the visible portion of the EMS (Electromagnetic Spectrum) due to the chlorophyll absorption and other pigments, and high reflectance in the NIR because of the internal reflectance by the mesophyll spongy tissue of a green leaf (Campbell, 1987). NDVI can be calculated as the ratio of red and the NIR bands of a sensor system and is represented by the following equation

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

NDVI values range from -1 to +1. Because of high reflectance in the (Near Infra-Red) NIR portion of the EMS and healthy vegetation is represented by high NDVI values between 0.05 and 1. Conversely, non-vegetated surfaces such as water bodies showing in the negative values through NDVI technique (Lille sand and Kiefer, 1994).

## 1.2 CAUSES OF RAPID INCREASE OF URBANIZATION & POPULATION IN BANGALORE:

1. The continue increase in the urbanization effect the excellent standard of living in Bangalore Metropolitan Region because the income of the peoples is maximum in the urban areas or in cities as compare to the income of the peoples living in the rural areas. The people in urban areas have their best opportunities of education and job facilities after completion of education, which increases the affordability of the peoples living in the urban areas.
2. Presently Bangalore is the centre of new technology in India, where near to 35% of working population is engage with IT sector and related industry works, which continue encouraging the technicians and IT youth along with their IT profession and with good salary packages. There is one important thing is that near to four new companies or firms start their business in Bangalore or in the in cities on their nearest cities every week and they create nearly 50,000 new jobs in each year (Silicon India 2005).
3. Agriculture sector is not much active in Bangalore region because of the heavy rainfall in Bangalore and unfavourable environmental conditions for farmers. "People in India migrate to cities "not due to urban pull but due to rural push" (Datta 2006, 12).

## 1.3 IMPACTS:

1. Bangalore was known as Garden City of India last from few years or decades of time but now due to above mentioned causes Bangalore losing its green spaces and forest land and developing as Industrial hub or IT hub. "In 2003, the percentage of parks and open spaces including lakes and water tanks was approximately 2.5-3%, much lower than 4.4% in 2002" (Sudhira 2003). The urbanization and IT industrialization affect badly on the planting trees, canopies and other vegetation in the Bangalore.
2. The level of ground water is also badly affected by the rapid increase of urbanization and decreasing of vegetation in the Bangalore. As according to Hunse in 2008," Ground water contributes to fifty per cent of the urban water requirements and eighty per cent of the drinking water in rural areas". The water consumption is also increasing day by day due to rapid increase in the population, dwelling units in the houses and industrialization.

## 1.4 AIM AND OBJECTIVES OF THE STUDY:

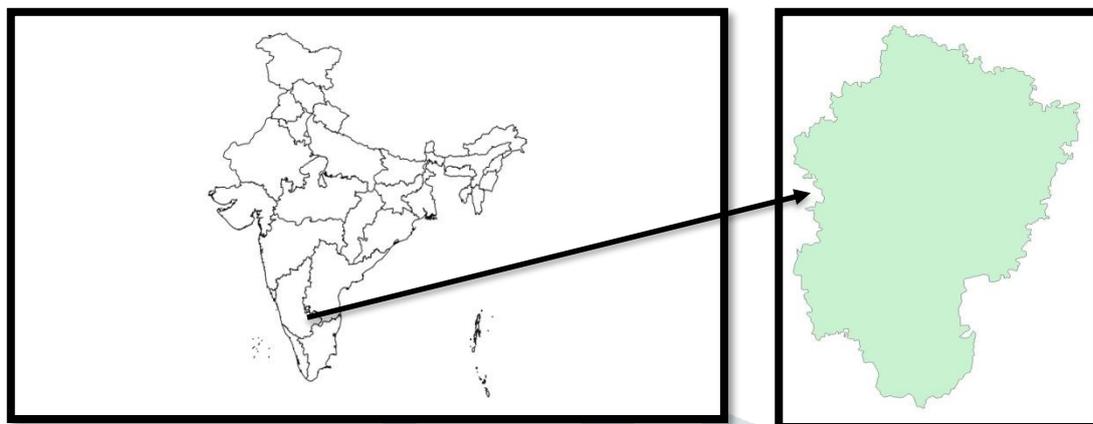
- I. To create an urban greenery map for the year 1999, 2009 and 2018 with the help of NDVI scheme.
- II. To evaluate the socio-economic implications of these changes.

## 2.0 STUDY AREA

### BANGALORE METROPOLITAN REGION:-

Bangalore Metropolitan Region (77°37'19.54" E and 12°59'09.76" N) is the principal administrative, cultural, commercial, industrial, and knowledge capital of the state of Karnataka with an area of 741 sq. km. "Bangalore has grown spatially more than ten times since 1949 (69 square kilometres) and is a part of both the Bangalore urban and rural districts. Now, Bangalore is the fifth largest metropolis in India currently with a population of about 7 million. The mean annual total rainfall is about 880 mm with about 60 rainy days a year over the last ten years. The summer temperature ranges from 18° C – 38° C, while the winter temperature ranges from 12° C – 25° C. Thus, Bangalore enjoys a salubrious climate all-round the year. Bangalore is located at an altitude of 920 metres above mean sea level, delineating four watersheds, viz. Hebbal, Koramangala, Challaghatta and Vrishabhavathi watersheds. The undulating terrain in the region has facilitated creation of a large number of tanks providing for the traditional uses of irrigation, drinking, fishing and washing. This led to Bangalore having hundreds of such water bodies

through the centuries. Even in early second half of 20<sup>th</sup> century, in 1961, the number of lakes and tanks in the city stood at 262 (and spatial extent of Bangalore was 112 sq. km)<sup>21</sup>. However, number of lakes and tanks in 1985 was 81 (and spatial extent of Bangalore was 161 sq. km)<sup>22,23</sup>.



Source: Prepared by the Author.

Figure 1: Location of study area – Bangalore Metropolitan Region.

There were nearly 11,731 trees were cut few years ago only because of the request of the local population and persons from public representatives parties just because of the unstable growth of bushes and trees around the residential areas but on other hand nearly 35,220 trees were cut down in the same time because to avoid the hurdles in the way of development projects or were leaning dangerously on street light poles<sup>24</sup>.

While the civic agency's record on this front is intelligent report, it continues to threaten more of the city's green cover with projects like the Jayamahhal road widening, placing Bengaluru's future as a Garden City at even greater risk<sup>24</sup>.

2.1. DATA USED

For the mapping of urban greenery area Landsat 5TM data have been used. The dates of the data are as follows: 02/04/1999, 06/04/2009 and 17/05/2018. The characteristics of the Landsat 5TM data are as follows:

Table 1 Orbit and Acquisition characteristics of Landsat 5TM:

Satellite	Sensor	Swath (km)	Inclines at	Altitude (km)	Revisit (days)	Scene Size	Pixel Size
L 5 MSS	TM	185	98.2 Degree	705	16	175 x 185 km	57 x 79 m

Source: [www.usgs.gov/landsat](http://www.usgs.gov/landsat)

Table2. Radiometric characteristics:

Satellite	Spectral Resolution (nm)	Band	Spatial Resolution(meters)
Landsat 5 MSS	Band 1: 0.45 – 0.52	Blue	30
	Band 2: 0.52 – 0.60	Green	30
	Band 3: 0.63 – 0.69	Red	30
	Band 4: 0.76 – 0.90	Near IR	30
	Band 5: 1.55 – 1.75	Mid IR	30

TM	Band 6: 10.4 – 12.5	Thermal	120
	Band 7: 2.08 – 2.35	Mid IR	30

Source: [www.usgs.gov/landsat](http://www.usgs.gov/landsat).

