Greenness Analysis of Dhaka Using NDVI MODIS Database

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A Thesis
Submitted in partial fulfillment of the requirements for the Degree of
Bachelor of Science in Computer Science and Engineering

Submitted by

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CANDIDATES' DECLARATION

We, hereby, declare that the Thesis presented in this report is the outcome of the investigation performed by us under the supervision of Prof. Dr. Kazi A. Kalpoma, Department of Computer Science and Engineering, Ahsanullah University of Science and Technology, Dhaka, Bangladesh. The work was spread over two final year courses, CSE4100: Project and Thesis I and CSE4200: Project and Thesis II, in accordance with the course curriculum of the Department for the Bachelor of Science in Computer Science and Engineering program.

It is also declared that neither this Thesis nor any part thereof has been submitted anywhere else for the award of any degree, diploma or other qualifications.

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CERTIFICATION

This Thesis titled, **"Greenness Analysis of Dhaka Using NDVI MODIS Database"**, submitted by the group as mentioned below has been accepted as satisfactory in partial fulfillment of the requirements for the degree B.Sc. in Computer Science and Engineering in January 2020.

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ABSTRACT

Greenness analysis refers to the analysis of forestation and green areas of a certain area. Remote sensing using satellite imaging is by far the most useful and easy way to do it.Remote sensing satellite images have not been thoroughly studied in greenness analysis of Bangladesh. The purpose of this study is to create a systemic database for greenness analysis of Dhaka Division of Bangladesh. Here, we developed a web-based greenness analysis tool for Dhaka Division using Moderate-resolution Imaging Spectroradiometer (MODIS) Normalized Difference Vegetation Index (NDVI) data. NDVI values from 2001-2015 of MODIS are used to extract the greenness of this regions and to show greenness has changed. NDVI is a vegetation index which is used to calculate amount of greenness and which is the most popularly used vegetation index used in Remote sensing. NDVI values of greenness ranges from 0.4 to 0.8. Using satellite images as base and performing algorithms and methods, this study has extracted each green pixels from the original images and used for analysis. Analysis of the study is shown in a web-based greenness analysis tool. This tool allows to see yearly changes, monthly changes, time-series analysis and comparisons between any district of Dhaka Division. These options can show how greenness changes yearly among the districts and if they are related to each other. The study has found that Dhaka division, and by a larger extent Bangladesh, is an agricultural country and most of the green is based on agricultural crops as it shows increase of green during the period of cultivation for crops. Moreover, yearly changes of green show the lower percentage during rainy season and high percentage during the periods of cultivation. This means Dhaka division's greenness is mostly not from forestation. We can say that amount of nursery, rooftop gardens and vegetable gardens have risen and lowering of water-logging. Even though there is no ground data to compare this study to, it can be showed that it is correct as it is proved by other researches that NDVI takes both crops and forestation green to it's account and by seeing the yearly changes of greenness.

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Chapter 1

Introduction

1.1 Overview

In the past decades, with the advent of modern industrialization and growing population, forestry and vegetation areas are becoming scarcer each year. Forest regions have a deep impact on environmental and climate issues [1]. Forest region around the world is mostly observed using remote sensing [2]. Nowadays, advanced remote sensing has become a powerful monitoring tool for many aspects of global monitoring for its convenience and high efficiency. Our work will be on greenness analysis for over a period of time in Dhaka division to see the changes happening. The method to observe greenness is based on vegetation indexes of which we will use NDVI. Normalized Difference Vegetation Index (NDVI) is one of the most important and commonly used satellite-based vegetation indexes for monitoring vegetation changes [3].

Natural forestry and more vegetation or green areas tend to better environment and better health [4]. We can also infer better environment areas and more satisfactory and healthy living areas from the greenness of each region. We can show this by performing our work and showing its results.

1.2 Motivation

Many countries have advanced greenness detection and database storage systems. This data is then used for various future works and other researches. Greenness analysis gives us the geographical changes in the area in a systemic way over a time period, which is needed to take further future actions and systemic evaluation. Some of the motivations of greenness analysis can be:

- **Detect Green Areas:** From our research , we will be able to see changes in the green area throughout our study area. We can also learn about how greenness changes based on the time of year and also year by year, Monthly changes will also be noticed.
- **Environmental:** Researching about greenness also gives us info about environments. We can detect which areas have better environmental areas, and which areas suffered more environmental degradation over the years. It also gives us a better understanding of each areas and which areas are more suitable to live.
- **Forestry:** This work will also be able to tell which areas are green are always green throughout the year. That means that these areas are forest areas, and we can find its area.
- **Research Applications:** Our database and analysis can be further implemented and researched in other ways by other people if they are interested. It also gives way to another form of works with this approach.
- **Government Use:** Government may be able to use our data to further their works. Most government based forest mapping are not yet remote sensed. They can integrate it to their work. This data will also be useful to Ministry of Environment, Forest and Climate change

1.3 Objective

The main objective of this research is to create MODIS NDVI database for Dhaka Division so that we can use it for our analysis. This database will also be able to help in other researches like environmental researchers, forestation and urbanization researchers. Government ministry of environment, forest and climate can use this to replace their old technology. These analyses include changes in greenness, how greenness is affected yearly and other comparisons between an area's location in our study area. We will also focus on to creating a web-based greenness analysis tool which will show us the results of the database dynamically chosen by the user. These will include monthly analysis, yearly analysis, comparisons are time-series analysis.

1.4 Thesis Outline

- **Chapter 1 Introduction:** This chapter will introduce to us about a short description of our thesis work and the reasons of a greenness analysis system, its' motivation and objectives.

- **Chapter 2 Literature Review:** In this chapter, we will review some works done on this field and see what each of them did and accomplished. A short summary about each of the works will also be detailed.
- **Chapter 3 Remote Sensing MODIS Data:** This chapter covers the necessary basics and needed background studies necessary for our thesis. We will learn about remote sensing, GIS, Satellite data, Modis, NDVI and reprojection, which will be necessary in our proposed methodology and works.
- **Chapter 4 Proposed Methodology:** In this chapter, We will briefly describe our entire procedure from the beginning, which is to acquire the data to the end where we complete the database. Our study area will also be shown here.
- **Chapter 5 Experimental Results:** This chapter includes the results found from our work and show some analysis based on this. We discuss some of the results and show how they have changed over the years.
- **Chapter 6 Web-based Greenness analysis tool for Dhaka division:** In this chapter, We will implement our entire work in a web-based system to visually show our work. This web-based implementation will be entirely dynamic and GUI oriented. There are at least four types of comparisons and analysis shown here.
- **Chapter 7 Conclusion and Future Work:** This is the final chapter of our thesis and contains the conclusion and shows the possibility of future works.

Chapter 2

Literature Review

2.1 Overview

Over the years, there have been some researches happening on remote sensing. However, not many are done on greenness analysis. Here we will discuss some of the previous works done in remote sensing and discuss about them.

2.2 Related Works

There are two fields of works that we will be interested in to conduct our analysis on. One is Remote sensing and another is Greenness analysis. Remote sensing is the concept of using images captured by satellites revolving around the Earth. Many such previous works have been done using remote sensing. There are many categories of remote sensing used using satellites. Some of these are - Fire detection, Vegetation Index sensing , Air pollution detection and some others. The reason remote sensing is important that it can give far better calculated values than normal field studies. Some works of remote sensing include Fire monitoring of Russia and Northern Asia using NOAA (National Oceanic and Atmospheric Administration) database [5]. Another NOAA database used project was Tohoku University's Japan image database (JAIDAS) using high-resolution picture transmissions (HRPTs) [6]. J. Cheng et al. emphasized the fact that satellite remote sensing has been widely used in crop monitoring program for the past several decades because it can provide effective and timely spatial and temporal information on crop planting areas and growth conditions [7]. MODIS satellite remote sensing has been used to locate greenness globally [8].

However the main challenge is to relate remote sensing to forestation and vegetation i.e greenness. It is quite obvious for anyone to wonder about the way, such a technology can be used in studying greenness. Louis Kouadio at el. said that the Normalized Difference Vegetation Index (NDVI) which is based on the contrast between the maximum absorption in the red portion and the maximum reflection in the near-infrared portion of the electromagnetic spectrum has been widely utilized for vegetation monitoring and agricultural statistics [9]. Another research said that the NDVI has been widely used for this type of methodology and activities [10].

NDVI related greenness works have been ongoing for a long time. Most of these researches include plant biomass and plant phenology [11] [12]. Researches have also shown how NDVI changes seasonally and how greenness is affected by it. Authors of [4] show how NDVI and greenness affect health and other factors in humans.

There are also researches which show NDVI's seasonal changes during a year and how forest regions changes [13]. Their work showed that NDVi value and greenness tend to keep high during spring and season as trees grow new leaves and is lower during summer and winter due to weather conditions.

Environmental changes also depend on greenness. According to another research, vegetation change plays a crucial role in the environmental process [14]. Vegetation indices can serve as a sensitive indicator of climate and anthropogenic influences by altering energy balance, climate and other factors.

Chapter 3

Remote Sensing Satellite Modis Data

3.1 Overview

In this Section we will learn about the prerequisites to understand before working our way through Greenness analysis . The sections in this chapter will talk through different topics that are related to each other and further down. Section 3.2 will be taking about Remote sensing and how it is done and also about its' significance. Section 3.3 will talk the Geographic Information system that handles the Remote sensed and Satellite data to produce results and analyses. Section 3.4 is about Satellite Data. Section 3.5 Focuses on Modis. Modis is a type of imaging sensor that is important in our analysis. Modis products are used to remotely sense the land areas of the world. Next, section 3.6 and section 3.7 talks about sensing greenness and types of method to sense it. However, we will be focusing on NDVI as it is our core focus and discuss how NDVI works and its' details. Finally, section 3.8 focuses on the reprojection system that we will use.

3.2 Remote Sensing

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on-site observations, especially the Earth. Remote sensing may be done by pixel or object sensing [15]. Different sensors or other such elements on Satellites to sense it from there. From the sensors, calculations are made to make datasets or more than occasionally, image is taken and that image can be used as datasets.

The sensors can be of two kinds - active sensors and passive sensors. An active sensor emits radiation in the direction of the target to be investigated. The sensor then detects and measures the radiation that is reflected or backscattered from the target. Passive sensors, on the other hand, detect natural energy (radiation) that is emitted or reflected by the object or scene being observed. Different sensors are mounted on different sensors to make it unique and do its relevant job.

Remote sensing usually works in a particular area for a long time to collect data. It allows data to be collected without using manpower and taking too much time. The advantages of remote sensing are:

- It can retrieve large amounts of data.
- It reduces manual field work dramatically.
- It allows retrieval of data in regions difficult or impossible to access.
- Remote sensing is a relatively cheap and constructive method reconstructing a base map in the absence of detailed land survey methods.
- It allows collection of more data in a short period of time
- It covers a limited study area at a time.
- Remotely sensed data can easily be processed and analyzed fast using a computer and the data utilized for various purposes.
- It is easier to locate floods or forest fire that has spread over a large region which makes it easier to plan a rescue mission easily and fast.

3.3 Geographic Information System (GIS)

GIS, or Geographic Information System is a system that is a computer-based tool for mapping and analyzing features and events on earth. GIS technology integrates common database operations . GIS is mostly used in Remote sensed data to analyze the collected data, do monitoring, mapping and do map analysis [16] [17]. ArcGIS is the most used GIS software and we will be using it to process our data before working our analytics on it.

3.4 Satellite Data

Satellite Data or satellite imagery taken from above the ground through remote sensing. Many different satellites orbit around the Earth to sense data. Some of these are MODIS, Landsat and others. We will be Using MODIS for our work. MODIS works on two, Terra and Aqua spacecraft and measures 36 spectral bands over three spatial resolution- 250m, 500m and 1000m. Vegetation and Forestry observation using Satellite data has been going for a long time [18].

Advantages of satellite based remote sensing are:

- **Cost Effectiveness** - Cost of satellite capacity does not increase with the number of users/receive sites, or with the distance between communication points. Whether crossing continents or staying local, satellite connection cost is distance irrelevant.
- **Global Availability** - Communications satellites cover all land masses and there is growing capacity to serve maritime and even aeronautical markets.
- **Superior Reliability** - Satellite communications can operate independently from terrestrial infrastructure. When terrestrial outages occur from man-made and natural events, satellite connections remain operational.
- **Superior Performance** - Satellite is unmatched for broadcast applications, the speed, uniformity and end-to-end control of today's advanced satellite solutions are resulting in greater use of satellite by corporations, governments and consumers.
- **Versatility** - Satellites have effective support on a global basis all forms of communications ranging from simple point-of-sale validation to bandwidth intensive multimedia applications. Satellite solutions are highly flexible and can operate independently or as part of a larger network.

3.5 Moderate Resolution Imaging Spectroradiometer (MODIS)

MODIS or, Moderate Resolution Imaging Spectroradiometer is an imaging sensor that is used by NASA and launched in 1999. This is used in Terra and Aqua Satellite and different bandwidths are used for different purposes. The instruments capture data in 36 spectral bands ranging in wavelength from 0.4 μm to 14.4 μm and at varying spatial resolutions (2 bands at 250 m, 5 bands at 500 m and 29 bands at 1 km).

With its low spatial resolution, but high temporal resolution, MODIS data is useful to track changes in the landscape over time. Examples of such applications are the monitoring of vegetation health by means of time-series analyses with vegetation indices, long term land cover changes (e.g. to monitor deforestation rates) [19] [20]. There are 8, 16 or 32- days monitoring system on MODIS. The images are mainly taken using the electromagnetive wave reflectance method. MODIS is designed to provide measurements in large-scale global dynamics including changes in Earth's cloud cover, radiation budget and processes occurring in the oceans, on land, and in the lower atmosphere [21].

There are quite a few MODIS products that can be used.Some of these are:

Table 3.1: Examples of MODIS products

Name	Collection	Keyword	Spatial Resolution	Time
MOD13A1.006	Terra MODIS	Vegetation Indices	500	Multi-Day
MOD13A2.006	Terra MODIS	Vegetation Indices	1000	Multi-Day
MOD13A3.006	Terra MODIS	Vegetation Indices	1000	Monthly
MOD13Q1.006	Terra MODIS	Vegetation Indices	250	Multi-Day
MOD14.006	Terra MODIS	Thermal anomalies and Fire	1000	$<$ Daily
MOD09A1.006	Terra MODIS	Reflectance	500	Multi-Day

What we need for our research is MOD13Q1 which takes values for vegetation indices and Takes data in 16-day periods.

3.5.1 MOD13Q1

The Terra MODIS Vegetation Indices (MOD13Q1) Version 6 data are generated every 16 days at 250 meters (m) spatial resolution as a Level 3 product . Each pixel in this has a resolution of 250m*250m. The MOD13Q1 product provides two primary vegetation layers. The first is the Normalized Difference Vegetation Index (NDVI) which is used in most cases where vegetation index is required and with MODIS [22]. The second vegetation layer is the Enhanced Vegetation Index (EVI), which has improved sensitivity over high biomass regions. The algorithm chooses the best available pixel value from all the acquisitions of the 16 day period. The criteria used is low clouds, low viewing angle, and the highest NDVI/EVI value.

The NDVI value of each pixel and its changes will need to be documented to see how the greenness changes. Each MOD13Q1 image has 12 layers, each having different values. Only the first layer has the NDVI index, which is called "250m 16 days NDVI".

250m 16 days NDVI has a valid range of -3000 to 10000 and scale factor of 0.0001. Which means if we want to get actual values, it needs to be multiplied by 0.0001. Unknown or unseen value is assigned -3000.

