Development of Greenness Analysis Tool Using Remote Sensing Satellite Images

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***Abstract*—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 using Remote sensing of MODIS (Moderate-resolution Imaging Spectroradiometer) satellite images. MODIS NDVI (Normalized Difference Vegetation Index) is the most popularly used vegetation index in Remote sensing to calculate the amount of greenness. Fifteen years MODIS NDVI images from 2001-2015 are used to extract greenness and accumulated the data of 13 Districts of Dhaka Division to create the database. Using this database and performing algorithms and methodology, this study has found and extracted each green pixels from the original images which is used for analysis. A web-based greenness analysis tool is developed here to display this study of greenness analysis of entire Dhaka. This tool allows mainly four options like Time Series Analysis, Monthly Single District Greenness Comparison, Yearly District Based Comparison and Comparison of two District of Dhaka Division at Chosen Date. These options show how greenness changes yearly among the districts and if they are related to each other and represent the results in graph, bar chart plot and map view. The study has shown us 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.**

I. Introduction

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 high efficiency. Our work will be on greenness analysis for over a while in the Dhaka division to see the changes happening. The method to observe greenness is based on vegetation indexes of which we will use Normalized Difference Vegetation Index (NDVI). 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 a better environment and better health [4]. Further a better environment areas can also be inferred, more satisfactory and healthy living areas from the greenness of each region. This can be shown by performing this work and showing its results. The main objective of this research is to create a MODIS NDVI database for Dhaka Division so that we can use it to do other analysis. These analyses include how greenness is affected yearly and other comparisons between an area's location in our study area. This work will also focus on creating a web-based greenness analysis tool that will show us the results of the database dynamically chosen by the user. In this paper, firstly, a study area of the greenness analysis is described. Then, a tool is developed for representing the greenness of Dhaka. After that, the method and the analysis of the experimental results is shown with proper depictions . Finally,it discusses about the working procedures and results of this paper which is shown in a web based tool.

II. Dhaka Greenness Analysis Method

A. Study Area

This work is concentrated on the greenness analysis of Dhaka division because popular opinions say that greenness has decreased. This work focuses to find if this is correct. For this reason, we have selected Dhaka as the experimental place. There are 13 districts all over the Dhaka division such as — Dhaka, Faridpur, Gopalganj, Munshiganj, Gazipur, Tangail, Shariatpur, Rajbari, Kishoreganj, Narsingdi, Narayanganj and Manikganj.

B. Remote Sensing MODIS Satellite Data Acquisition

The Terra MODIS Vegetation Indices (MOD13Q1) Version 6 data are generated every 16 days sat 250 meters (m) spatial resolution as a Level 3 product. Each pixel in this has a resolution of 250m$\times$250m . The MOD13Q1 product provides two primary vegetation layers. The first one is NDVI or Normalized Difference Vegetation Index. This NDVI images are used in this work. Our objective was to make a database of Dhaka division's NDVI images over a course of 15 years ranging from 2001 to 2015 to do greenness analysis of entire Dhaka. The area of Dhaka Division is 20,508.8 km^2 and is constituted of 13 districts.