### 3.0 LITERATURE REVIEW:

India's Silicon Valley-Bengaluru is fast losing its green cover with urbanisation having risen by 125 per cent between 2000 and 2014, researchers at Indian Institute of Science (IISc) claimed. Rapidly urbanising at a pace of 4.6 per cent, Greater Bengaluru has witnessed a decline of vegetation and water bodies by 62 and 85 per cent respectively in this period. The study was carried out using remote sensing data through Landsat satellites to explore spatial patterns of land use changes and have found interesting and alarming patterns.

The IISc team studied data of Bengaluru from 1999 to 2014 and used software to analyse the land use patterns and understand the change in urban cover. The land use classification was algorithmically computed and categorised as urban (buildings, roads and paved surfaces), vegetation (parks, botanical gardens and grass lands such as golf course), water bodies (lakes, sewage treatment tanks) and others (play grounds, quarry regions and barren land). The study found that during this time, urban land use – for buildings, roads, - had increased by 184 per cent, while vegetation had decreased from 45 per cent to a mere 8.4 per cent. The water bodies also diminished to a mere 0.74 per cent – a drastic reduction of 85 per cent. "The results also show a tendency of dispersed growth in all directions. This phenomenon is most prominent in North West and South West directions," the research stated. This work, titled 'Spatial Patterns of Urban Growth with Globalisation in India's Silicon Valley', was published in the Proceedings of National Conference on Open Source GIS: Opportunities and Challenges, and was awarded the best paper award. "Bengaluru has become a land of opportunities and growing ideas for various job markets. There has been an extreme growth in the industrial sector (IT sector) in last couple of years and migration of people to these places for housing and work has brought severe pressure on the environment. "Further, we lack efficient transportation and thus we see people craving to stay close to their workplace adding to dependency on private vehicles," said Aithal, a post-doctoral research scholar at the Centre for Sustainable Technologies, (IISc), one of the members of the team, which carried out the research. The study found that due to these factors the outskirts of the city towards northeast and southeast show numerous urban patches and Irregular shapes. "Our study aimed to bring out the lacunae in our planning system and to help policy makers in understanding the entire landscape. It also benefits citizens of the city to voice their opinions and obtain basic amenities as promised under our constitution. It also forms a basis to provide solutions to their elected representatives," Aithal said. "We have modelled the urban revolution of Bengaluru with various models. The study clearly indicates that this rate of unprecedented urbanisation would create more troubles for citizens of the city, if we don't start planning a futuristic city," he added. Aithal noted that urban India is expected to house 60 per cent of India's population (about 5 billion) by 2030 and that the number of metropolis cities had increased to 49 in 2011.

"Urbanisation being a complex product of population explosion and one major factor being poverty induced rural to urban migration. It has led to the dispersed haphazard development in the city outskirts or the periphery, which is a result of unplanned urbanisation, referred to as 'urban sprawl'. "These areas are devoid of basic amenities and also cause fragmentation of land into smaller chunks that alter the ecosystem pattern. Greater Bengaluru, being a metropolitan city, is experiencing unprecedented urban growth of 4.6 per cent per annum in recent times," he said. Past studies have always been the base for every research. Whenever a problem arise in our mind we try our best to practically solve this problem the next step that we follow is to check out what other people think about the problem. In this we start our work by taking a base of the previous work. The present work is based on urban greenery, urban vegetation, and urban forestry with the help of RS and GIS techniques. There has been many works done on this in various parts of the world. Some of the major ones related to the study are presented below.

#### 3.1 DIFFERENT WORK VEGETATION ANALYSIS

Green vegetation has significant position within cities. Trees play important role in cleaning pollution, equilibration of water cycle and climate stability of the environment. They have influence on physical health of citizens – parks are used as recreational areas. The management of vegetated areas by urban planners relies on detailed and updated knowledge of their nature and distribution<sup>25</sup>. (Mathieu and Aryal 2005).

*Menon and Bawa (1997)* inferred that remote sensing imageries can be used to assess the health of forest ecosystem and the extent of degradation. Fuzzy classification models and vegetation indices (i.e. NDVI) were used to estimate regeneration levels, biomass, and species composition at the pixel levels *Xing et.al, (1998)*, did the change detection with accuracy of 61% through parameters such as biomass, brightness and wetness indicators using Landsat thematic mapper data<sup>26</sup>.

*Macleod and Cognation (1998)* list four aspects of change detection which are important when monitoring natural resources:

- i. Detecting the changes that have occurred
- ii. Identifying the nature of the change
- iii. Measuring the area extent of the change
- iv. Assessing the spatial pattern of the change

The basis of using remote sensing data for change detection is that changes in land cover result in changes in radiance values which can be remotely sensed<sup>27</sup>. Techniques to perform change detection with satellite imagery have become numerous as a result of increasing versatility in manipulating digital data and increasing computer power. It is required to investigate the spatial distribution of vegetation in urban areas on a regional scale for not only the improvement of urban environment but also the conservation of ecosystem. Satellite remotely sensed data have contributed to the regional analysis generally because of their spectrum information on vegetation. Wu and Murray (2003), “estimated the distribution of impervious surface, vegetation cover, and soil cover through a fully constrained linear spectral mixture model using Landsat ETM+ data for monitoring urban areas and understanding human activities”. Normalized Difference Vegetation Index (NDVI) calculated from satellite remotely sensed data has been traditionally applied to the remote sensing of urban heat islands, the estimation of vegetation cover ratio, the mapping of the urban forest carbon storage, etc (Wilson, et al. (2003), Myeong, et al. (2006)). NDVI, which can save time and money and speed the process of various kinds of urban mapping, has been conducive to regional scale analysis<sup>27,28</sup>.

#### **4.0 METHODOLOGY:**

Landsat imagery is relatively resolution earth observation data that is acquired through sensors on one of the NASA Landsat satellites. The satellite sensors acquire high integrity images of the Planet surface in a systematic fashion. Users can take this imagery and use it to determine the health and type of vegetation, amount of built surfaces, success of agriculture, or apply it for a myriad other uses. In order to estimate snow cover area we have used the Landsat TM data from different period and applied NDVI (normalized difference vegetation index) calculation method.

#### **4.1 DATA PRE-PROCESSING:**

Raw satellite data contains various types of geometric and radiometric errors with it, thus it is necessary to remove these errors before further use of data. Pre-processing of satellite data consist of image geometric correction, haze or cloud removal etc. In present study only the cloud free data were selected.

#### **4.2 IMAGE GEOMETRIC CORRECTION AND RECTIFICATION:**

The raw satellite data contain geometric distortion and it is necessary to rectify them from the images in order to enable correct measurement of area, precise localization and multi-source data integration (Zhang.J and Zhang.Y, 2007). In case of land use change detection the proper geo-rectification is essential and the accuracy of geo-rectification should be within 1 to 2.5 Pixels (Zhang.J and Zhang.Y, 2007). A rectification have been done in Landsat 5TM images using the ArcGIS 9.3 software and the images have been given the base map coordinates (i.e. UTM projection, and 44N zone) for the purpose to identify the study area in the image.