We have downloaded a total of 10 years of MOD13Q1 data content. Each image having 200-250 MB of size and Bangladesh uses two blocks of these each time. There are about 23 imagesets every year, for this our total content to work with is at almost 90GB for 15 years.

3.5.2 Datasets

There is a total of 23 datasets available per year with 16 days interval. The datasets are available to download in DOY (Day of Year) Format. Acquisition of Satellite images are stored in DOY. Each year, 11 months have 2 data each and 1 month has 1. This change factor during leap years. Years with leap years have two datasets during October and one during Novembers. Other years have reverse of this with October having one and November having two [23]. The details of this are given in table 3.2.

Table 3.2: Modis datasets acquisition dates

Data no.	**DOY**	**Non Leap Year**	**Leap Year**
1	001	Jan 01	Jan 01
2	017	Jan 17	Jan 17
3	033	Feb 02	Feb 02
4	049	Feb 18	Feb 18
5	065	Mar 06	Mar 05
6	081	Mar 22	Mar 21
7	097	Apr 07	Apr 06
8	113	Apr 23	Apr 22
9	129	May 09	May 08
10	145	May 25	May 24
11	161	Jun 10	Jun 09
12	177	Jun 26	Jun 25
13	193	Jul 12	Jul 11
14	209	Jul 28	Jul 27
15	225	Aug 13	Aug 12
16	241	Aug 29	Aug 28
17	257	Sep 14	Sep 13
18	273	Sep 30	Sep 29
19	289	Oct 16	Oct 15
20	305	Nov 01	Oct 31
21	321	Nov 17	Nov 16
22	337	Dec 03	Dec 02
23	353	Dec 19	Dec 18

3.6 Greenness Analysis by NDVI MODIS Data

Remote sensing for information regarding greenness, environmental monitoring, checking biodiversity, agriculture and such other works have existed for at least the last three decades [24]. In terms of platforms, the advantages of satellite based remote sensing include high spatial resolution, which makes possible the extraction of long time data series of consistent and comparable data, which can be cost effective [10]. The method of which detection can happen is based on the Vegetation indexes (VI) used.

The reason for satellite based remote sensing is mainly its Spatial Resolution, which makes possible the extraction of long time data series of consistent and comparable data, which can be cost effective. The pixel resolution of MODIS satellite can range from 250m*250m towards 1000m*1000m. These are much better to work on large scale areas. As discussed before, MODIS uses electromagnetive wave reflectance information from passive sensors to gather data. However, this has a problem as passive sensors sometimes have trouble penetrating clouds and therefore, data found during cloudy days maybe somewhat misleading [25].

3.6.1 Vegetation Index

Vegetation indexes (VI) are the main performance ratios by which the greenness of a place is calculated. Vegetation indexes are mainly used for:

- examine climate trends [26]
- estimate water content of soils remotely [27]
- schedule crop irrigation and crop management [28]
- monitor drought [29]
- classify vegetation [30]

The First vegetation index was proposed by Jordan in 1969. This was called Ratio Vegetation Index (RVI). This was based on the principal that leaves absorb more red than infrared light. This also had another form which was the Difference Vegetation Index (DVI) which says the difference between red (RED) and infrared (NIR) lights [31].

The most common Vegetation index, which is used is NDVI (Normalized Difference Vegetation Index) and EVI (Enhanced Vegetation Index). NDVI uses a ratio between red and infrared to calculate and EVI is an optimized vegetation index designed to enhance the vegetation signal with improved sensitivity in the high biomass region and has a complicated equation to quantify it [31]. GNDVI (Green Normalized Difference vegetation index) and OSAVI (optimized soil-adjusted vegetation index) are also used to monitor ground and crop areas [32]. These type of indexes may also use green reflected (GREEN) and blue reflected (BLUE) lights.

Some comparison between used Vegetation indexes are given below:

Table 3.3: Examples of Vegetation Indexes

Vegetation Index	Full form	Equation
RVI	Ratio Vegetation Index	$\frac{NIR}{RED}$
DVI	Difference Vegetation Index	NIR- RED
NDVI	Normalized Difference Vegetation Index	$\frac{NIR-RED}{NIR+RED}$
EVI	Enhanced Vegetation Index	$2.5* \frac{NIR-RED}{NIR+6*RED-7.5*BLUE+1}$
GNDVI	Green Normalized Difference vegetation index	$\frac{NIR-GREEN}{NIR+GREEN}$
OSAVI	optimized soil-adjusted vegetation index	$\frac{NIR-RED}{NIR+RED+0.16}$

3.7 Normalized Difference Vegetation Index (NDVI)

NDVI or, Normalized Difference Vegetation Index is a simple graphical indicator that can be used to analyze remote sensing measurements, typically, but not necessarily, from a space platform, and assess whether the target being observed contains live green vegetation or not. NDVI is used concurrently with MODIS Terra and Aqua Satellites. (NDVI) is one of the most important and commonly used satellite-based vegetation indexes for monitoring vegetation changes and its interaction with various climatic variables to interpret its impact on biosphere [3].

Out of all the bands MODIS uses, only seven of them are used in NDVI. These are band 1 (620 – 670 nm), band 2 (841 - 876nm), band 3 (459 –479 nm), band 4 (545 – 565 nm), band 5 (1230 - 1250 nm), band 6 (1628 - 1652 nm) and band 7 (2105 – 2155 nm). However, only band 1(RED) and 2(NIR) are used to calculate NDVI. Where NIR is the reflectance in the near-infrared channel and RED is the reflectance in the red channel. More than 90 percent of vegetation information is contained in these RED and NIR band [33].

NDVI value ranges from -1 to +1. The more it is towards positive, the more green that location is. Water areas tend to be around 0 and more deserted places are closer to -1.

NDVI value is, however sensitive as it relies on wavelengths as wavelengths can vary for a few reasons like:

- Atmospheric effects
- Clouds
- Soil Effects
- Spectral effect

3.7.1 Measuring NDVI

NDVI is measured using the RED and NIR bands of light. Plants take in both infrared and red light bands. However, only a percentage of this is reflected off of the plant afterwards. This is the reflected percentage of the light bands. This value is then necessary to calculate NDVI value. The formula for NDVI is :

$$NDVI = \frac{NIR - RED}{NIR + RED}.$$

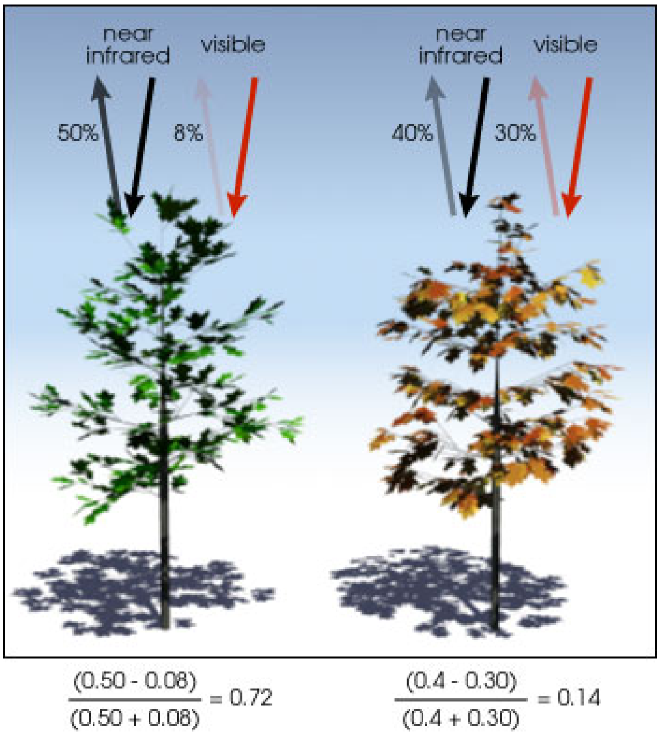


Figure 3.1: NDVI calculation

The underlying principle of the above formula is that the radiation from visible red light is considerably absorbed (or poorly reflected) by chlorophyll in green plants, while the radiation from near infrared light is strongly reflected by the spongy mesophyll leaf structure [34].

As we can see, the percentage of light that is reflected is used to determine the NDVI value. Nearly all satellite Vegetation Indices employ this difference formula to quantify the density of plant growth on the Earth.

The NDVI image taken from the MOD13Q1 MODIS satellite takes images of the Earth in a 16-bit signed format [35]. So the total number of pixel values that can be acquired is 2^{16} or 65536 . As is it in a signed integer format the value is from -32767 to +32767. Now, NDVI has a value of -1 to +1 . So the pixel value is normalized at a factor of 10000 that means the entire pixel values of the image is divided by 10000. The pixel that has no values are assigned 32767.

3.7.2 NDVI Ranges

The ranges of NDVI as previously discussed before ranges between 0 and 1. This range is divided into multiple sections depending on the soil and ground condition. More deserted areas tend to be closer to -1 and greenish area go near +1. Watery area cover around 0. The table 3.4 shows the range of NDVI Values [36].

Table 3.4: NDVI ranges

Sr. No	NDVI	Main ground cover
1	$<$ -0.185	Water
2	-0.185 - .063	Urban used Area
3	.063 - 0.4	Natural ground
4	$>$ 0.4	Forestation or Vegetation

However NDVI has a tendency to change its value depending on the weather, season or different natural causes. Therefore This range of values may change depending on various factors.

3.8 Reprojection

The MODIS and NDVI data or images taken from the space are sinusoidal [37]. This image of Earth is taken on 36 horizontal and 18 vertical blocks. Which means there are a total of 648 blocks.

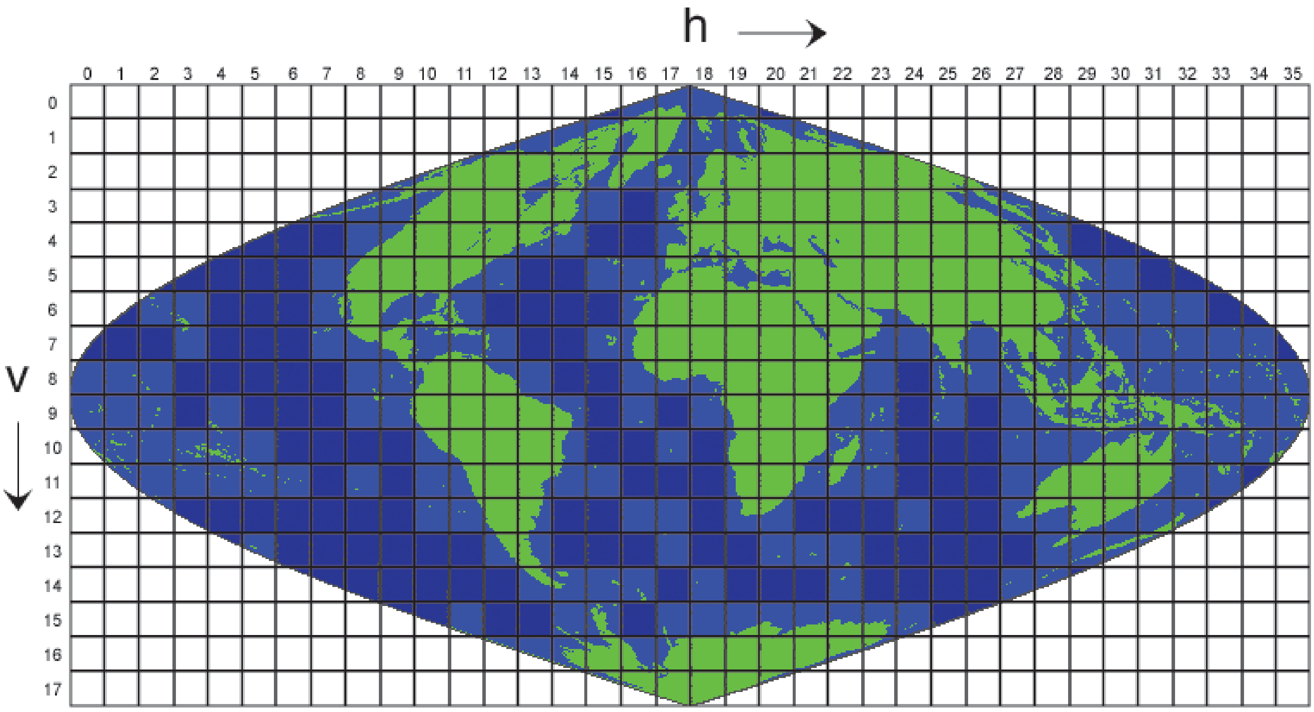


Figure 3.2: MODIS sinusoidal

This image, however does not represent the Earth's map honestly and more and more changes are seen as it moves to either south or north pole. To fix this and find a better one, we need the more consistent WGS84 projection. This projection is better and more consistent to Earth's geography [38].

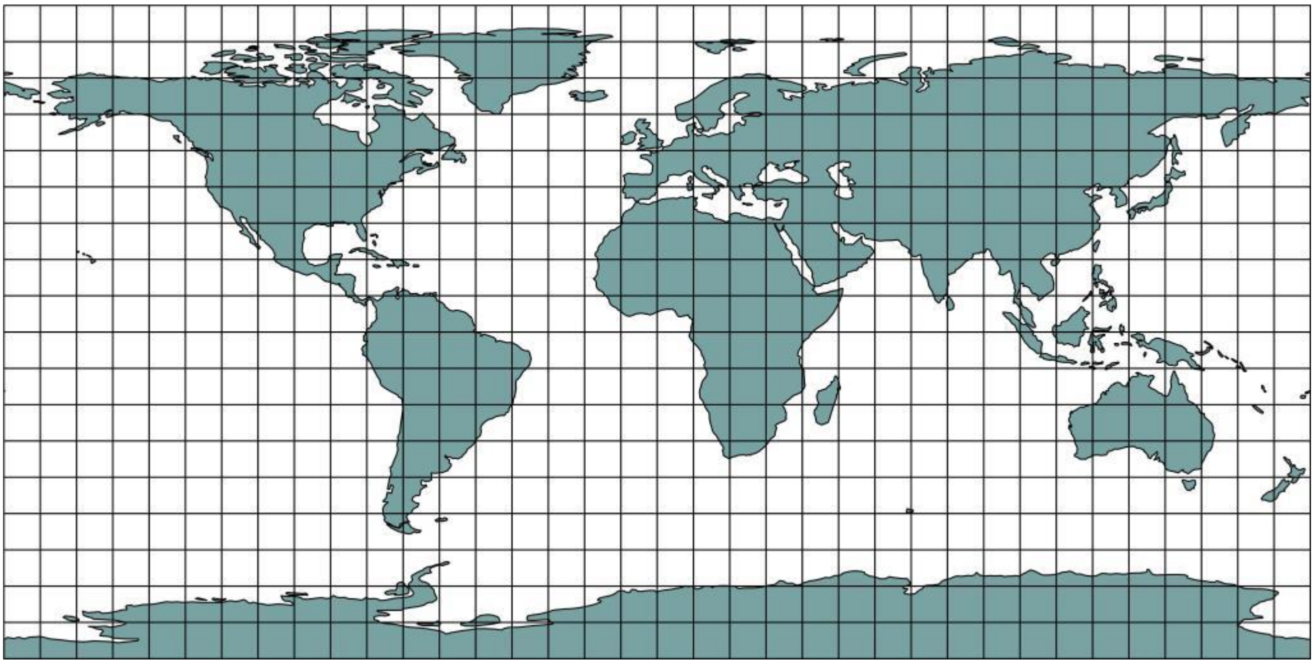


Figure 3.3: WGS84

Chapter 4

Proposed Methodology

4.1 Study Area

Our objective is to make a database of Dhaka division's NDVI images over a course of 15 years ranging from 2001 to 2015 and then do analysis from it. The Area of our study is Figure 4.1 which is the entire Dhaka division.