C. Green Pixel Extraction and Dataset Creation

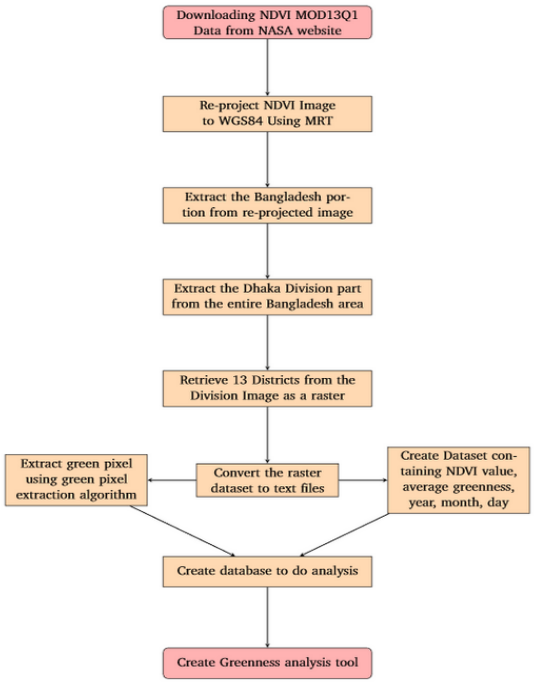
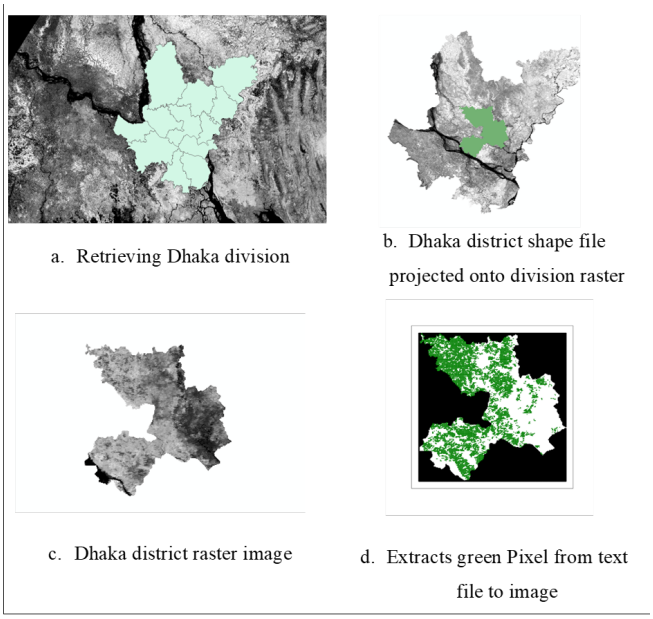


Fig. 1. Methodology Flowchart

Fig. 1 shows the methodology of this work. It starts from downloading the MOD13Q1 NDVI images of MODIS / Terra satellite from NASA's USGS Earth Explorer website. This image cannot use directly for the sinusoidal projection. Re-projected NDVI Image to WGS84 using MRT tool.



a. Retrieving Dhaka division

b. Dhaka district shape file projected onto division raster

c. Dhaka district raster image

d. Extracts green Pixel from text file to image

Fig. 2. Method of Green pixel extraction from MODIS NDVI image for dataset creation.

First retrieve the Bangladesh portion from re-projected image. Then retrieved the Dhaka division part from the entire Bangladesh area by using divisional shape files as shown in figure 2(a). Raster image for Dhaka division needs to be further broken down for individual districts. Shape files for 13 districts of Dhaka division are used and single district has retrieved from the division Image as a raster. These images are saved as raster data into text files for processing. Figure 2(b) shows the retrieving district images of Dhaka district shape file projected onto division raster and figure 2(c) shows the raster image of Dhaka district. An inspection of the NDVI value on the final Dhaka district raster image needed to find green pixel. This text file can use 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. The more it is to positive the more green that location is. Water areas tend to be around 0 and Deserted places are closer to -1. Our main purpose is to find a map with NDVI values exceeding 0.4, which means forestry. To extract green pixel from text file and to create the image of figure 2(d), function 1 and 2 of figure 3 are used.

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
```

Fig. 3. Algorithm for extracting green pixels

The processes use the text files as base and give an image where the values from 0.4 to 0.8, represent as green. Figure 2(d) shows the extracted green pixel image of Dhaka district.

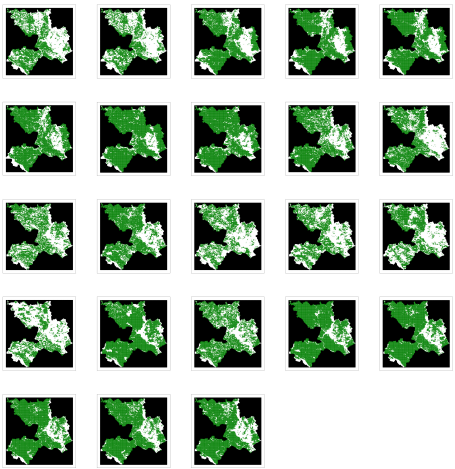


Fig. 4. Dataset of Green pixel images for Dhaka district in 2001.

For Dhaka district, the size of the image is 218 by 226 pixels. Each pixel has a resolution of 250m. The result image insert into the database. Figure 4 shows the data set of Green pixel images for Dhaka district of 2001. Same process for all 13 districts have done and 13 raster for each original image retrieved. At this point, we have the images for each of the 13 districts ranging from 2001-2015. We find the percentage of greenness, average NDVI and standard deviation of the NDVI value for each image and these images inserted into the database using another algorithm as shown in fig. 5 and display the results as a table.

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();
    DB.insert(new row(y,d,greenness,ndvi));
```