#### **4.3 SCANNING:**

First the JPEG of the study area Bangalore Metropolitan region has been scanning. Than converting the hard copy map to digital form for the making different vector layer like boundary of the Bangalore Metropolitan region.

#### **4.4 LAYER STACK:**

Layer stacking is the process where different band's (layers) combined in one image. Create new output file by stacking layers from two or more input images.

#### **4.5 MOSAICKING:**

Mosaicking is the process of joining georeferenced images together to form larger image or asset of images. The input images must all contain map and projection information, although they need not be in the same projection or have the same cell sizes. Calibrated input images are also supported. All input images must have the same number of layers.

#### 4.6 GEOREFRENCING:

After

that georeferencing the study area map with the help of LANDSAT satellite image.

#### 4.7 NORMALIZED-DIFFERENCE VEGETATION INDEX (NDVI) ESTIMATION

In the present study Landsat 5TM data have been used for Bangalore urban green space Mapping. For this Landsat 5TM Band 4 NIR IR (0.76 – 0.90 nm) and Band 3 RED (0.63 – 0.69 nm) with spatial resolution of 30meter has been stacked and then used for NDVI estimation, on the basis of ERDAS IMAGINE software.

$NDVI = (TM \text{ Band } 4 - TM \text{ Band } 3) / (TM \text{ Band } 4 + TM \text{ Band } 3)$ . Based on the above condition the NDVI is being calculated for the entire stacked image (i.e. Band 4 and Band 3) for the years 1999, 2009 and 2018.

#### 4.8 STUDY AREA SUBSET:

The study area i.e. Bangalore has been clipped using its shape file from NDVI image. The following steps have been performed in ERDAS IMAGINE and ArcGIS 9.3 software, by superimposing Shape file over NDVI image and select the shape file as the area of interest by AOI tool and subset by viewer method.

#### 4.9 RECLASSIFICATION:

The NDVI (Normalized-Difference vegetation Index) clipped raster data is being reclassified into two classes i.e. forest and non-forest cover area on the basis of threshold value. This step have been performed in Arc-GIS 9.3 software, by using the 'Spatial Analyst tool' and the reclassification of Bangalore NDVI image values for three years 1999, 2009 and 2018 have been done on the above suggested threshold value.

#### 4.10 CHANGE DETECTION:

As the forest cover map is being generated with the help of reclassification technique, the next step was to change detection technique in ERDAS IMAGINE software.

#### 4.11 DIRECTIONAL ANALYSIS:

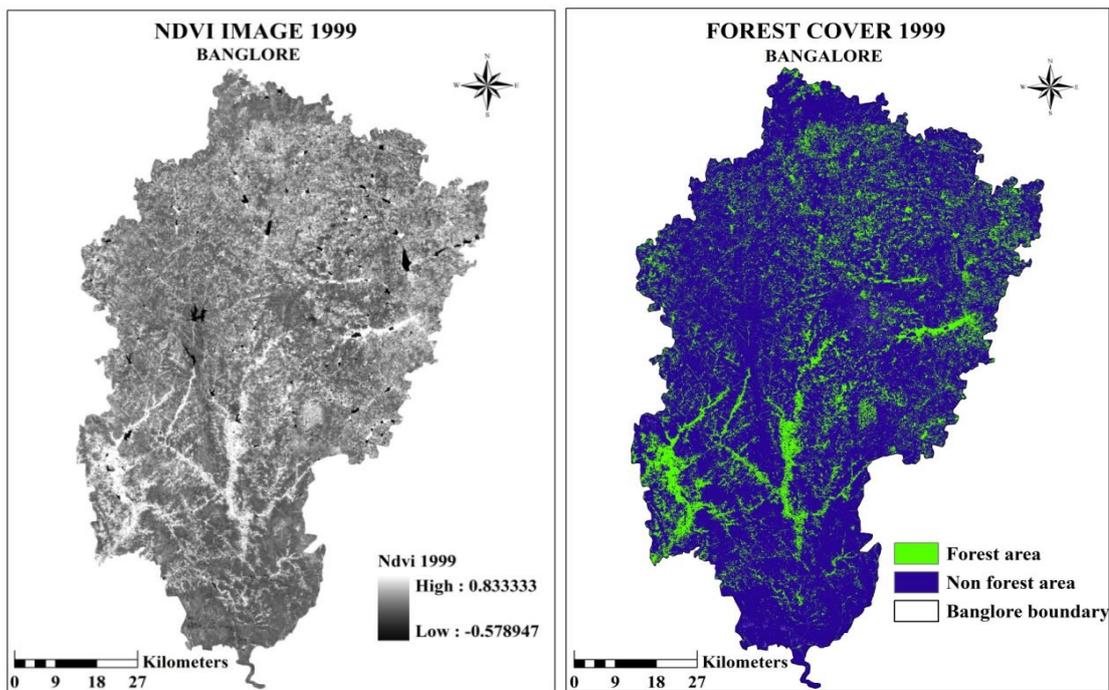
In analysis of urban greenery we need to understand directional expansion of forest, we can do this by measuring portion of forest area within specified major as well as minor directions Identification of concentration of forest in which direction could find out with this method.

#### 4.12 SOFTWARE USED:

Software such as, ArcGIS 9.3, Erdas Imagine and were used for this study. ArcGIS 9.3 was used for data preparation, analysis and map composition. Erdas Imagine was used for image processing and change detection. Microsoft office (Word and Excel) was used for reporting and analysis. Finally, ArcGIS 9.3 were used for reclassification and directional analysis.

#### 5.0 FINDINGS:

Land covers by forest of Bangalore Metropolitan Region study area were categorized in to two types; these are: Forest cover land and non-forest area cover land. The forest in the study area has been divided in to forest and non-forest based on variation in tone and NDVI values, and field verification. The intension was to separately identify the natural dense undisturbed forest with disturbed by human forest. The three different years (1999, 2009 and 2018) of forest cover land and non-forest cover land classification map of the study area is presented in the figures 1,2 and 7.