The area of Dhaka Division is 20,508.8 km^2 and is constituted of 13 districts. These districts are:

Table 4.1: districts in Dhaka divisions and their area

Districts	**Area (km^2)**
Dhaka	1,463.60
Faridpur	2,052.68
Narsingdi	1,150.14
Gazipur	1,806.36
Gopalganj	1,468.74
Kishoreganj	2,688.59
Madaripur	1,125.69
Manikganj	1,383.66
Munshiganj	1,004.29
Narayanganj	684.37
Rajbari	1,092.28
Shariatpur	1,174.05
Tangail	3,414.35

We will conducting our analysis on these districts. Figure 4.1 shows our entire study area in respect to our country and Figure 4.2 shows the districts inside.

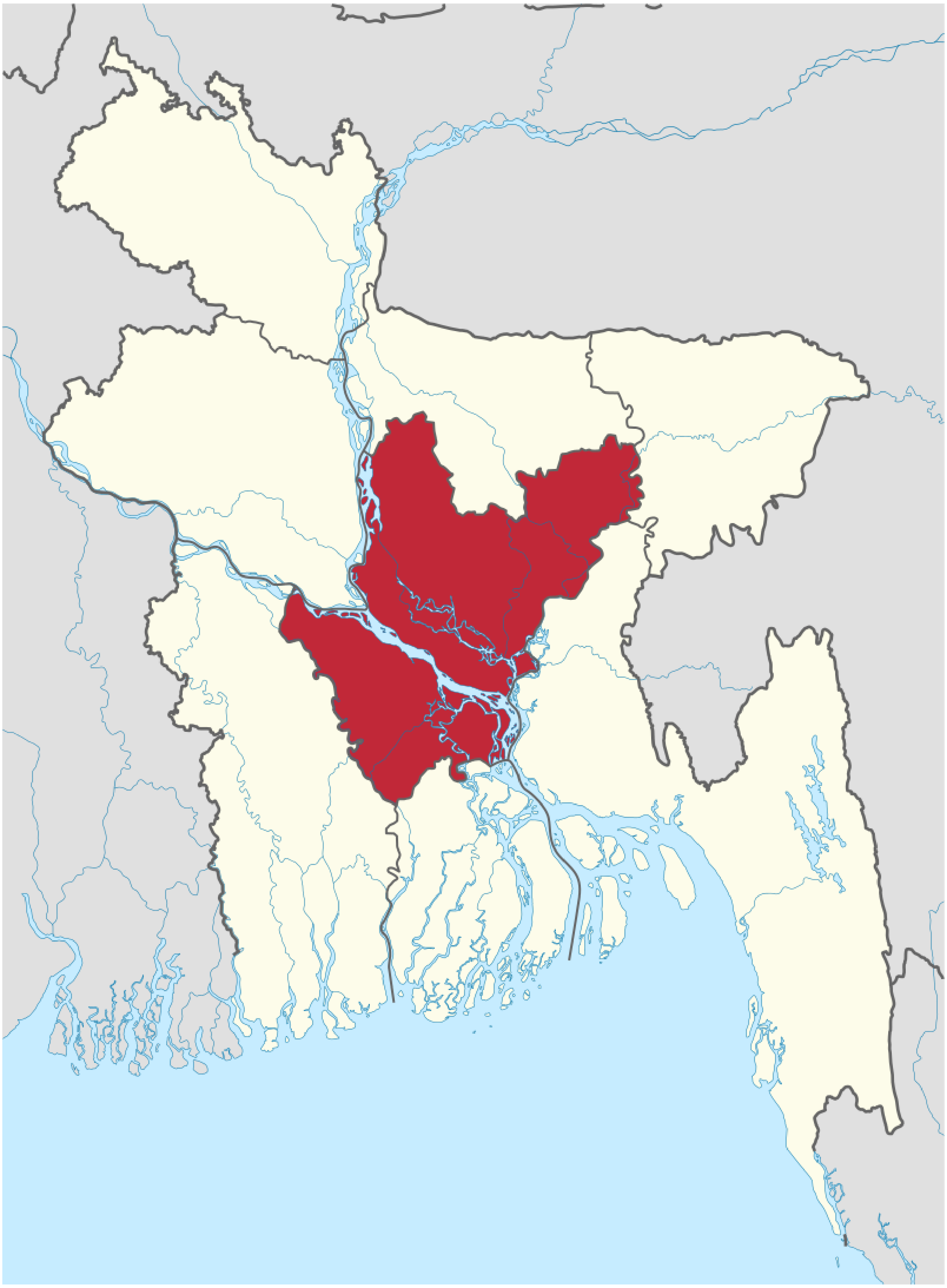


Figure 4.1: Study Area for Greenness Analysis

Figure 4.2: Districts in Dhaka Division of Bangladesh

4.2 Database Creation Overview

Figure 4.3 is a flowchart that shows our workflow on how we will create the database of images from NDVI MOD13Q1 images acquired from NASA. This process shows the beginning from taking the image from NASA's USGS website to creating our database.

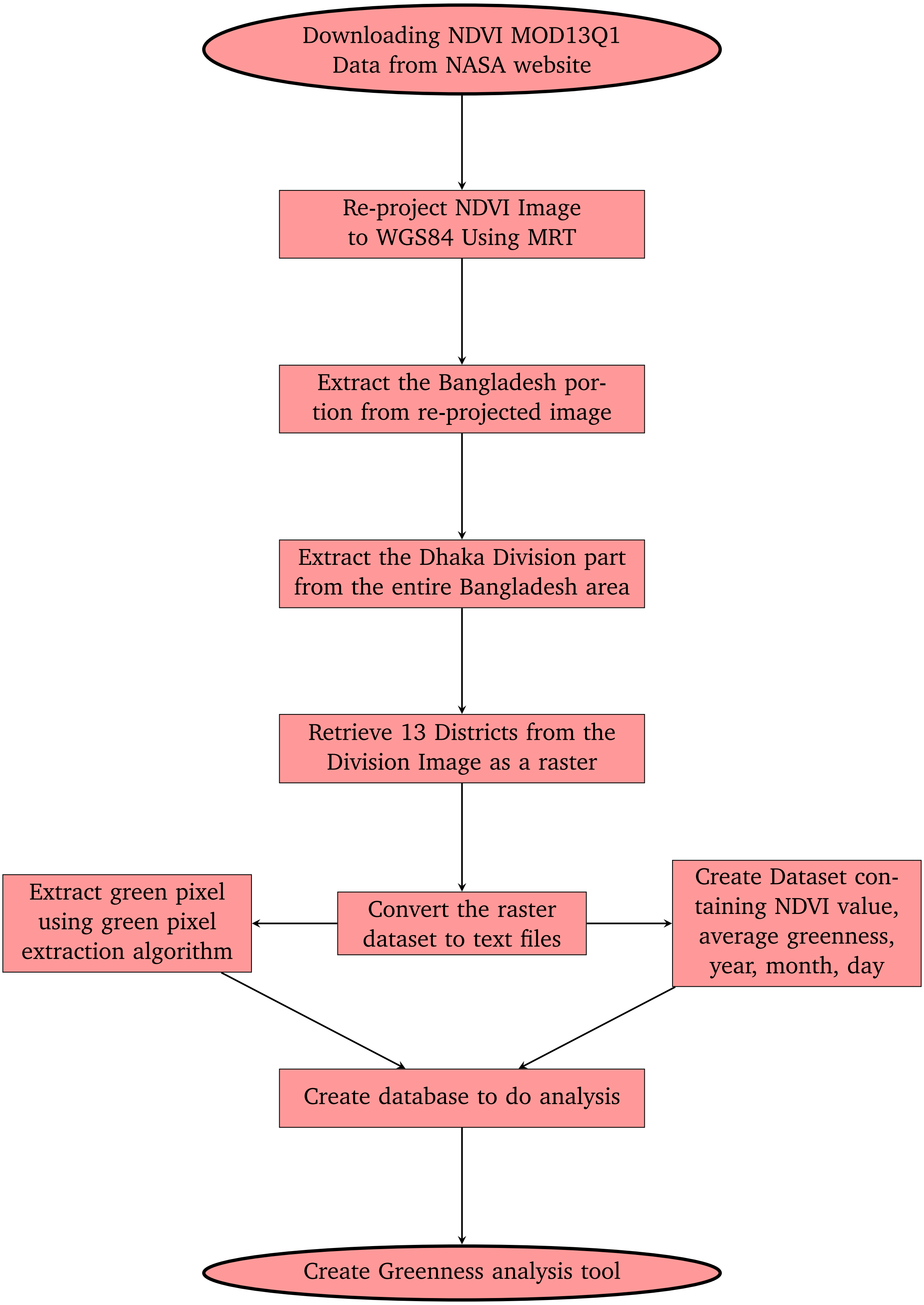


Figure 4.3: Flowchart of workflow

4.3 Illustration of the Method

4.3.1 Original Image

The first part is to get our images of the MODIS / Terra satellite. This satellite revolves around the Earth and takes images in 16 days interval. This image can be downloaded from NASA's USGS EarthExplorer website [39]. This website provides our MOD13Q1 datasets which will be needed. However, as discussed before , this data is on a sinusoidal projection, which can not be used for our thesis. For this, we will have to reproject this to WGS84 format so that it can be used.

Our data was collected from their website from the range of years 2001-2015. However, the original image will not be in our required WGS84 projection format and we will have reproject it to get the correct shape. Each original image has a size of 200-250 MBs.

This is our original Image. This image is of horizontal 26 and vertical 6 position of the Earth in sinusoidal projection.

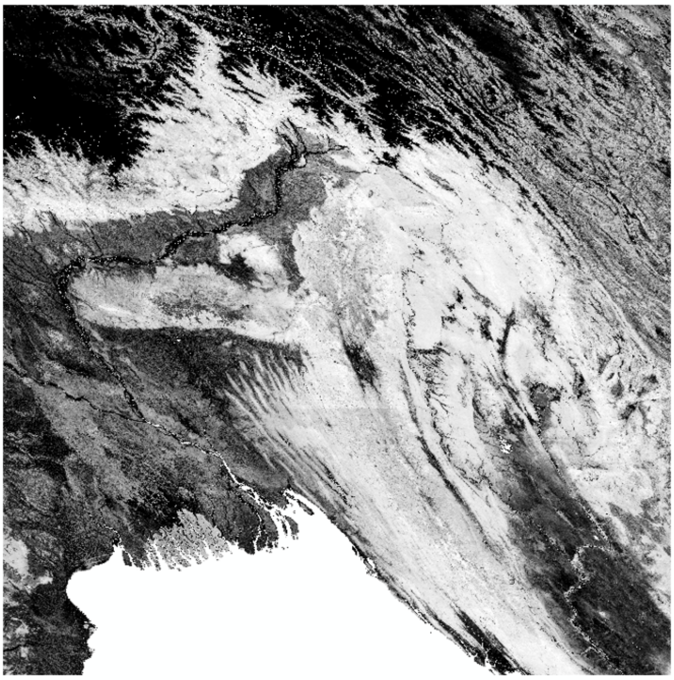


Figure 4.4: Original NDVI Image

4.3.2 Image Reprojection

Now we will have to use MODIS MRT tool reproject it to WGS84 Format so that we can use it further. Figure 4.5 shows the UI of MRT which helps us reproject our image.

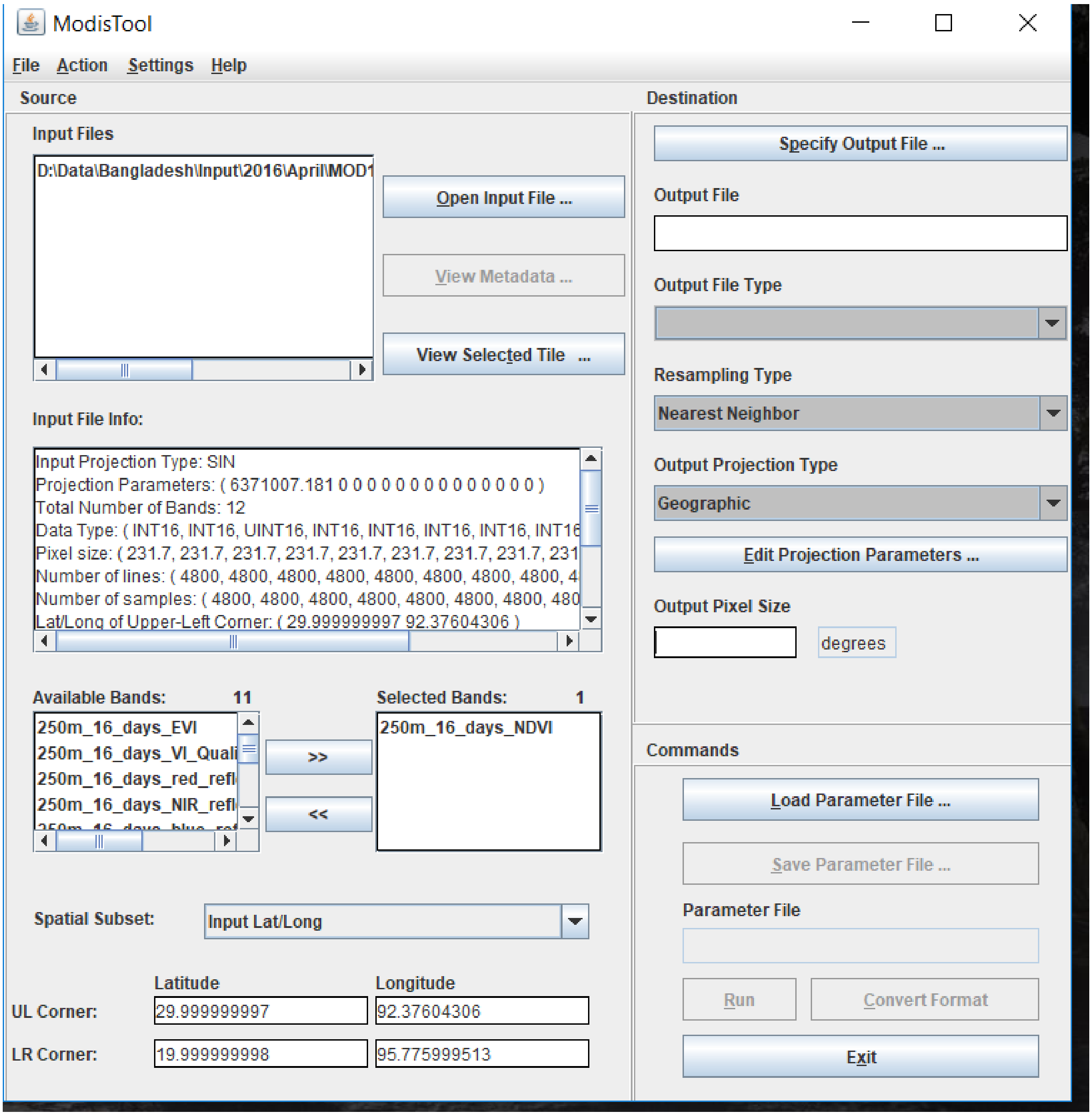


Figure 4.5: MRT tool

After transforming the image using MRT tool, we get a reprojected image that can be further processed. Figure fig. 4.6 shows us the reprojected image.