Fig. 5. Database creation algorithm

III. Result Analysis

This work has been done for the entire Dhaka division data of 15 years. Results found for each of the districts and analyzed to see how greenness changed over the years. Some results from this work presented here.

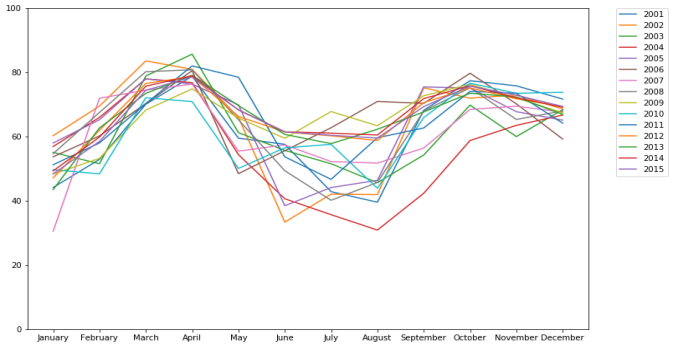


Fig. 6. A depiction of Dhaka district mean greenness per month.

Fig. 6 shows the monthly changes of greenness in Dhaka district from 2001 to 2015. It shows that the greenness value increases during March-May and decreases after that. Bangladesh is an agricultural country. The greenness increases during the season of crops growing. The green crop increases the value of NDVI and thus greenness. It decreases in June-July because of rain, flood and no major agricultural crops at that time. However, the percentage which is the lowest (around 40%) should be the actual amount of green area or forest area in Dhaka. Table-I shows the mean greenness of Dhaka district monthly from 2001-2015. The same variations that we have found from figure 6 is seen here.

TABLE I
DHAKA DISTRICT MEAN GREENNESS PER MONTH

Month	Average greenness (%)
January	44.118
February	52.867
March	70.052
April	78.759
May	59.484
June	57.536
July	42.816
August	39.535
September	68.171
October	77.352
November	75.780
December	71.674

IV. Web Based Tool for Greenness Analysis

A web-based greenness analysis tool is developed here to display this study of greenness analysis of Dhaka. Database was analyzed using Spyder, Pycharm using various python packages like Numpy, Pandas, CSV, Pyplot with python 3.7 version, and integrated our entire system of database in the web application. 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 for each year. Therefore, we worked with a total of ($23\times13\times15$) or, 4,485 images. For front-end, we used Angular framework and ChartJS JavaScript charting on designing and web development. Our back-end uses Spring boot, Python to do background calculations along with Springboot and MySQL database. Figure 7 shows the Home page of our Web-based Greenness Analysis tool for Dhaka Division.

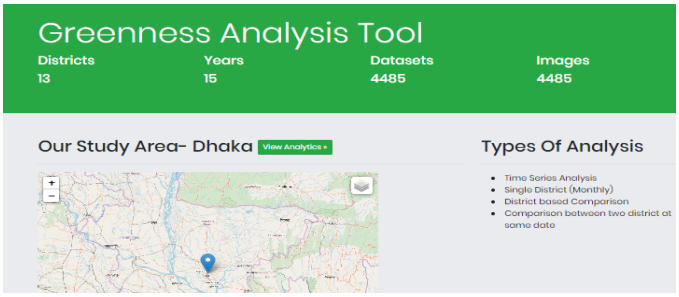


Fig. 7. Home page for the Web based Greenness Analysis tool for Dhaka Division

This Web tool allows analysis options as follows:

- Time Series Analysis
- Single District (Monthly Greenness Percentage comparison)
- Yearly District based Comparison
- Comparison of two/same district(s) on same/different date/year
- Single District (Composite Years Greenness Percentage comparison)

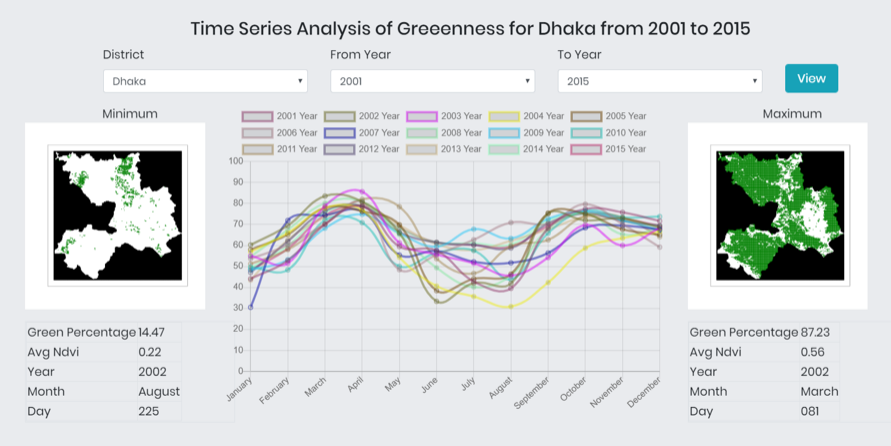


Fig. 8. Yearly changes of greenness in Dhaka district

These options show how greenness changes yearly among the districts and the relation to each other by representing the results in graph, bar chart plot and map view. Figure 8 shows the changes of greenness of Dhaka division from 2001 to 2015 in a time series analysis. The left and right images show the minimum and maximum greenness for any image found in the time frame chosen.

Figure 9 is showing yearly comparisons. Both showing almost the same pattern. Figure 10 shows a comparison that can be done with one district or between two districts. It also display the average NDVI values and percentage of greenness.

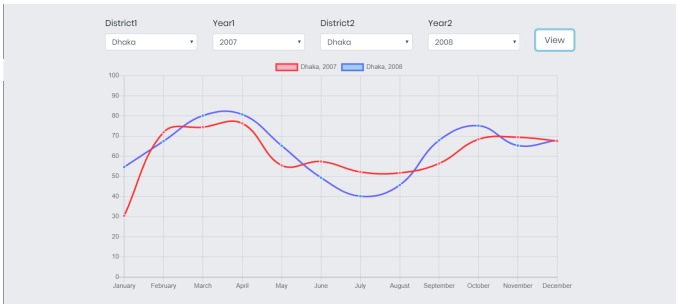


Fig. 9. Yearly Comparison of Dhaka district, in 2007 and 2008

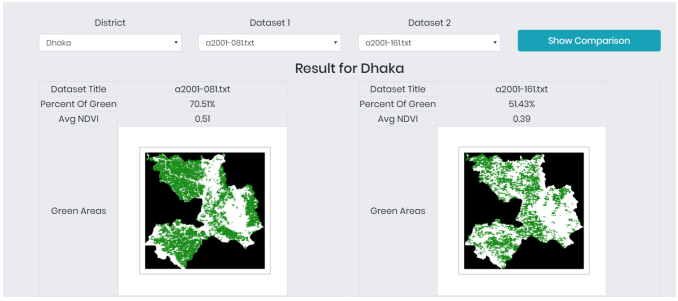


Fig. 10. Comparison between two different images

V. Conclusion

A web-based greenness analysis system using NDVI 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.

References

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[4] K. Fong, J. Hart, and P. James, *A review of epidemiologic studies on greenness and health* Curr Environ Health Rep. 2018, pp. 502–513, 2018.