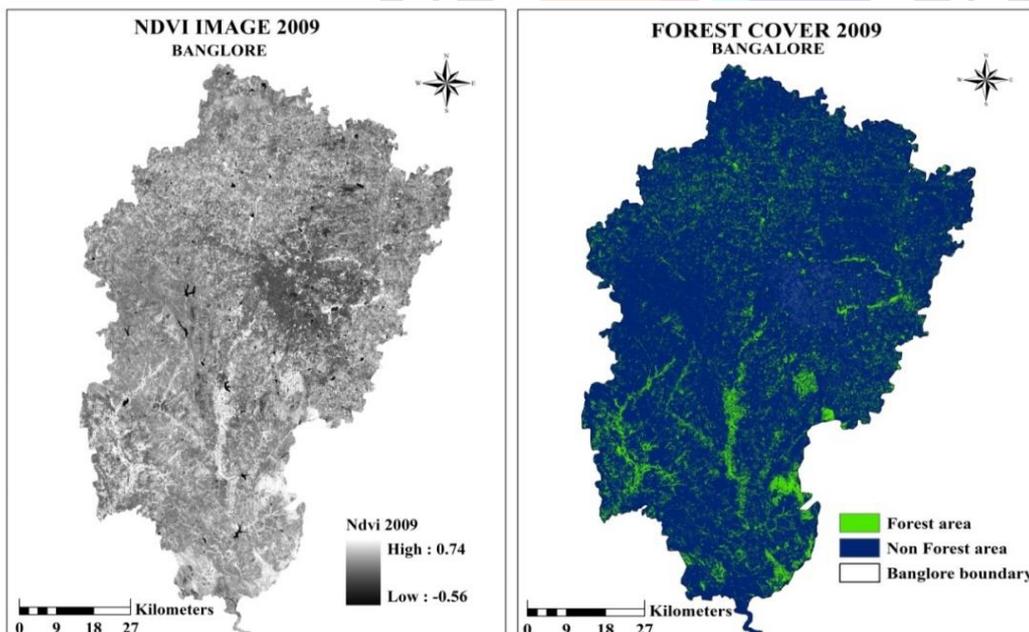


Source: Calculated with NDVI Technology from ArcGIS 9.3.

Figure 1: NDVI image of Bangalore Metropolitan Region of 1999

**5.1 CHANGES DETECTED BY NDVI DIFFERENCING:**

NDVI image differencing cannot provide detailed change information. It can only give the information of increase or decrease in NDVI value.



Source: Calculated with NDVI Technology from ArcGIS 9.3.

Figure 2: NDVI image of Bangalore Metropolitan Region of 2009

The negative threshold indicates loss in NDVI and positive threshold indicates area of increased NDVI. As indicated in figure 2 there was change of forest land cover area in general in the two different time period of image. To this effect the standard value decreased in certain amount, showing that there were changes or decrease of green vegetation and forest.

From the 1999 forest cover land area, the areal coverage of forest was accounted for 1270.7 sq. km or 17.5% from the total study area. And from the 2009 forest cover land area, the areal coverage of forest was accounted for 721.652 sq. km or 9.95% from the total study area. So the total area change of decrease of forest in 2009 is for accounted as 548.348 sq.km or 7.56%, as compare to

time period of forest cover land area in 1999 and 2009, the total forest land cover area change detection is measured in below table 5.1(describe as above).

**Table 3 Total area under Forest in Bangalore Metropolitan Region**

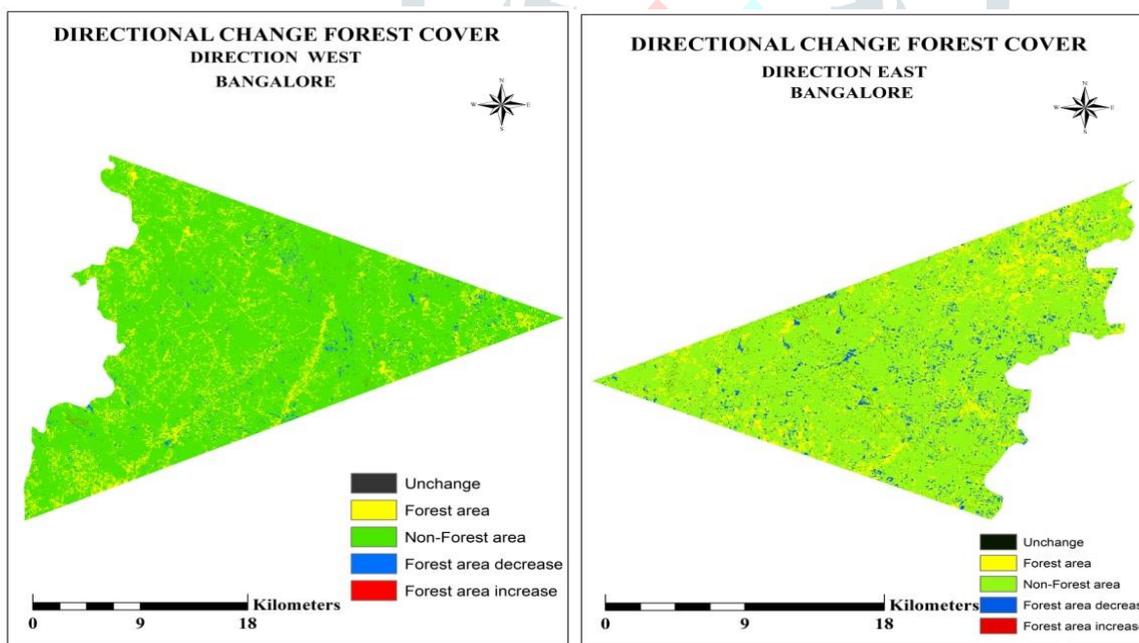
NAME OF AREA	1999		2009		CHANGE (1999-2009)	
	FOREST AREA		FOREST AREA		FOREST AREA	
	Sq Km	(%)	Sq km	(%)	Sq Km	(%)
BANGALORE METROPOLITAN REGION	1270.7	17.51	721.652	9.95	548.348	7.56

Source: Primary Calculated from NDVI.

**Table 5.1: Change detection of forest cover land area.**

WEST

EAST



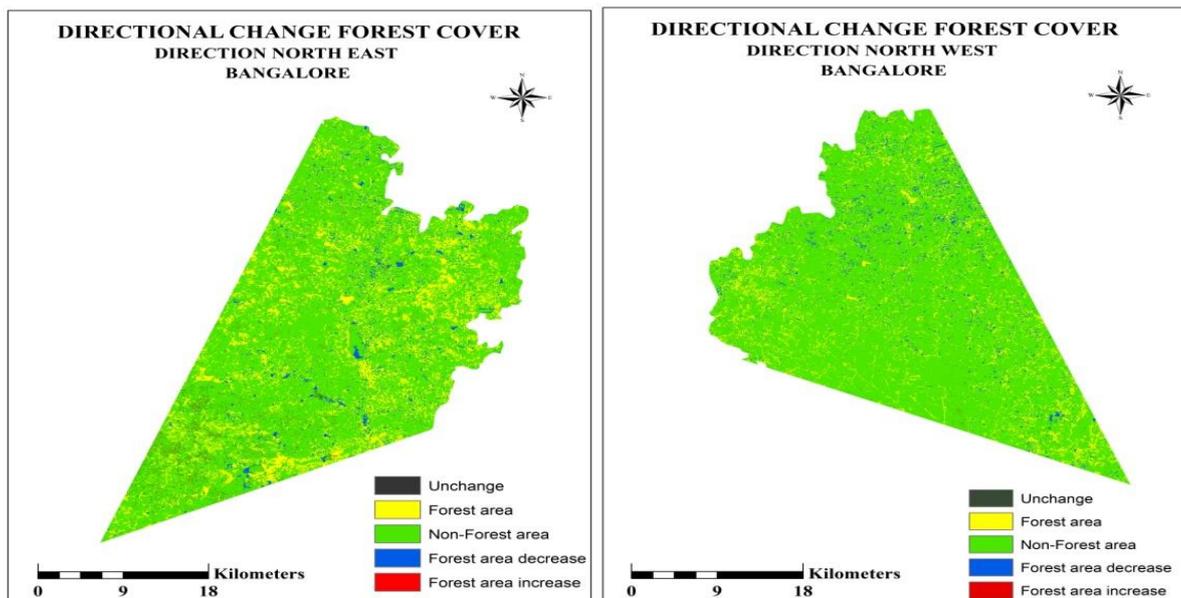
Source: Calculated

with NDVI Technology from ArcGIS 9.3.