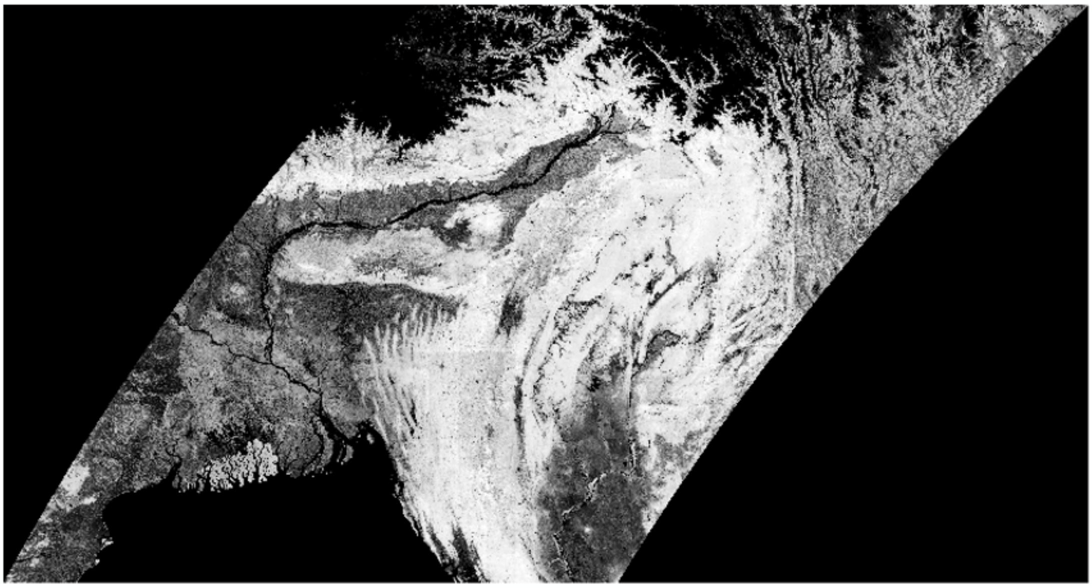


Figure 4.6: Re-projected Image

4.3.3 Image Acquisition

Now, we have a re-projected image which we will further to get the shape of Dhaka so that we can analyse it and store it in our database.

From this Image as shown in Figure 4.6 , we will have to crop it to Dhaka Division's shape in order to take our image for the division. For this, we will have to use Shape file of Dhaka, which will be used on top of it.

Figure 4.7 shows us the Dhaka division figure which we will be using to crop it the shape out of it. The shape file will allow ArcGIS to create a layer onto the image so that we can clip the section. This process is called raster clipping.

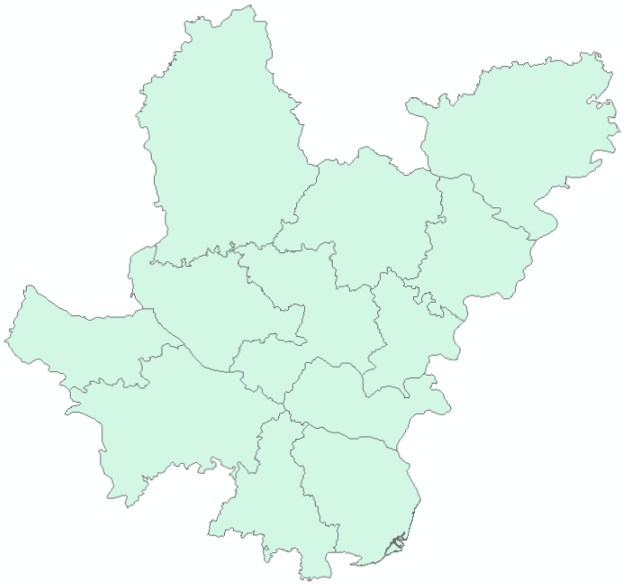


Figure 4.7: Dhaka Division Shape file

Figure 4.8 shows us shape file positioned on our original image.

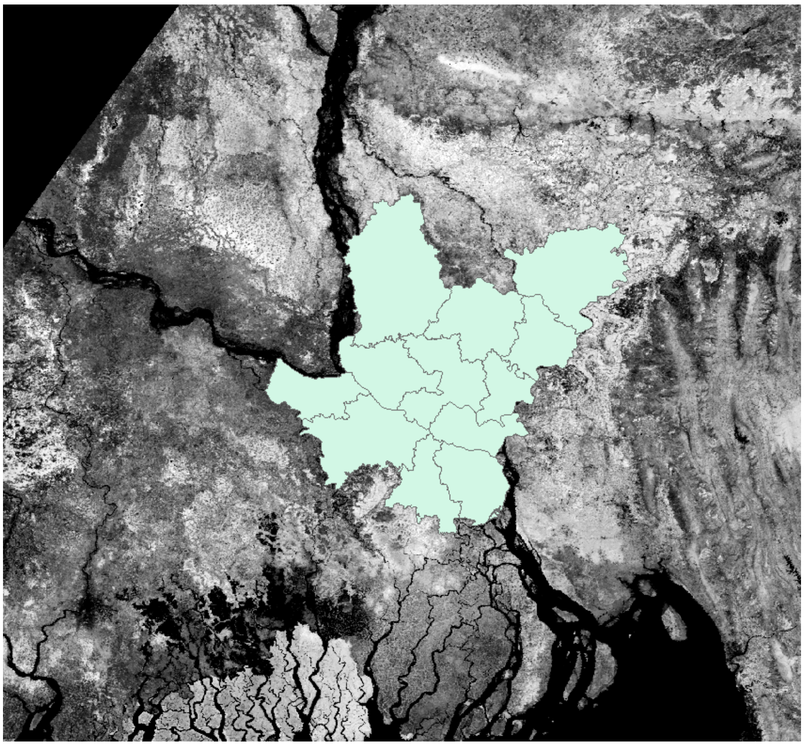


Figure 4.8: Cropping Division

Creating a raster of this image will give us the image for only Dhaka Division like shown in Figure 4.9.

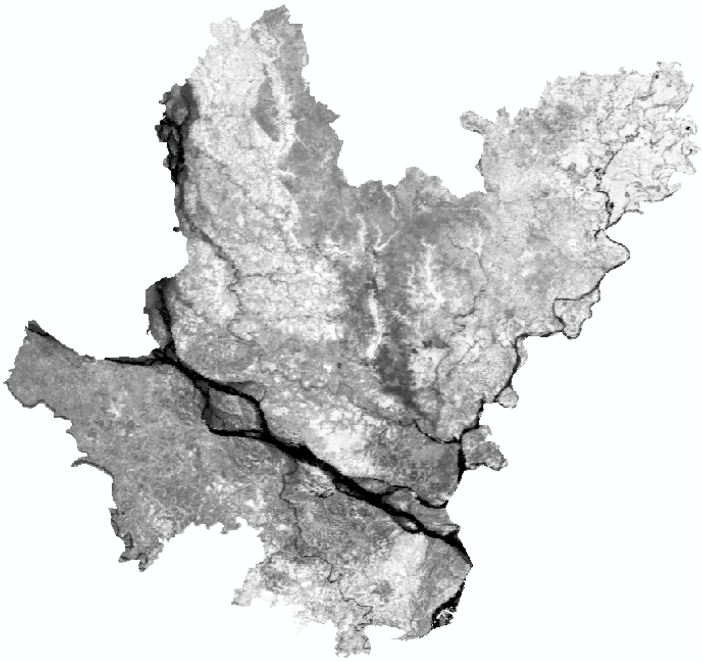
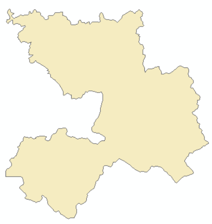
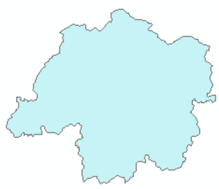


Figure 4.9: Dhaka Division

As we have found our image for Dhaka division for one day, for 15 years we will have to repeat our process a total of 15×23 times as each year has a total of 23 images. From this image now we will have to extrapolate all 13 districts' images using their respective shape files. Some of these are shown below in Figure 4.10.



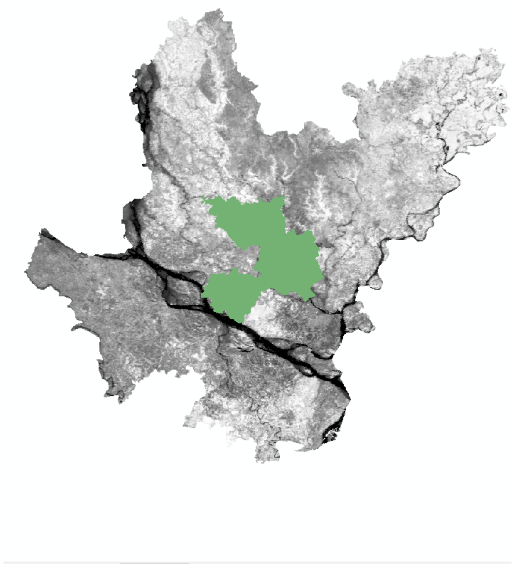
(a) Dhaka



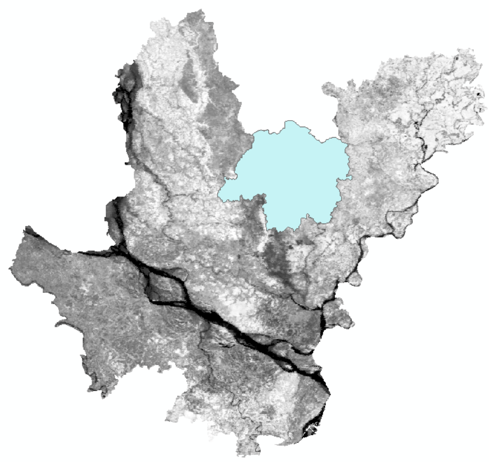
(b) Gazipur

Figure 4.10: District shape files

We will now project these shape files on the Division image shown in Figure 4.9. And we will have something like Figure 4.11.



(a) Dhaka



(b) Gazipur

Figure 4.11: District shape files applied on Division

Applying raster clipping we can get respective rasters for each district.

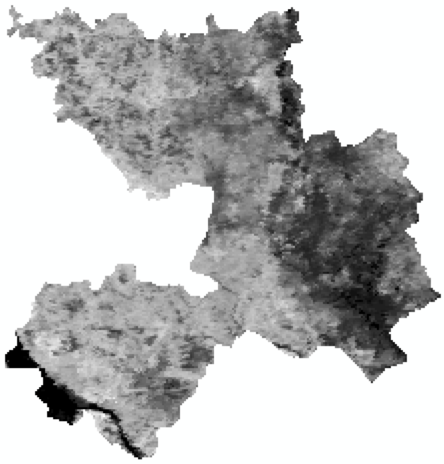


Figure 4.12: Final Dhaka district image

We can inspect the NDVI value from this image

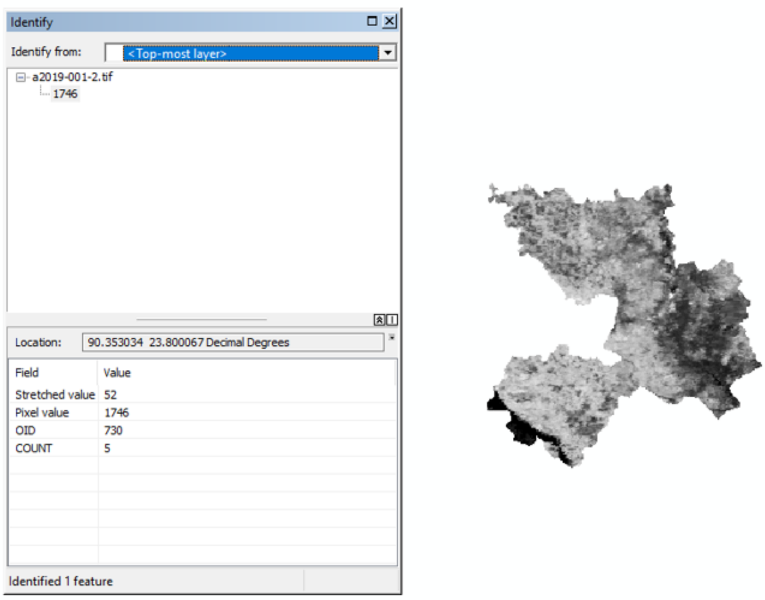


Figure 4.13: NDVI value

NDVI uses a factor of 10000 .So to get original value of that pixel, we have to divide it by

10000. For this image the value is 1746, so original NDVI value is

$$\frac{1746}{10000} = 0.1746.$$

4.3.4 Green Pixel Extraction method

However, to work with the image, we will have to convert the pixel values to a text file. This text file will let us do our processes with the image.

This text file can be used in many ways to achieve many needs. The text file has values from -3.2767 to +3.2767 although the NDVI values will be between -1 and +1. Each pixel that does not have a value will be automatically assigned the value of 3.2767. Our main purpose was to find a map with NDVI values exceeding .4 which means to forestry [40].

The function shown below lets us convert the text file into Figure 4.14 and Figure 4.15.

Function 1: Create Image I

Input: Text file set $Text$
Output: Image I

```
for each t in Text do
    row ← no.of rows in t;
    col ← no. of col in t;
    I ← empty image of size row ∗ col;
    for each row ∈ t do
        for each col ∈ t do
            color ← findPixelColor(t[row][col]);
            I[row][col] ← color
```

Function 2: findPixelColor $value$

Input: float $value$
Output: String $color$

```
if value = 3.2767 then
    color ← black
if value > .4 and value < .8 then
    color ← green
```

Functions 1 and 2 are required to find the green parts from the text files and create the image.

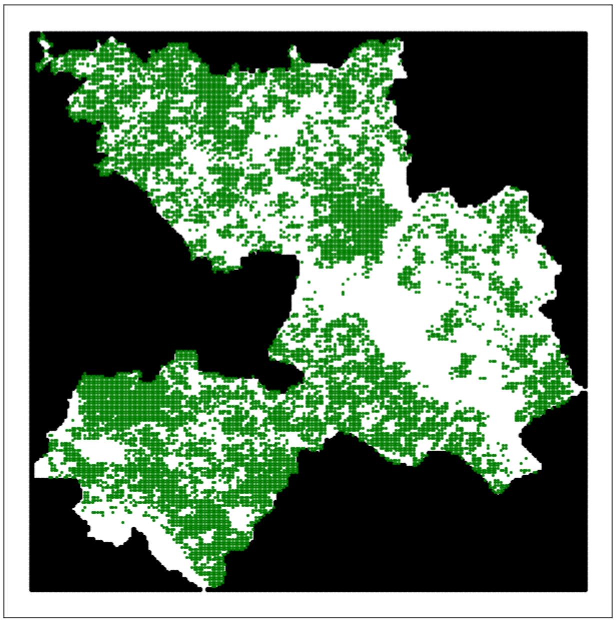


Figure 4.14: Extracted green pixel plotting in shape file of Dhaka district

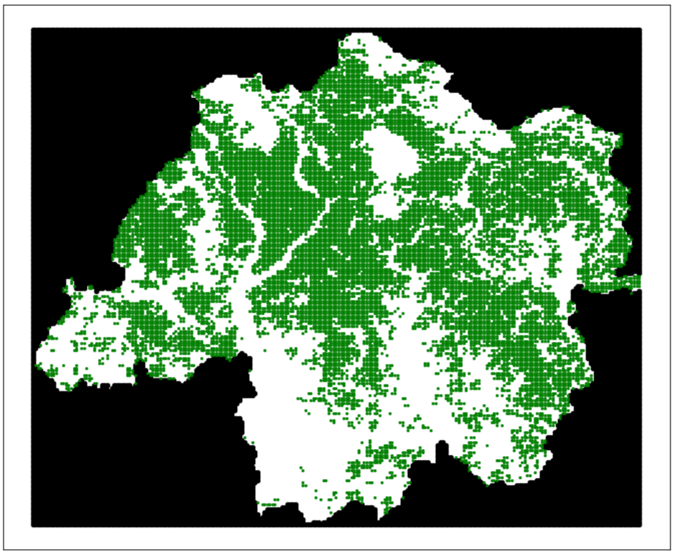


Figure 4.15: Extracted green pixel plotting in shape file of Gazipur district

Figure 4.14 shows the extracted green pixel image of Dhaka district. For Dhaka district, the size of the image is 218 by 226 pixels. Each pixel has a resolution of 250m.