**Figure 3: Directional change of Bangalore Metropolitan Region.**

NORTH EAST

NORTH WEST

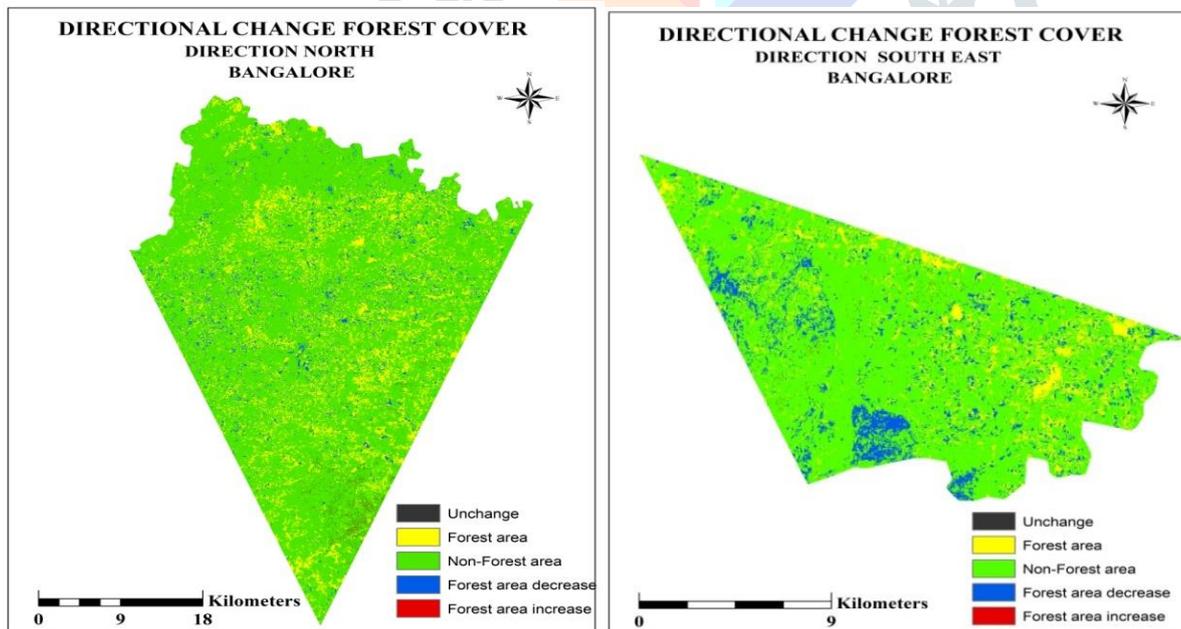


Source: Calculated with NDVI Technology from ArcGIS 9.3.

Figure 4: Directional change of Bangalore Metropolitan Region.

NORTH

SOUTH EAST

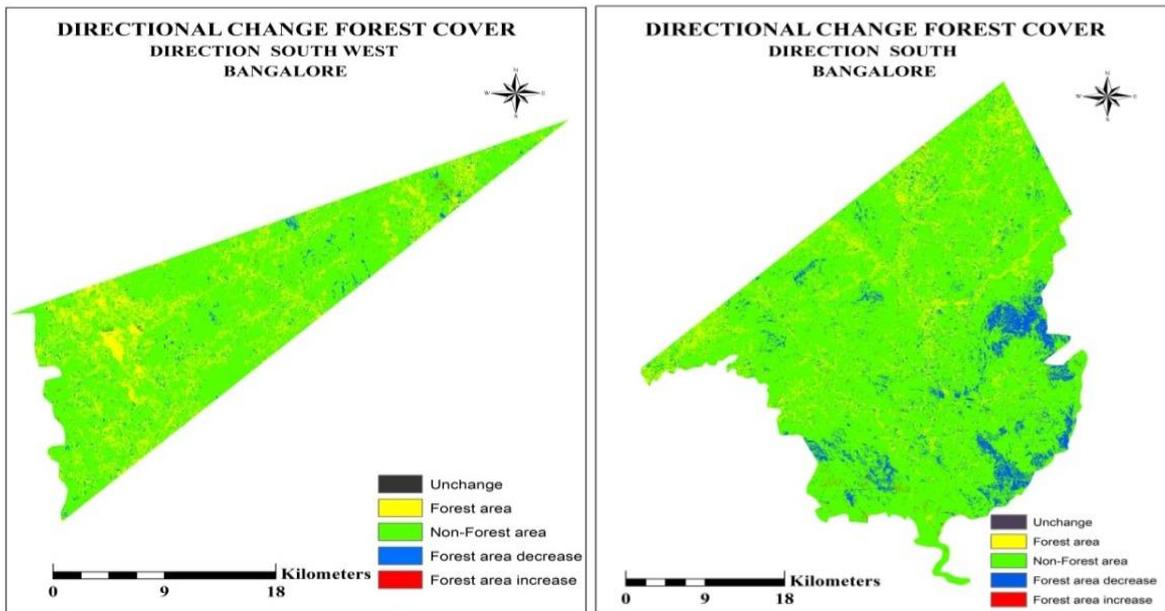


Source: Calculated with NDVI Technology from ArcGIS 9.3.

Figure 5: Directional change of Bangalore Metropolitan Region.

SOUTH WEST

SOUTH



Source: Calculated with NDVI Technology from ArcGIS 9.3.

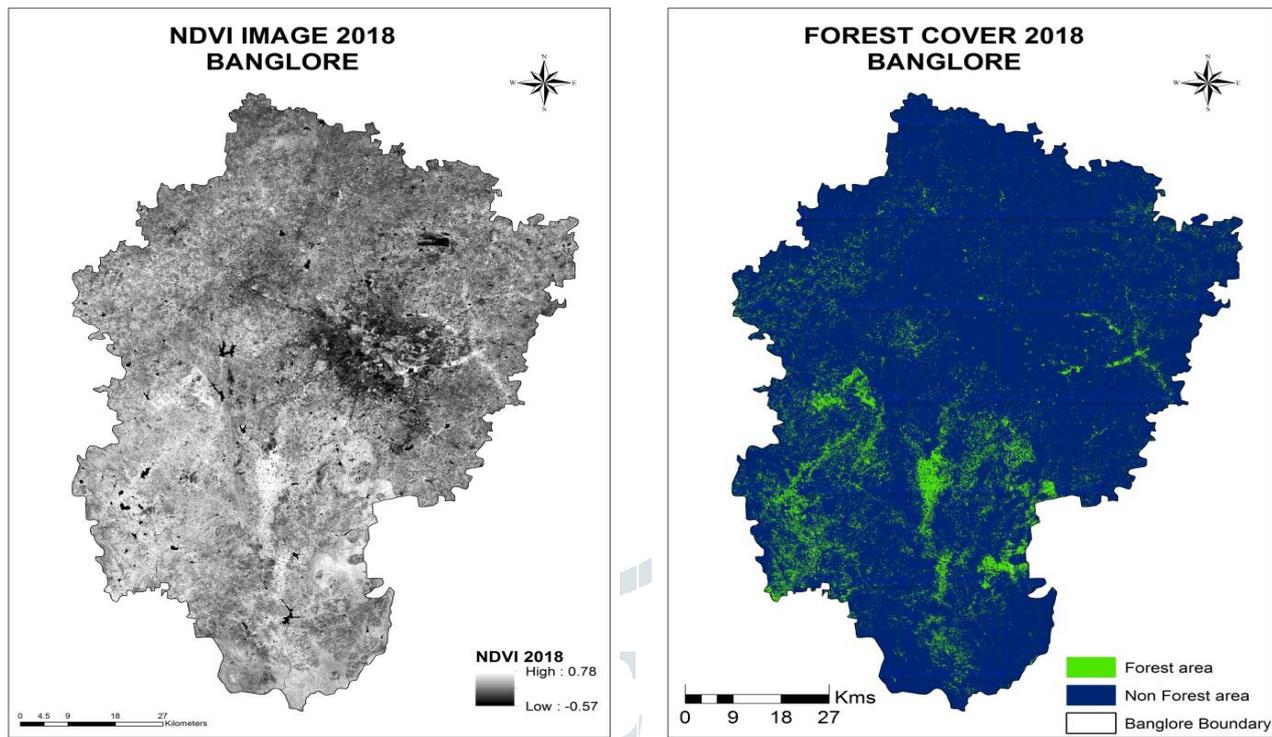
Figure 6: Directional change of Bangalore Metropolitan Region.

Table 4: Directional change in the Forest area of Bangalore Metropolitan Region

NAME OF THE AREA	DIRECTION	FOREST AREA (in sq.km)	CHANGE AREA(Decrease) (in sq.km)	CHANGE AREA (Increase) (in sq.km)
BANGALORE METROPOLITAN REGION	Highlight Image	37.0454	21.884	15.1614
	North	9.747	6.7887	2.9583
	East	2.3994	1.6731	0.7263
	South	4.8042	0.8334	3.9708
	West	1.1043	0.4257	0.6786
	North-east	15.223	10.2825	4.9401
	South-west	1.1808	0.4284	0.7524
	South_east	0.7029	0.4203	0.2826
	North_west	1.8675	1.0242	0.8433

Source: Primary Calculated from NDVI.

**NDVI RESULTS OF BANGALORE METROPOLITAN REGION IN 2018:**



Source: Calculated with NDVI Technology from ArcGIS 9.3.

Fig.: 7 NDVI image of Bangalore Metropolitan Region of 2018

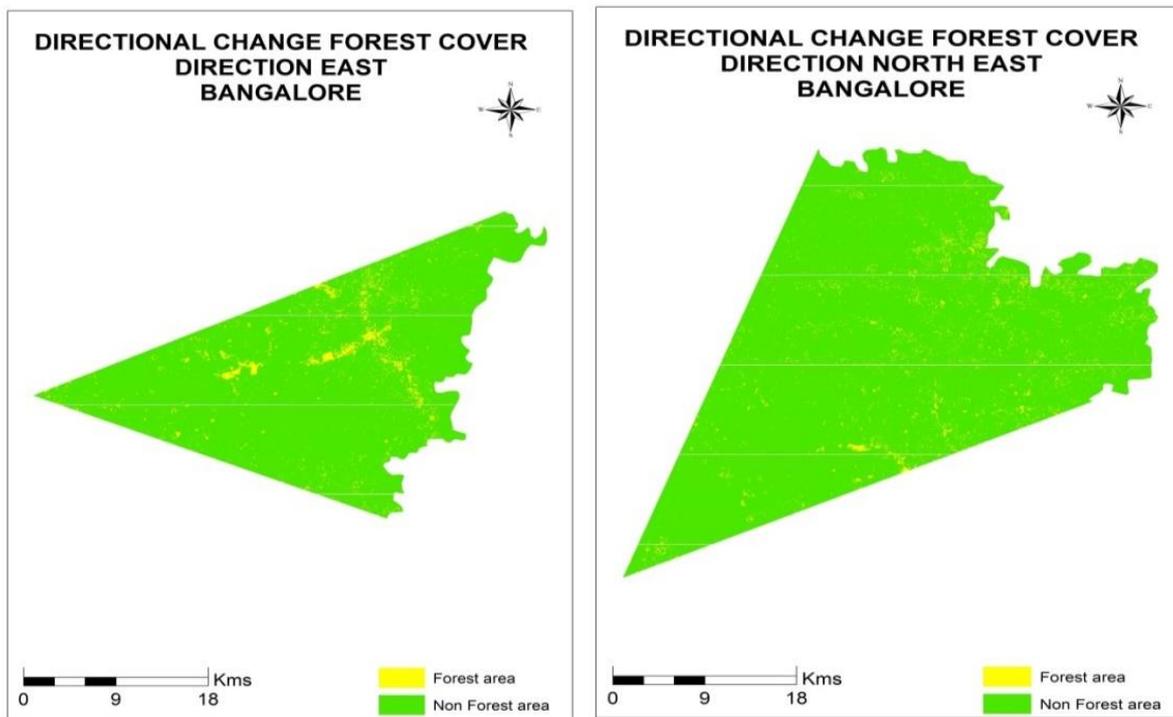
Table 5. Directional change detection of forest cover land area of Bangalore Metropolitan Region in 2018:

	DIRECTION	FOREST AREA (in sq.km) in 2018
BANGALORE METROPOLITAN REGION	North	27.20
	East	30.77
	South	193.78
	West	5.54
	North-east	41.64
	South-west	204.21
	South_east	50.85
	North_west	54.72

Source: Primary Calculated from NDVI.