Figure 4.15 shows the extracted green pixel image of Gazipur district. For Gazipur district, the size of the image is 200 by 239 pixels. The same image was found for each of the 13 districts.

4.3.5 Acquiring Database

At this point we have the images for each of the 13 districts ranging from 2001-2015.We will have to create our database with it. We will have to consider district and yearwise distribution and also find the percentage of greenness, average NDVI and standard deviation of the NDVI for each image. We will use the following algorithm for each district imageset to do it.

Algorithm 1: Insert into Database(I)

```
Input : An I image dataset for each district
for each i ∈ I do
    pixel ← 0;
    greenpixel ← 0;
    y ← Year of i;
    d ← Date of i;
    row ← no.of rows of i;
    col ← no. of col i;
    for each row ∈ i do
        for each col ∈ i do
            if CheckPixel(i[row][col]) = true then
                pixel ← pixel +1 ;
            if CheckGreenPixel(i[row][col]) = true then
                greenpixel ← greenpixel +1 ;
    greenness ← greenpixel/pixel * 100;
    ndvi ← i.getavgNDVI();
    std ← i.getStandardDeviation();
    csv.write(district, i, y, d, greenness, ndvi, std);
```

This algorithm will give a table of each district looking somewhat like this

Table 4.2: Database dataset

Year	DOY	Average NDVI	Greenness (%)
2002	001	0.372	45.070
2002	017	0.367	43.072
2002	033	0.411	63.629
2002	049	0.455	68.725
2002	065	0.470	69.567
2002	081	0.513	70.466
2002	097	0.515	79.458
2002	113	0.484	77.954
2002	129	0.419	65.261
2002	145	0.375	53.664
2002	161	0.390	51.392
2002	177	0.403	52.211
2002	193	0.342	47.381
2002	209	0.395	55.568
2002	225	0.359	47.283
2002	241	0.343	43.895
2002	257	0.350	43.244
2002	273	0.513	75.608
2002	289	0.464	74.009
2002	305	0.446	69.831
2002	321	0.448	72.897
2002	337	0.461	74.950
2002	353	0.428	62.137
2003	001	0.421	61.941
2003	017	0.381	48.086
2003	033	0.345	53.981
2003	049	0.444	68.909
2003	065	0.474	73.563
2003	081	0.532	74.045

We have only shown only a few lines of table 4.2. As discussed in section 3.5.2 we know which DOY falls in which months. we can use that to find our monthly data-sets and work our analysis with it . Table 4.3 shows the Months and Greenness percentage of Dhaka district in 2001.

Table 4.3: Greenness for Dhaka district in 2001

Month	**Average Greenness (%)**
January	44.118
February	52.867
March	70.052
April	78.749
May	59.484
June	57.563
July	42.816
August	39.535
September	68.171
October	77.372
November	75.780
December	71.647

Chapter 5

Experimental Results

5.1 Overview

In this chapter, results from the data we created from the methodology is shown. Here, we took some results acquired from our work and discuss about it.

5.2 Experiment Setup

We have analysed our database using Spyder, Pycharm using various python packages like Numpy, Pandas, CSV, Pyplot. We will be using python 3.7 version to do our analysis and run the model.

5.3 Dataset Results

We have the Data for all 13 districts for 15 years. We can do monthly and a yearly analysis of it.

Our first figure, Figure 5.1 shows the yearly Greenness changes on per month basis. Here, the X-axis shows the month and the Y-axis shows the percentage of greenness.

We can clearly see a trend in our greenness that it changes during few months where crops are grown and during the summer and rainy season; greenness goes low because of rain and weather factors. We can also show the means of greenness of each year, which clearly shows the changes in monthly basis. See Figure 5.2.

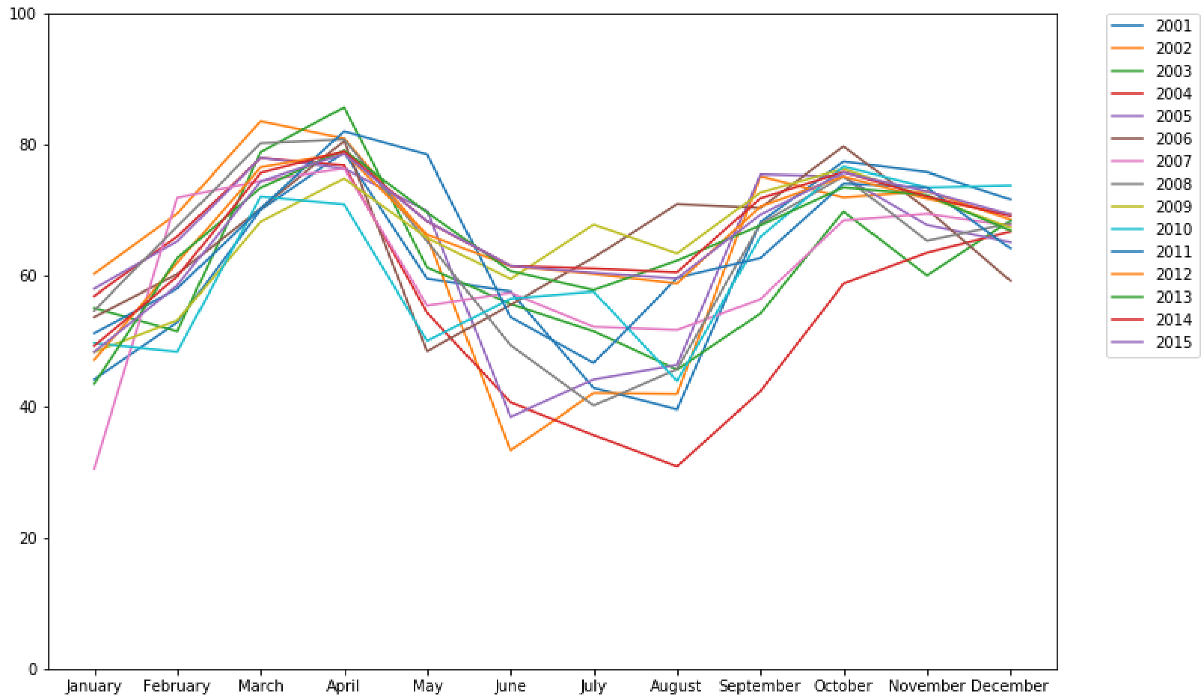


Figure 5.1: Dhaka yearly change in greenness

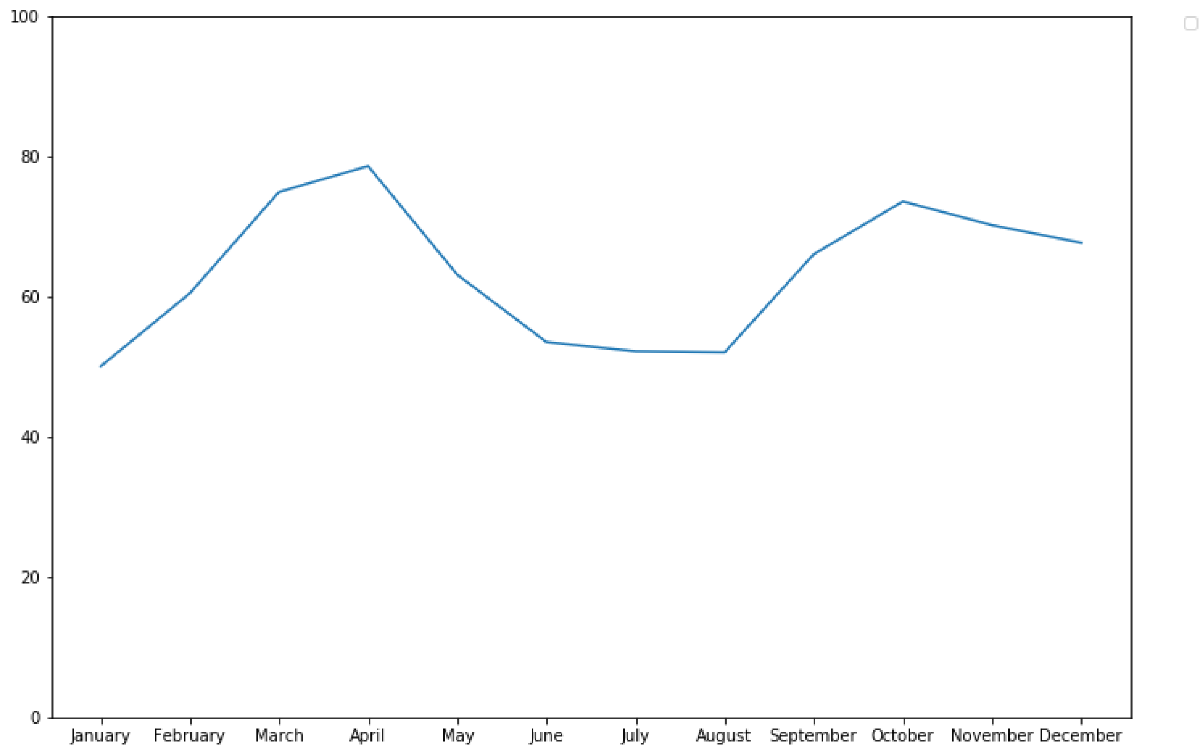


Figure 5.2: Dhaka mean yearly change in greenness

We can clearly see the changes here.The Reason the percentage of green is high during April-May period is because of the time. At that time different kind of crops like rice, mustard and wheat are cultivated and they factor in the greenness. In June to August , no such crops exist and that's why greenness lowers. It again rises during October-November period.

The tables, table 5.1 through table 5.13 shows the yearly mean greenness of all 13 districts. It shows the changes of each district in the period from 2001 to 2015.

Table 5.1: Percentage of green pixels in Dhaka District

year	greenness (%)	year	greenness (%)	year	greenness (%)
2001	61.513	2002	63.832	2003	61.446
2004	55.850	2005	61.298	2006	65.133
2007	60.977	2008	62.317	2009	63.764
2010	61.552	2011	64.512	2012	63.472
2013	64.771	2014	63.974	2015	62.385

Table 5.2: Percentage of green pixels in Gazipur District

year	greenness (%)	year	greenness (%)	year	greenness (%)
2001	65.830	2002	71.802	2003	71.335
2004	67.756	2005	75.806	2006	76.615
2007	72.708	2008	76.327	2009	74.061
2010	71.624	2011	77.450	2012	79.574
2013	80.741	2014	78.810	2015	80.548

Table 5.3: Percentage of green pixels in Tangail District

year	greenness (%)	year	greenness (%)	year	greenness (%)
2001	66.510	2002	67.199	2003	65.992
2004	63.784	2005	64.821	2006	70.523
2007	65.680	2008	67.317	2009	73.297
2010	68.044	2011	71.147	2012	74.109
2013	72.886	2014	74.492	2015	73.708

Table 5.4: Percentage of green pixels in Faridpur District

year	greenness (%)	year	greenness (%)	year	greenness (%)
2001	59.556	2002	63.414	2003	61.808
2004	61.372	2005	63.517	2006	68.548
2007	58.791	2008	64.031	2009	66.503
2010	65.493	2011	67.812	2012	67.864
2013	68.642	2014	69.065	2015	67.280

Table 5.5: Percentage of green pixels in Madaripur District

year	greenness (%)	year	greenness (%)	year	greenness (%)
2001	67.822	2002	70.3260	2003	67.906
2004	65.654	2005	70.308	2006	73.425
2007	67.093	2008	66.866	2009	75.464
2010	69.310	2011	74.4687	2012	76.426
2013	74.883	2014	73.639	2015	77.248

Table 5.6: Percentage of green pixels in Narayanganj District

year	greenness (%)	year	greenness(%)	year	greenness(%)
2001	59.008	2002	63.334	2003	66.280
2004	57.302	2005	64.7381	2006	64.384
2007	62.895	2008	60.541	2009	65.103
2010	59.591	2011	63.959	2012	65.396
2013	64.974	2014	65.525	2015	62.974

Table 5.7: Percentage of green pixels in Shariatpur District

year	greenness(%)	year	greenness (%)	year	greenness (%)
2001	58.020	2002	59.996	2003	57.511
2004	51.566	2005	59.919	2006	61.209
2007	54.473	2008	57.531	2009	63.967
2010	57.922	2011	63.062	2012	61.007
2013	60.915	2014	62.308	2015	60.093

Table 5.8: Percentage of green pixels in Rajbari District

year	greenness(%)	year	greenness(%)	year	greenness (%)
2001	51.404	2002	60.769	2003	57.632
2004	58.054	2005	61.082	2006	64.807
2007	60.025	2008	63.722	2009	63.428
2010	63.988	2011	65.268	2012	62.088
2013	61.514	2014	62.267	2015	61.661

Table 5.9: Percentage of green pixels in Munshiganj District

year	greenness (%)	year	greenness(%)	year	greenness (%)
2001	61.578	2002	61.480	2003	63.996
2004	56.604	2005	65.676	2006	64.097
2007	63.589	2008	70.545	2009	64.794
2010	69.105	2011	68.299	2012	67.744
2013	62.892	2014	66.525	2015	62.825

Table 5.10: Percentage of green pixels in Narsingdi District

year	greenness (%)	year	greenness (%)	year	greenness(%)
2001	71.311	2002	70.233	2003	66.033
2004	68.285	2005	71.171	2006	69.197
2007	67.658	2008	67.660	2009	70.3294
2010	69.496	2011	69.4867	2012	72.127
2013	70.086	2014	69.077	2015	68.616

Table 5.11: Percentage of green pixels in Manikganj District

year	greenness (%)	year	greenness (%)	year	greenness (%)
2001	57.781	2002	61.015	2003	54.130
2004	52.225	2005	59.346	2006	67.272
2007	57.116	2008	61.694	2009	69.787
2010	66.612	2011	66.883	2012	65.892
2013	66.694	2014	65.695	2015	64.948

Table 5.12: Percentage of green pixels in Gopalganj District

year	greenness (%)	year	greenness (%)	year	greenness (%)
2001	73.234	2002	75.770	2003	76.050
2004	76.334	2005	74.009	2006	75.205
2007	77.516	2008	71.796	2009	75.831
2010	73.433	2011	75.352	2012	81.410
2013	79.911	2014	79.632	2015	79.749

Table 5.13: Percentage of green pixels in Kishoreganj District

year	greenness (%)	year	greenness (%)	year	greenness (%)
2001	66.709	2002	66.899	2003	64.588
2004	64.865	2005	67.453	2006	69.867
2007	66.619	2008	68.671	2009	67.7534
2010	64.111	2011	68.594	2012	69.450
2013	69.605	2014	69.033	2015	68.905

Extrapolating from tables table 5.1 through table 5.13, we find table 5.14 which gives us the average greenness of all 13 districts from 2001 to 2005.

Table 5.14: All 13 districts average greenness over 15 years

District	Average greenness (%)
Dhaka	63.520
Faridpur	65.313
Gopalganj	76.349
Munshiganj	66.050
Gazipur	74.866
Tangail	69.501
Shariatpur	60.367
Kishoreganj	67.541
Rajbari	63.114
Narsingdi	71.518
Manikganj	63.539
Madaripur	71.789
Narayanganj	63.067

table 5.14 shows us which districts have the most green areas and which districts have the least. We can see that the districts with more green areas are Gazipur and Gopalganj with around 75% of green. The least green places are Tangail, Dhaka, Shariatpur, Narayanganj with the percentage about 61% or lower. The reason of Gazipur having this much greenness is due to the amount of Shal and Deciduous forest being located there [41]. Dhaka, Tangail and Narayanganj have the most concentration of people in Dhaka division [42]. This factor in the decrease of forest areas to meet the population growth. Table 5.14 is shown as a bar graph in Figure 5.3

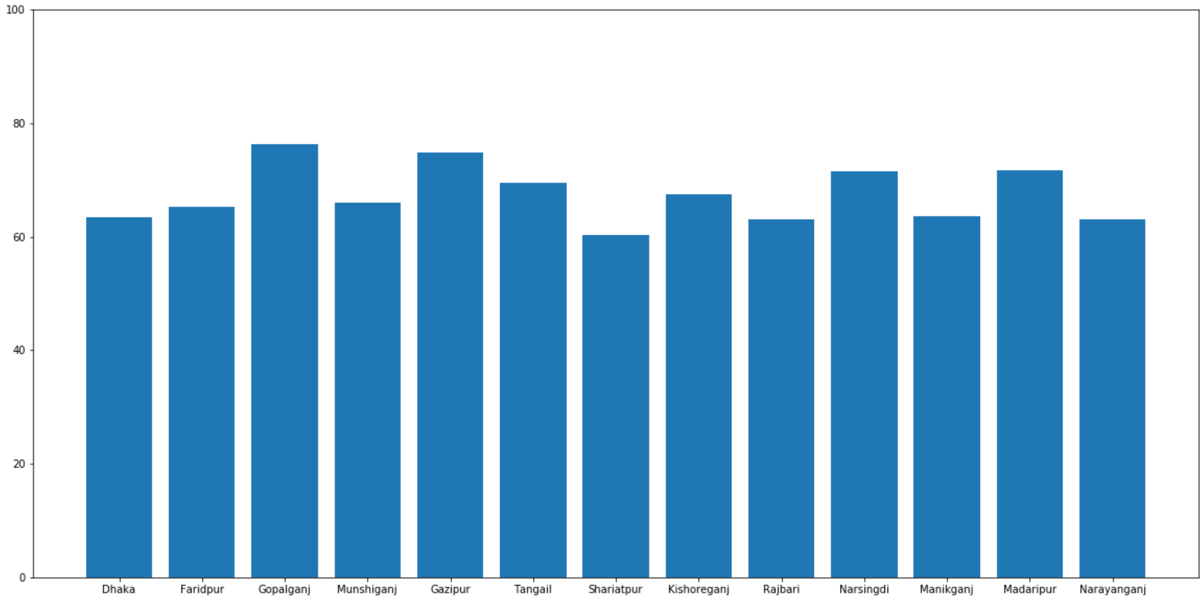


Figure 5.3: All 13 districts average greenness bar graph

We can also see the comparison between two years of same district, shown in Figure 5.4 or between two different district, shown in Figure 5.5.

Figure 5.4 shows the changes of greenness between two years in Dhaka district. The blue line shows the changes in year 2001 and orange line shows the changes of year 2007. We can see that most of the time,they follow the same trend which we have said before.

Figure 5.5 show the changes of Dhaka district and Faridpur district, both in 2001. The blue line shows the changes in year 2001 of Dhaka and orange line shows the changes of year 2001 in Faridpur.

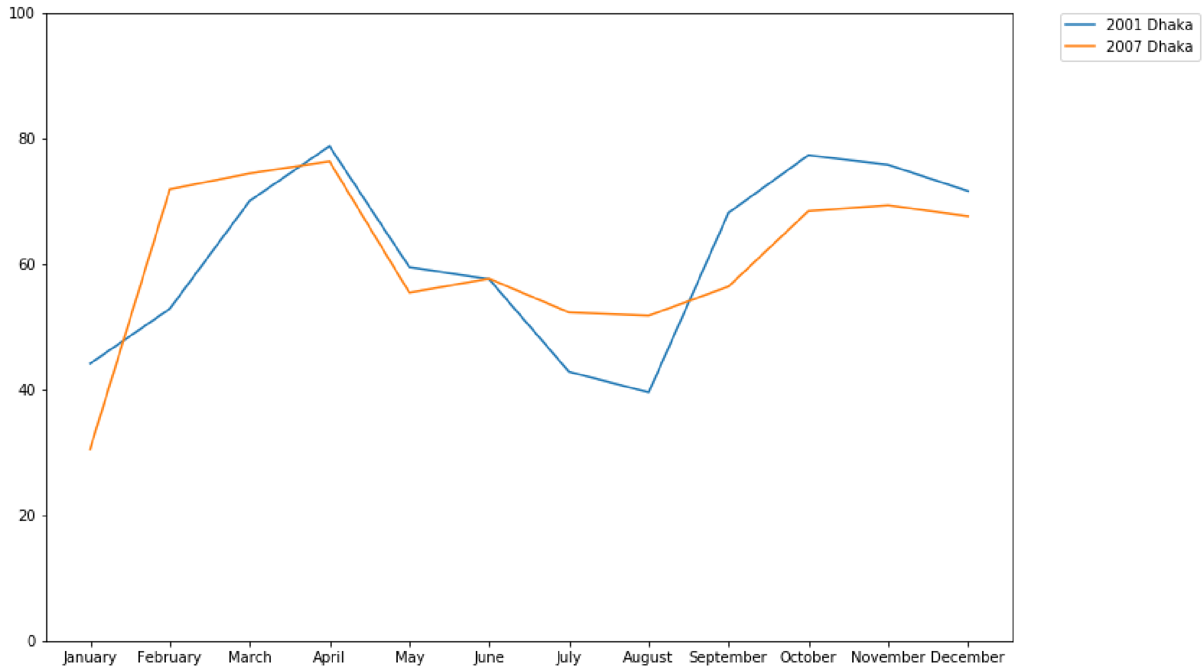


Figure 5.4: Greenness change Comparison of same district

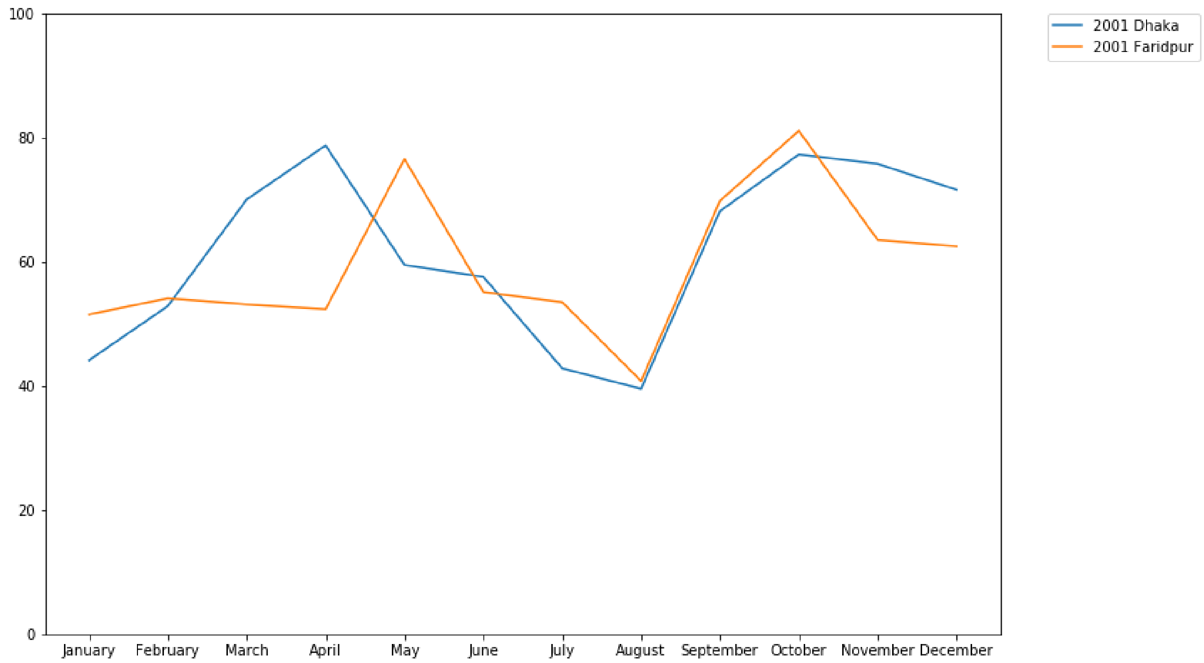


Figure 5.5: Greenness change Comparison of different district

Figure 5.6 shows each of the images with the green areas shown of Dhaka district in 2001,

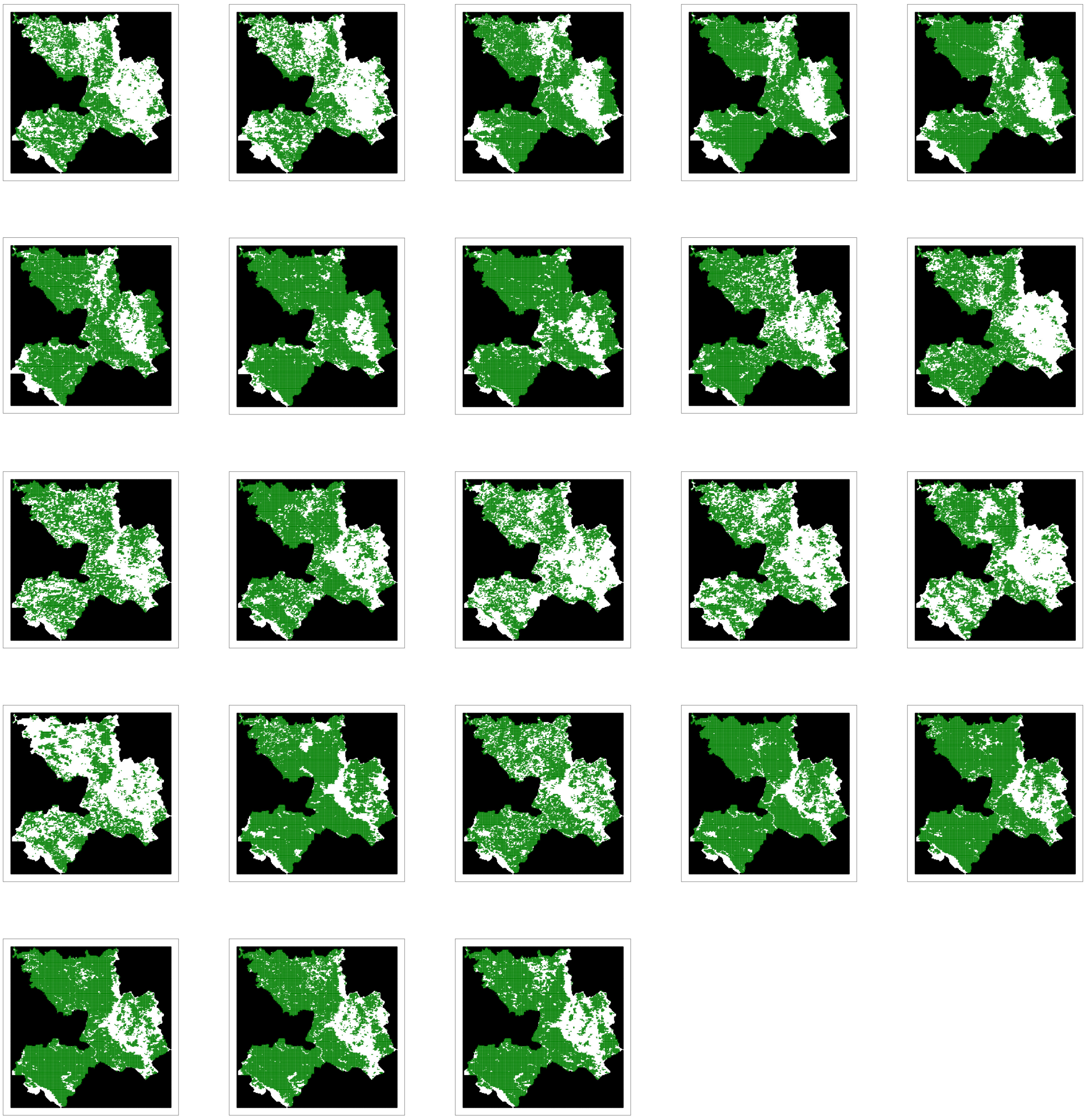


Figure 5.6: Change of greenness for each images in Dhaka district(2001)

Figure 5.7 The bar chart of greenness of each DOY for the year 2001, with it having 23 bars because of 23 images in a year. We can the changes happening by looking at these images. Greenness rises in the second row, which is for months from late March to May. It is low during July and August which can be seen in the end of third row.

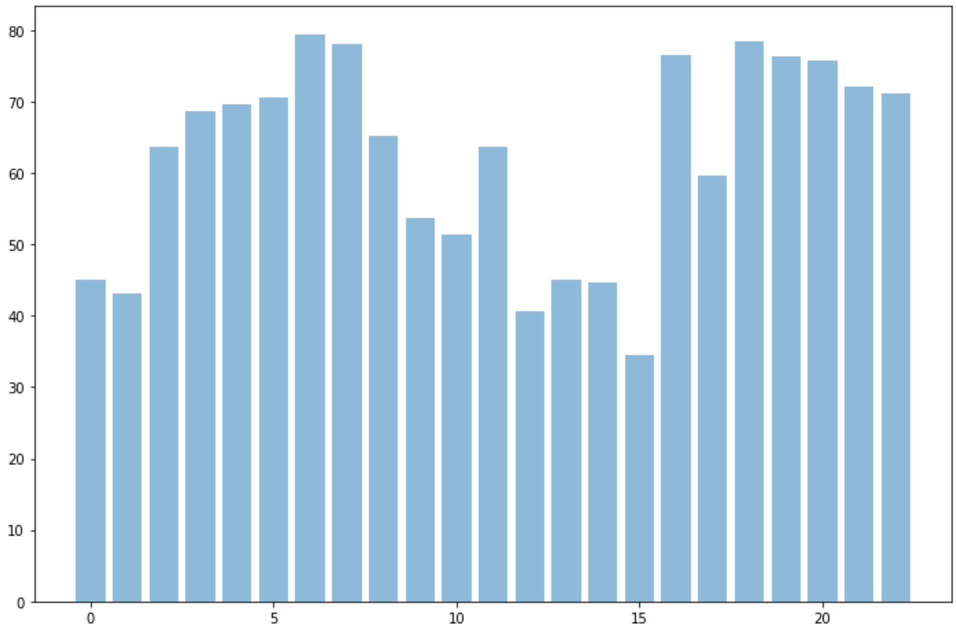


Figure 5.7: Greenness bar chart of Dhaka district (2001)

Chapter 6

Web-based Greenness Analysis Tool for Dhaka Division

6.1 Overview

Here, we have integrated our entire system of database in a web application to develop a greenness analysis tool. This tool allowed us to display our findings and data in both ways static and, if needed, dynamic. Our web-based tool has data sets for 13 districts, each having 23 images and data. So, there are a total of 4,485 image data that we worked with. We have used some tools to make this. Let us go through what we have used for the web application.

6.2 Web tools Used

6.2.1 Front-end

For front-end, we use:

- **Angular:** Angular is TypeScript-based open-source web application framework which is mainly derived from JavaScript. Angular framework is a high-end framework that works on all platforms, has high speed and performance and possesses incredible tooling.
- **ChartJS:** ChartJS is a simple yet flexible JavaScript charting for designing and web developing. This is based on html5 and uses javaScript to operate.