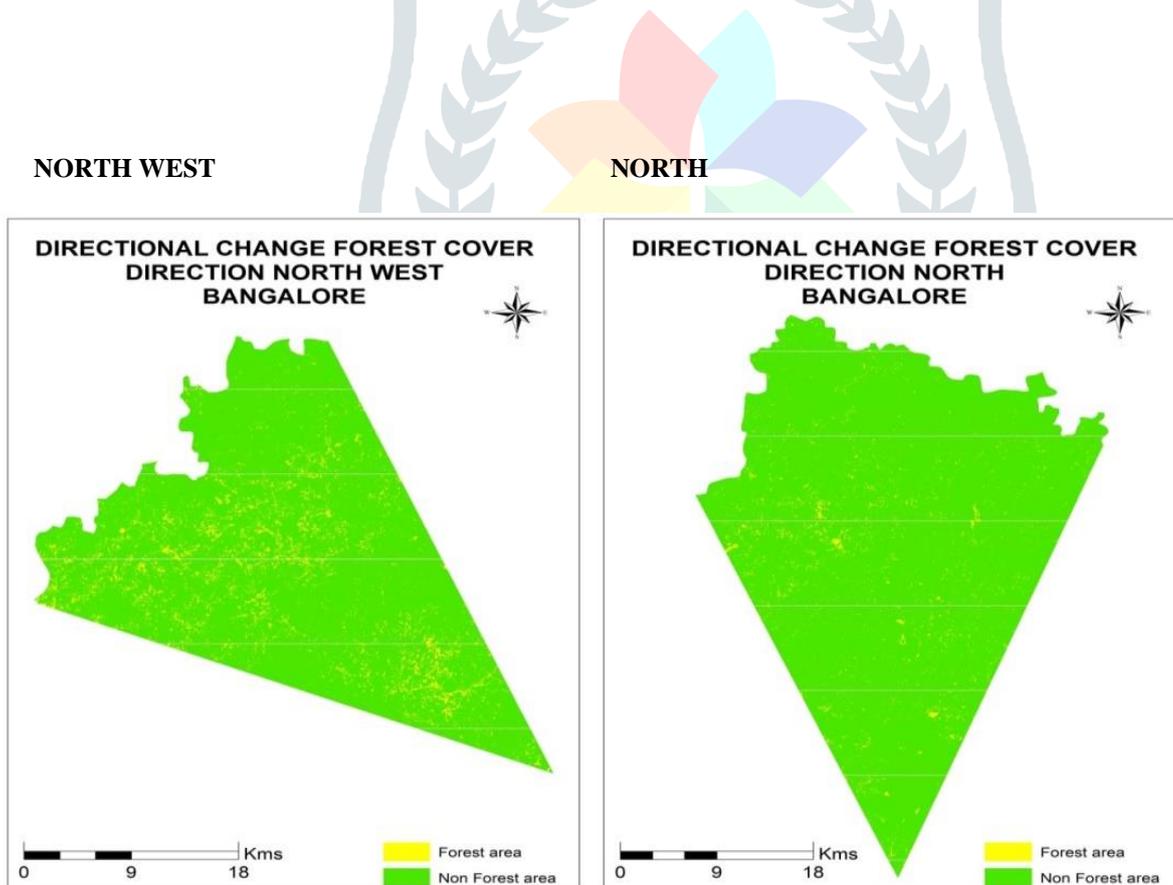
EAST

NORTH EAST



Source: Calculated with NDVI Technology from ArcGIS 9.3.

Fig.: 8 NDVI image of Bangalore Metropolitan Region of 2018.

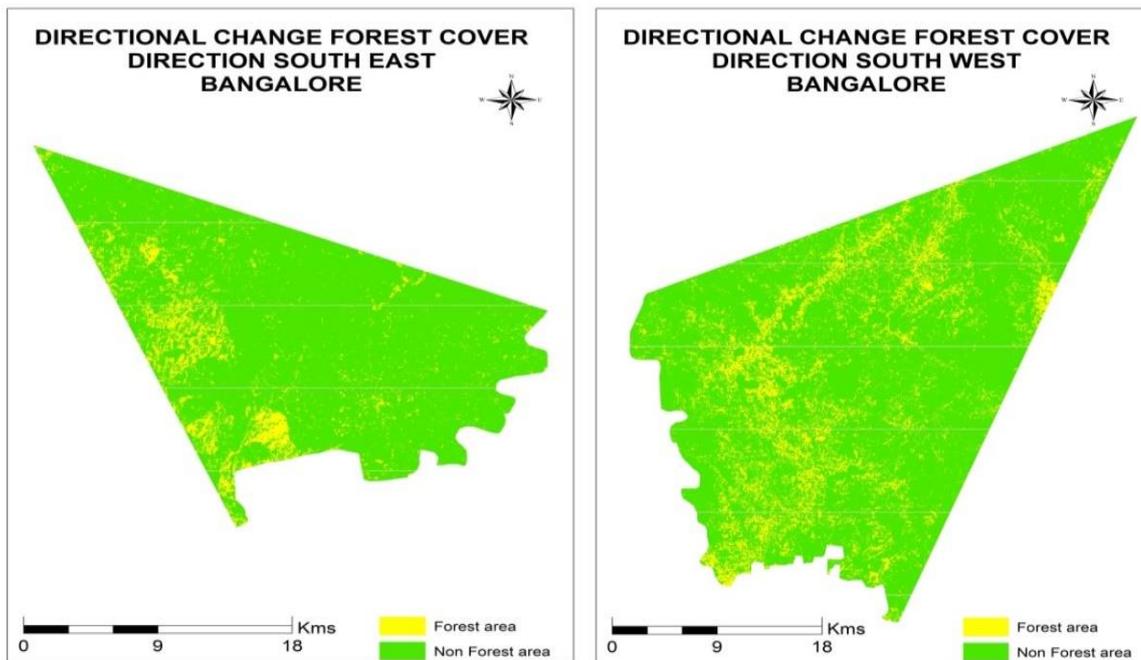


Source: Calculated with NDVI Technology from ArcGIS 9.3.

Fig.: 9 NDVI image of Bangalore Metropolitan Region of 2018.

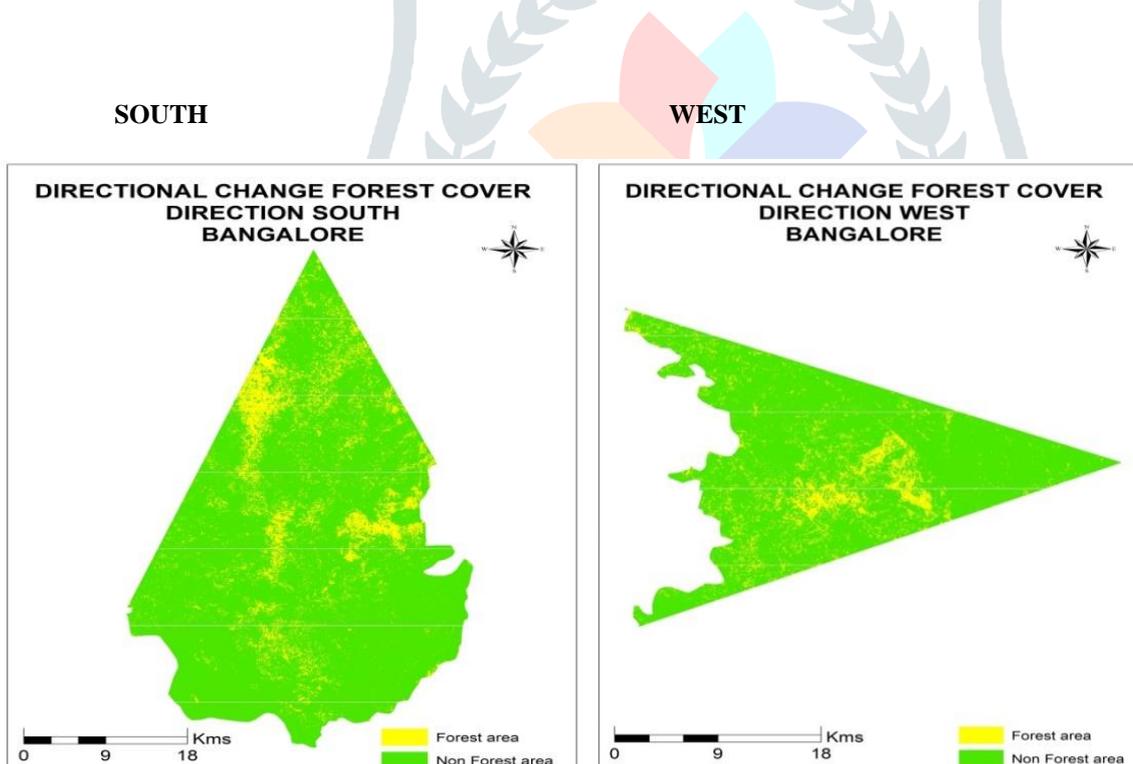
SOUTH EAST

SOUTH WEST



Source: Calculated with NDVI Technology from ArcGIS 9.3.