6.2.2 Back-end

Our back-end uses:

- **Spring boot:** Spring boot or Java Spring is based on Spring Framework. The Spring Framework provides a comprehensive programming and configuration model for modern Java-based enterprise applications - on any kind of deployment platform.
- **Python:** Python is a high-level general purpose programming language that can be used in almost any place. Our system will use python to do background calculations along with Springboot.
- **MySQL:** Our database is stored in a MySQL database.

Figure 6.1 shows the homepage of this greenness analysis tool.

Figure 6.1: Home page of Greenness Analysis tool

6.3 Type of Analysis

Almost all of our works and finding will be shown on the website. We have done the comparisons and shown the changes dynamically chosen by the user. We discuss some of our findings here. Our findings will be in district, time series and comparison based.

6.3.1 Time Series Analysis

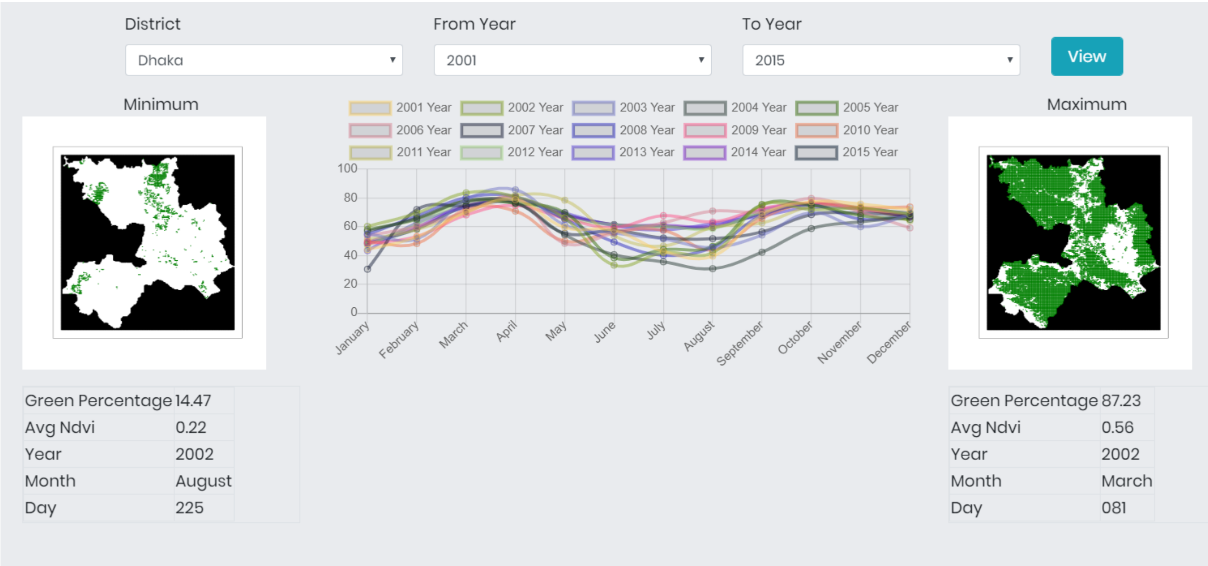


Figure 6.2: Dhaka Yearly Variations

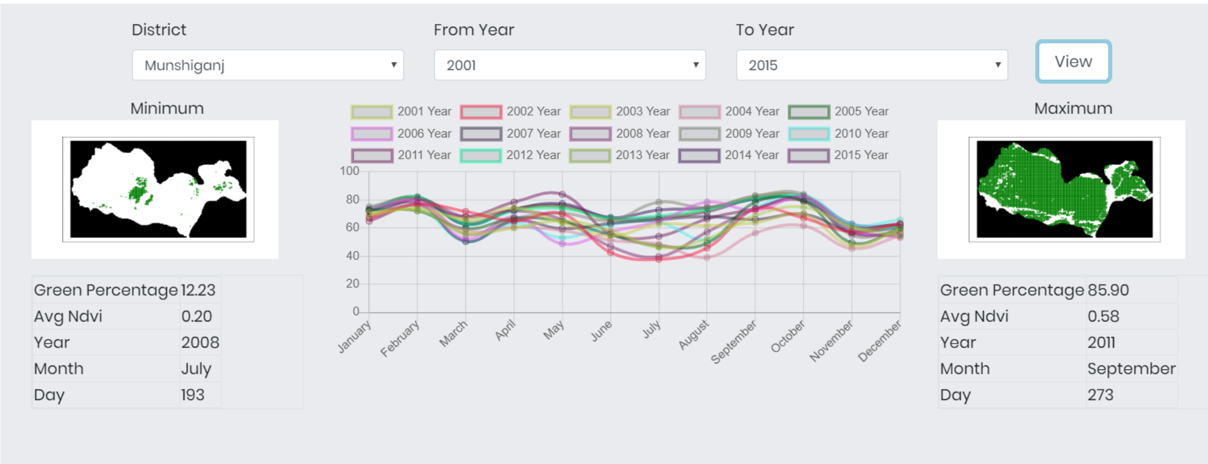


Figure 6.3: Munshiganj Yearly Variations

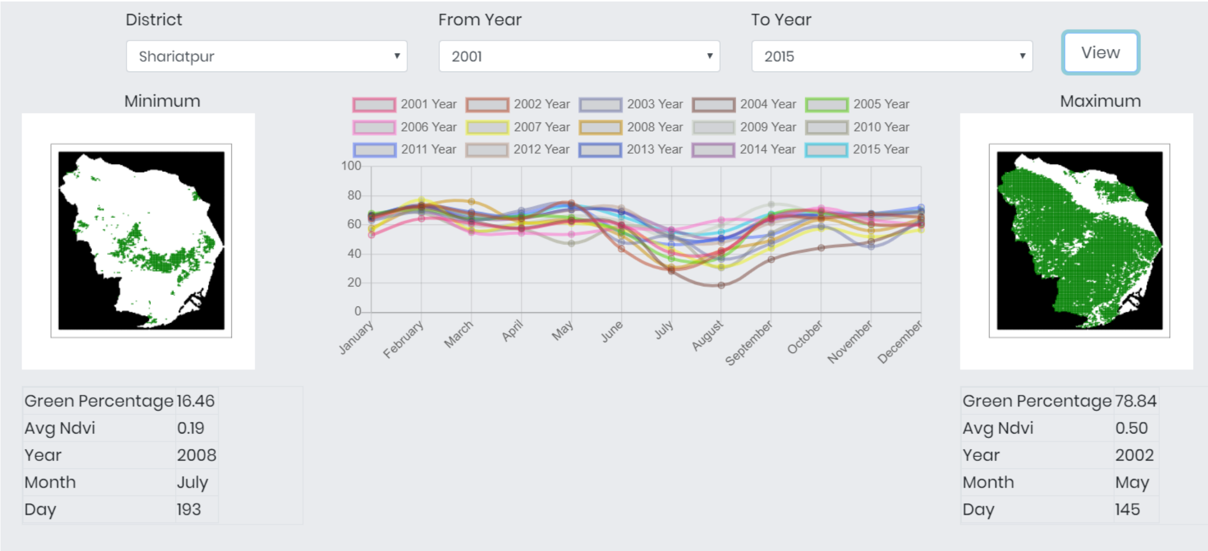


Figure 6.4: Shariatpur Yearly Variations

Figure 6.2, Figure 6.3, Figure 6.4 show the variations of greenness of Dhaka, Munshiganj and Shariatpur district. We have chosen these three as examples to describe the results. The image of Dhaka shows us the changes of greenness over the period of 15 years. We can see that these years, almost follow the same pattern. The left and right images in each figures show which image found the minimum and maximum greenness for the range chosen . Now, as Bangladesh is an agricultural country. We can see that Greenness rises during the periods of March to May as this is the reaping period of many agricultural crops such as rice, wheat, mustard, jute and other. At this time the greenness becomes the largest. During the summer and rainy season time, the greenness is the lowest. These are when there are no crops and only the natural forestation are reflected. The percentage that is common for each cycle is around 40%, which we can say is the percentage of greenery throughout the year in Dhaka.

By analyzing the image of Munshiganj and comparing it to Dhaka, we can see that there is some difference. The major difference is that the peak percentage in Munshiganj reaches the peak at a different time. This is because of agriculturual crops difference between the two districts. The image of Shariatpur also follows the same trend.

6.3.2 Single District (Monthly)

Figure 6.5 and Figure 6.6 shows the monthly greenness of Dhaka in 2001 and 2005 respectively. We can see that the overall greenness in months that have crops have slightly decreased in 5 years.

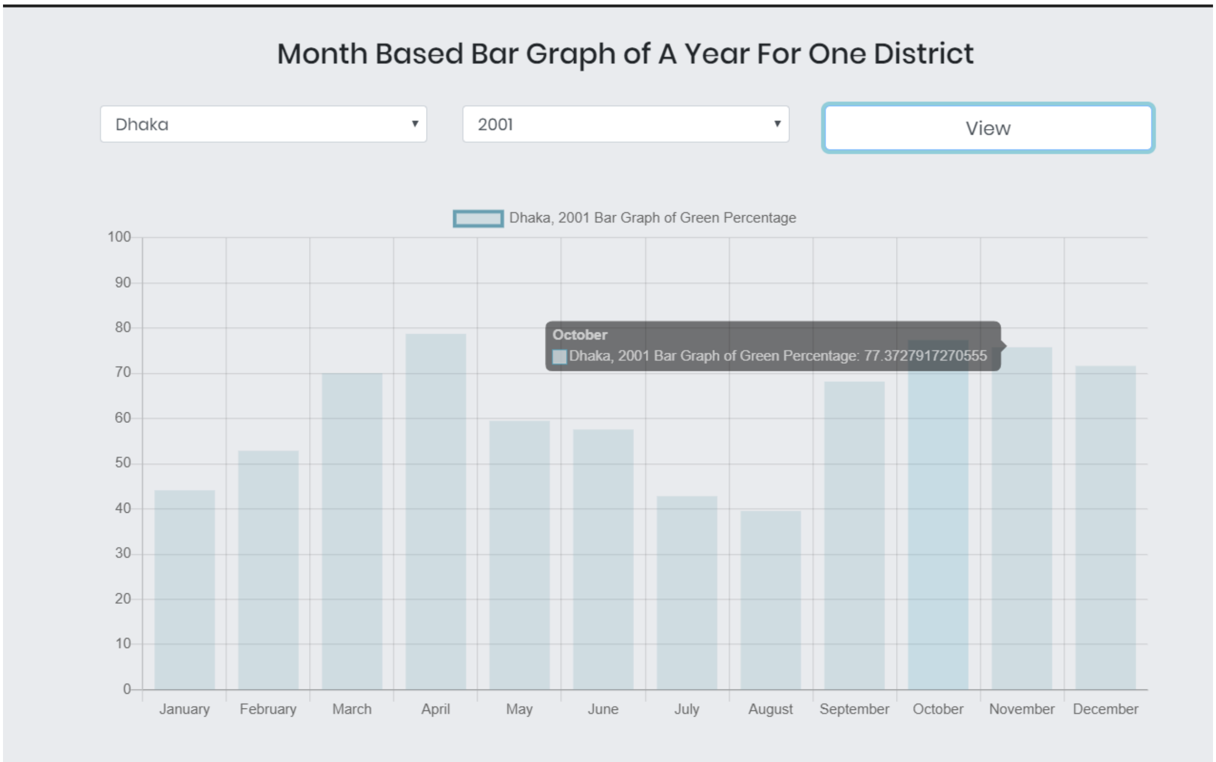


Figure 6.5: Dhaka 2001 monthly Greenness

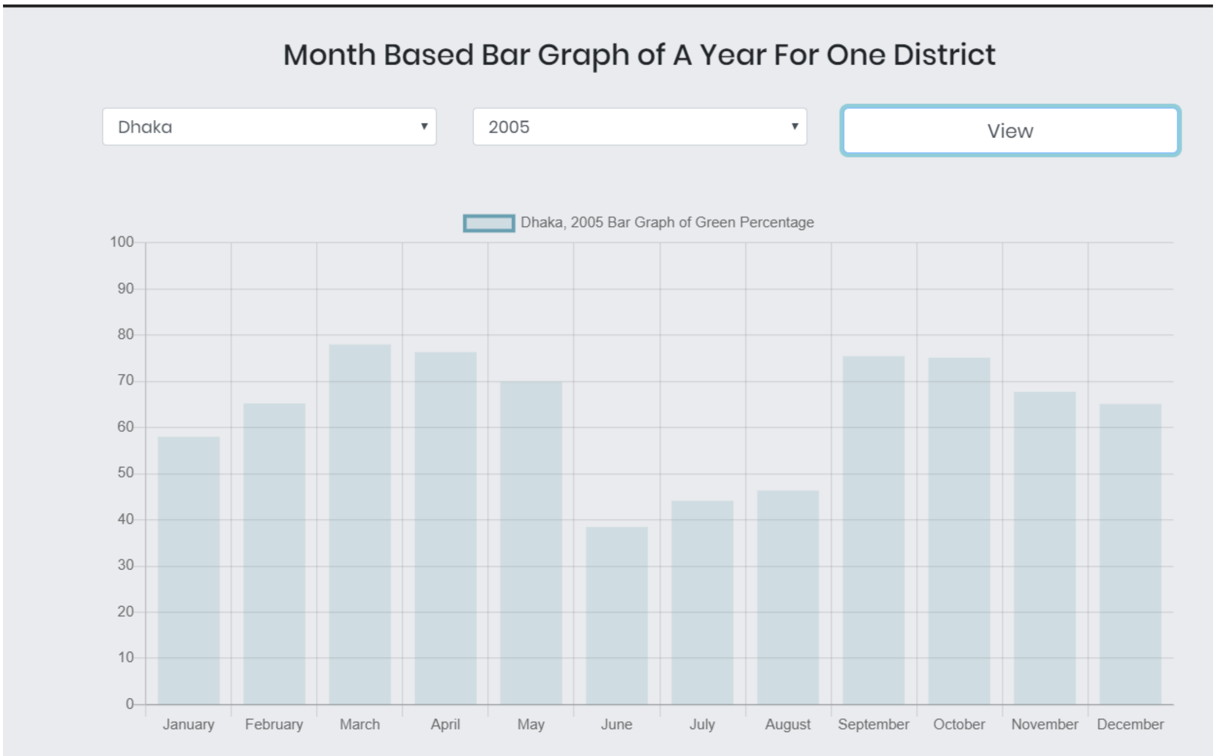


Figure 6.6: Dhaka 2005 monthly Greenness

6.3.3 District based Comparison

We also can show the changes between different dates of a district by showing the differences between them.