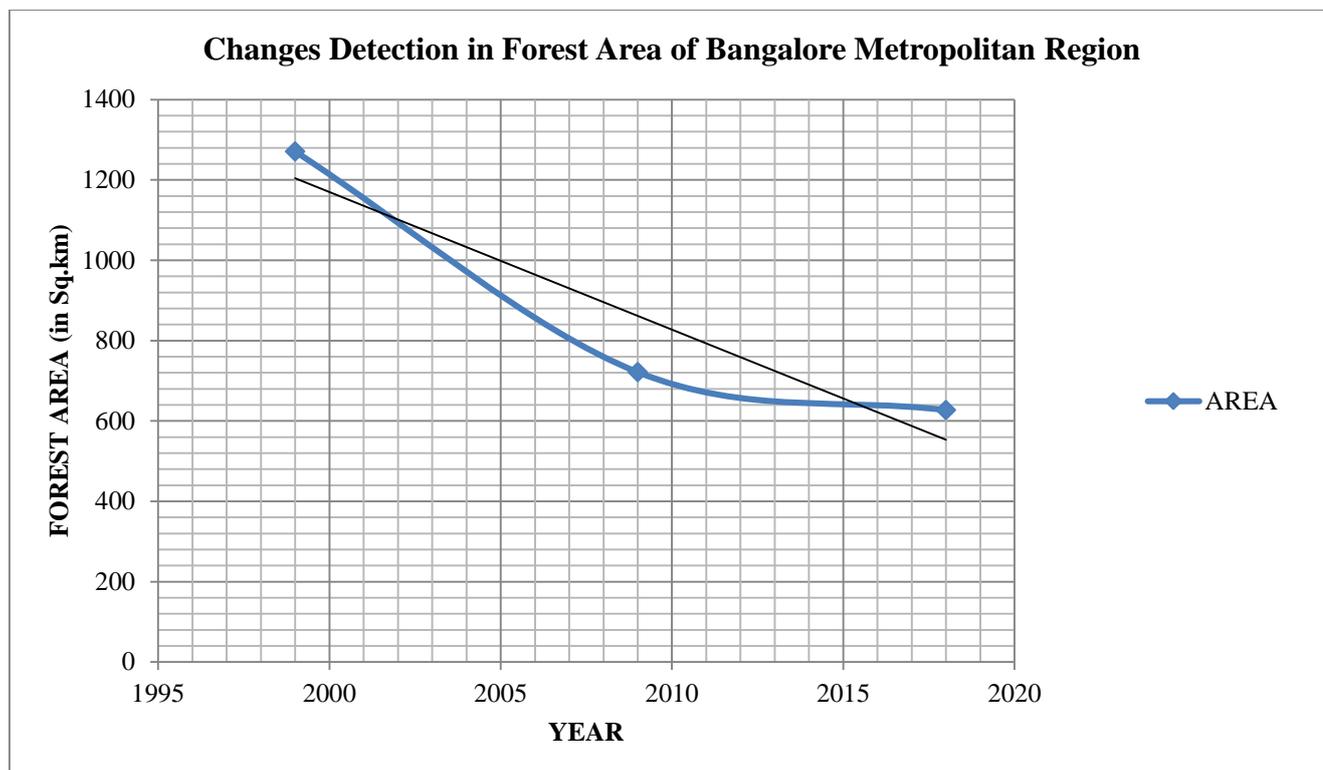
Fig.: 10 NDVI image of Bangalore Metropolitan Region of 2018.



Source: Calculated with NDVI Technology from ArcGIS 9.3.

Fig.: 11. NDVI image of Bangalore Metropolitan Region of 2018.

The results of forest land cover map (Figure 1,2 & 7 and Table 3,4 & 5) show that the area of forest is decreased in every direction and decrease in overall area of the Greater Bangalore. The table data and forest land cover area maps of different time periods (1999, 2009 and 2018) shows the area of forest is declined very much. The below graph show the increase of area of the forest land cover area from 1270.7sq.km in 1999 to 721.652 sq.km in 2009 and decrease near to 627.18 in 2018 as shown in the below graph no. 1.



Source: Primary calculated through MS Excel

Graph 1: Forest area detection in between 1999, 2009 & 2018.

Table 6: Total area under forest in Bangalore Metropolitan Region:

NAME OF AREA	1999		2009		2018		CHANGE (1999-2009)		CHANGE (2009-2018)	
	FOREST AREA		FOREST AREA		FOREST AREA		FOREST AREA		FOREST AREA	
	Sq. Km	(%)	Sq. Km	(%)	Sq. Km	(%)	Sq Km	(%)	Sq Km	(%)
BANGALOR METROPOLITAN REGION	1270.7	17.51	721.652	9.25	627.18	8.63	548.348	7.56	94.472	1.30

**6. RECOMMENDATIONS:** The conversion of forest land is effect the ground water table and other natural resources of water in the area. The soil erosion also increases with depletion of forest land, which effect the issue of soil erosion on large scale. So for controlling these issues, below mention recommendations should be adopted:

- a. Planting more trees around the industrial areas for decreasing the bad effect of industrial wastages and for make the air clean around industrial areas.
- b. Planting of trees around the commercial areas as well residential areas by taking the case study of Singapore. This will affect the carbon emission in the IT hub Bangalore.
- c. Planting of trees along the growth corridors in continue way affect the monsoon pattern and carbon sink of the area.

**7. CONCLUSION:**

The depletion of forests areas also effect on the temperature conditions of that specific areas. The depletion of the big forests badly affects the climatic conditions of Bangalore Metropolitan region. The major carbon sinks are converted into crop land, it can be very dangerous. All deforestation is human induced in Bangalore because with the passage of time the Garden city of India is converted into Silicon city of India and IT hub city of India. The taking off forest patch from Bangalore Metropolitan region continuously in a simulation model effect the roughness of soil and local climate is impacted also. One of the main universal truth states that afforestation has increases the rainfall and decreases the floods over the past 50 years across the world. There is also

evidence that many forests in the Bangalore Metropolitan region are being converted to industrial land. By using the multi resolution imageries or satellite data which had captured through satellite sensors, to analyse the estimation and determination of vegetation in the urban area. "Multi resolution satellite data includes the description of spatial things at different levels. After the analysing and processing of satellite data by using various techniques like as NDVI to estimate the green cover and classify the land use & land cover existing in Bangalore Metropolitan Region. The vegetation cover is extracted for all the wards that constitute in the Bangalore Metropolitan Region. There has been rapid increase in the Concrete jungle in Bangalore, Which might seem to be increase in the carbon contents in Bangalore due to degradation of forest cover. But this loss will affect the land and danger in the coming years by loss of ground water and safe water for drinking. The rapid increase in population increasing the land for building utilisations in the Bangalore Metropolitan Region and degrading the natural vegetation and green forest include the green patches.

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