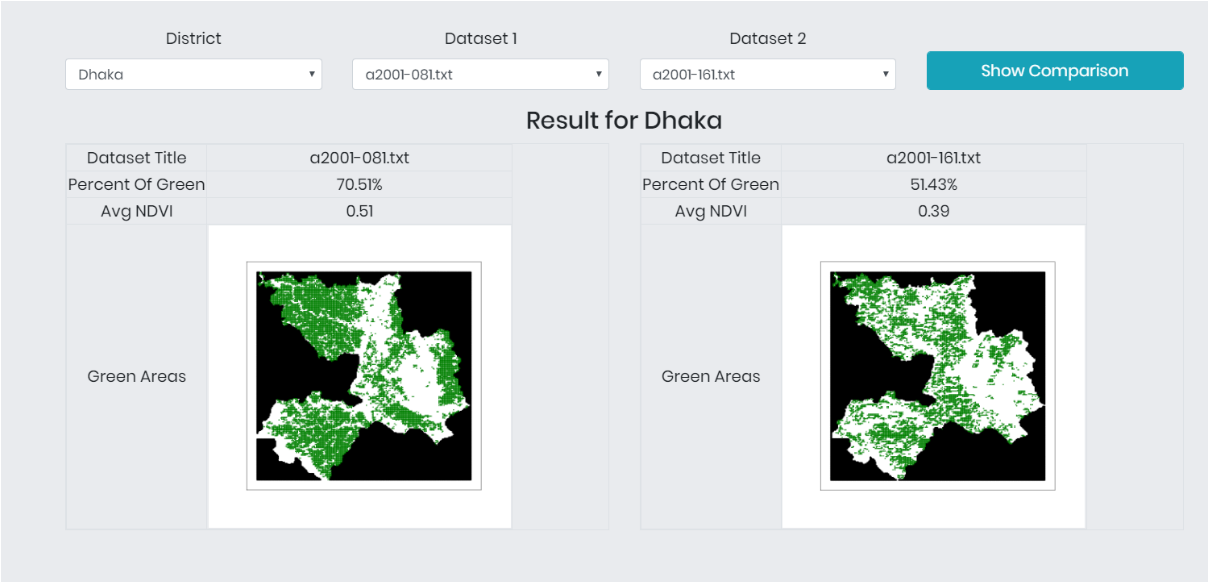


Figure 6.7: Comparison between two dates - Dhaka district

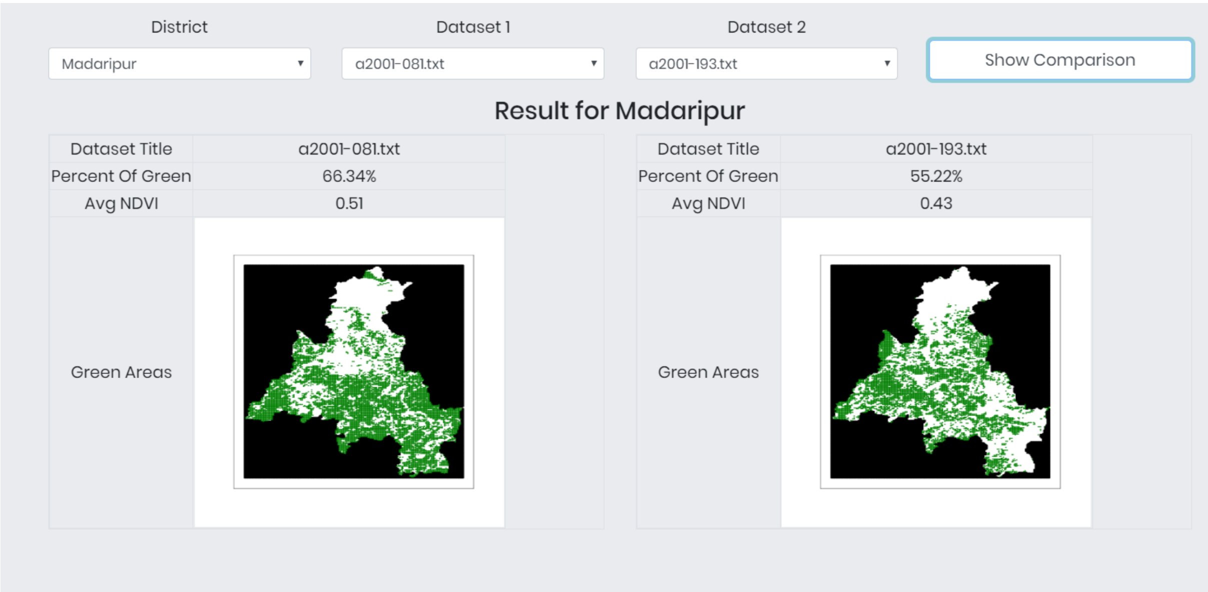


Figure 6.8: Comparison between two dates - Madaripur district

Figure 6.7 shows the changes of Dhaka from March at first one to June in second one. The changes in green area is noticeable. The green has lowered because of crops being harvested during reaping season. Figure 6.8 also shows the changes of Madaripur district between the time in March and July.

We can also do the comparison between any two districts for any two day. Figure 6.9 shows the comparison between Dhaka and Gazipur at the time 1st January of 2001. It shows the percentage of greenness for each image.

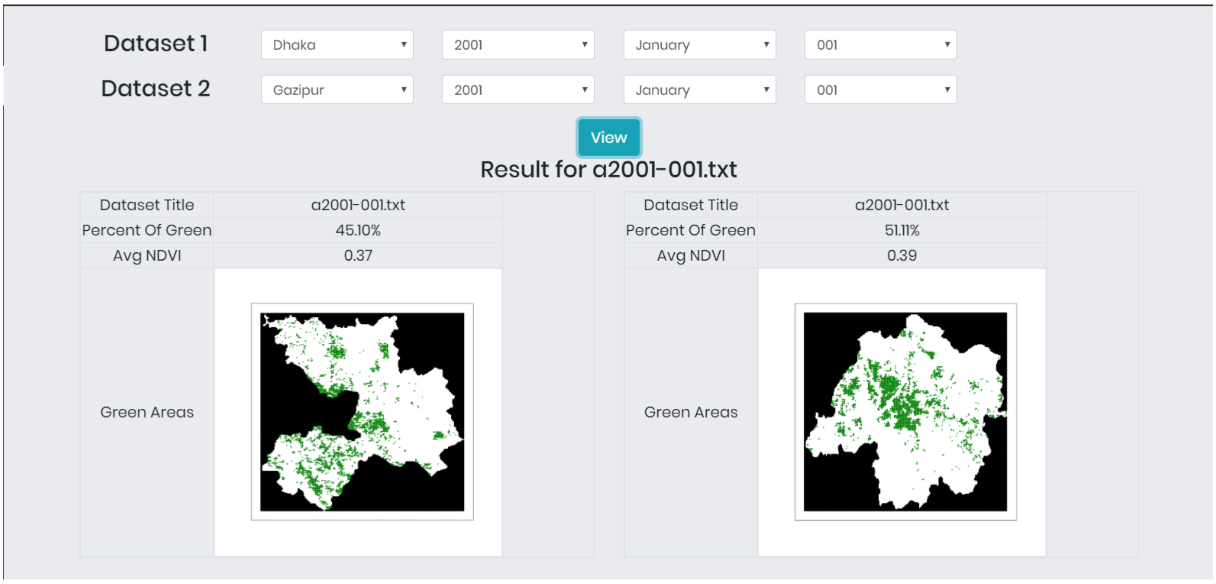


Figure 6.9: Comparison between two district at the same date

6.3.4 Multiple District (Yearly) Comparison

fig. 6.10 shows the changes of Dhaka in 2007 and 2008

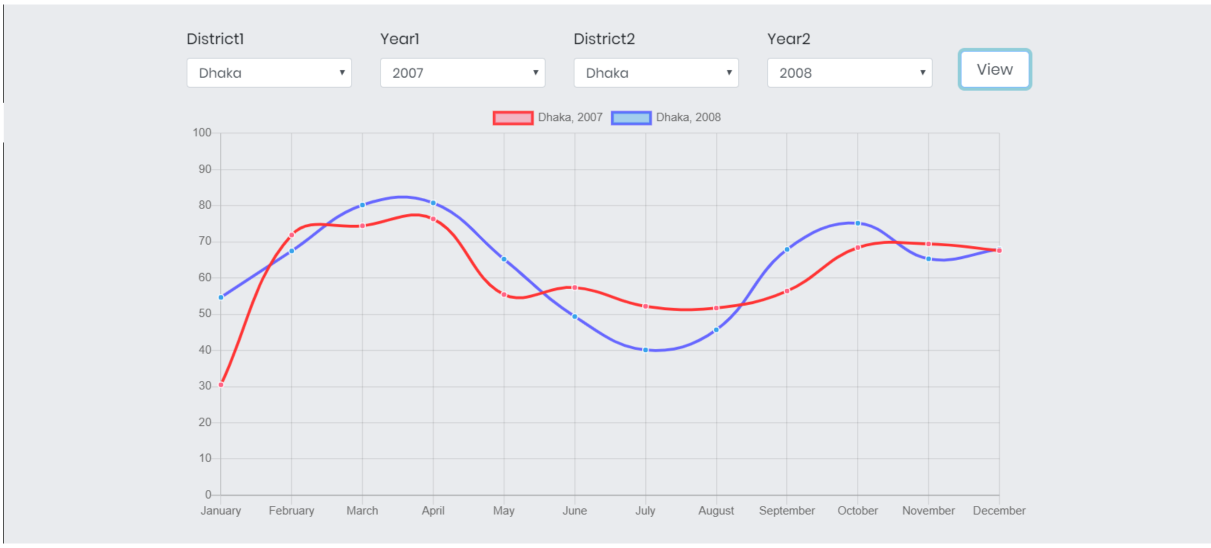


Figure 6.10: Comparison of greenness in 2007 and 2008 of Dhaka district

The red line shows us the 2007 and blue line shows us 2008. We can see a decrease in green in June-July period of 2008 because at that time there was a flood [43]. Water decreases NDVI value and thus greenness of that period.

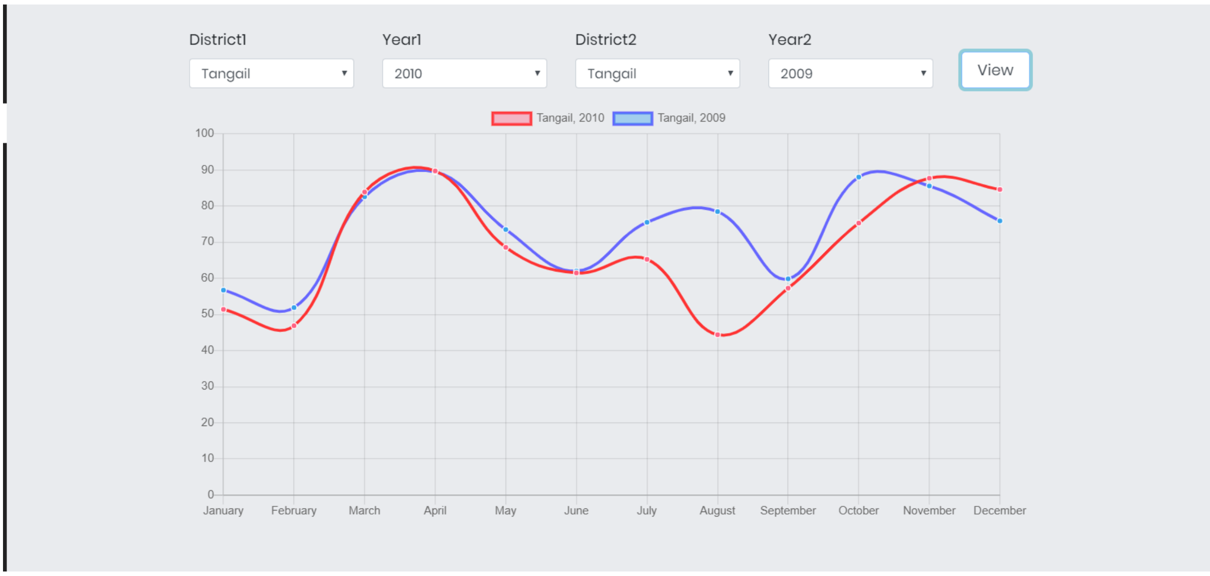


Figure 6.11: Comparison of greenness in 2009 and 2010 of Tangail district

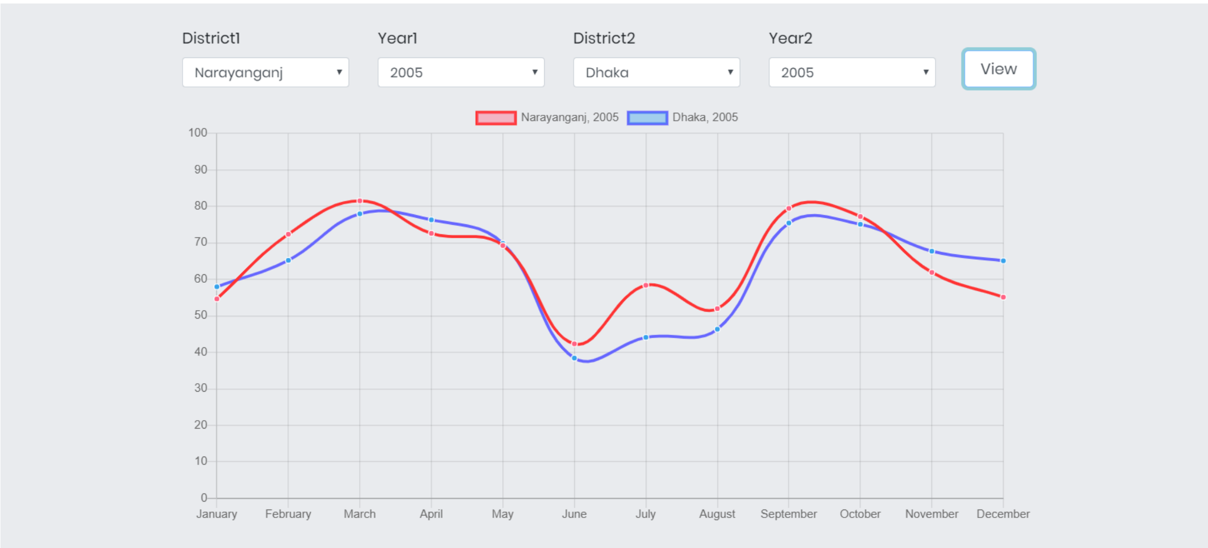


Figure 6.12: Comparison of greenness of Narayanganj district and Dhaka district in 2005

Figure 6.11 is showing the changes of green in the year of 2009 and 2010. Here, red line represents 2010 and blue represents 2009. Figure 6.12 shows the Narayanganj and Dhaka in 2005. We can see that they follow almost the same pattern.

Our country is mainly agricultural. When the crops are growing during early in the year, the percentage of green rises, and when no crops are available, only the forestation green is shown. We can also analyse and say that even though percentage of green rise during that period, The amount of Oxygen produced by tree do not increase that much.

We also find from this results and analysis that The Dhaka division's greenness is mostly from agriculture, not from forestation. The amount of greenness in Dhaka division during the rainy season has risen slightly. It's because flood and water logging areas are not so prevalent as before. This makes it so that waters dont get bundled up during rainy season and greenness is not adversely affected. Also, we can say that increase in the amount of vegetable gardens, rooftop gardens and nursery also may have a hand with our results.

Chapter 7

Conclusion and Future Work

A web-based greenness analysis system using NDVI MODIS database is developed here. This work brings a new way to show how greenness have changed in Dhaka in the last 15 years. This will create a new wave of innovation and help us analyze other potential issues related to it. The results show that greenness in the Dhaka division has not decreased by a large margin over the last 15 years. However, the reason for this is, Bangladesh is mostly an agricultural based country. This is why we can clearly see a spike in greenness in seasons in which crops are cultivated. Another thing this paper has found is that, greenness during the summer season has risen a few percentages. It's because of water logging is reduced at Dhaka and may also for the growth of the cultivation of perennial vegetables, fruit gardens, nursery, parks and rooftop garden. MOD13Q1 has a 250m×250m resolution. Even if almost half or less is green, that pixel is shown green. A higher resolution would have been better.

7.1 Future Work

Our work was with 13 districts of Dhaka Division. some more work can be done with it by dividing the districts further into areas and do the same analysis with it. As our analysis is ready, if the data is ready, any such work can be done.

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