A Digital Approach of Satellite Image Processing for Retrieving Surface Parameters

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ABSTRACT

Remote sensing offers an efficient and reliable means of collecting surface parameters required for many applications in crop model, flood monitoring and environment changes. Remote sensors flown on space based vehicles can provide structural information about the health of the vegetation over very large areas on the Earth. The spectral signature of a vegetative area varies with respect to changes in the phenology (growth), stage type, and health of vegetation present, and thus can be measured and monitored by multispectral sensors. In the present study NOAA-AVHRR images has been processed to find NDVI (normalized difference vegetation index) of the surface area of Bangladesh. Using this method surface NDVI maps for three prominent seasons of Bangladesh have constructed. Studying these maps it is observed that this type of processing technique may be suitable to derive long term NDVI maps for Bangladesh to study the soil condition, crop acreage and possible environmental changes.

*Keywords***:** Environmental change, NDVI, NOAA-AVHRR**,** Remote sensing, Vegetation Index.

1. Background

Vegetation indexes are a tool that can be used to map the presence of vegetation on a pixel basis as well as measuring the amount or condition of vegetation within each pixel. They are dimensionless numbers created by exploiting the unique spectral properties of plants, particularly in the red and near infrared portions of the spectrum. Plants reflect a very low amount of red energy because this energy is absorbed by chlorophyll for photosynthetic activities, which have maximum absorption at 470 nm (blue) and 670 nm (red). At the same time green healthy leaves reflect a very high amount of near infrared energy in the scattering process.

Therefore, the contrast between red reflectance to near infrared reflectance can provide a good indication for the presence of plants. Healthy vegetation absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light.

The combination of responses from different channels in the satellite radiometer can be used to find a parameter called vegetation index (VI) to monitor terrestrial landscapes and have been highly successful in assessing vegetation condition, foliage, cover, phenology, and processes such as evapotranspiration (ET) and primary productivity, related to the fraction of photosynthetically active radiation absorbed by a canopy (fPAR) [1-3].

Although many different VIs have been formulated, most of them are related to the Simple Ratio [4]

$$SR = NIR/Red \quad (1)$$

The most-used VI is the NDVI [1] [3]

$$NDVI = (NIR - Red)/(NIR + Red) \quad (2)$$

where NIR and Red are reflectance values of Red and Near Infrared light received at the sensors. The NDVI was first formulated by Rouse *et al* [5] and applied to a wide range of practical remote sensing applications in a series of studies by Tucker et al [6].This ratio can range from -1 to +1 but normal values fall between 0 and 0.8.

A zero means no vegetation, and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves.

At higher amounts of vegetation, the red band becomes saturated (approaches zero) because of chlorophyll absorption, and the NDVI changes only due to variations in the near-IR reflectance. In the real world, desert regions have been found to have the lowest, or baseline NDVI, followed by semi-arid and grassland regions. The highest NDVI values are found in closed forest canopies and open forests. Intermediate values usually indicate mixed regions. Over 70% of the earth's surface falls within this category [7].

Another form of VI called enhanced vegetation Index (EVI) (i.e., [3]) is calculated as

EVI = 2.5 x (NIR - Red)/ (1+ NIR + (6 x Red - 7.5 x Blue) (3)

Where, the coefficient "1" accounts for canopy background scattering and the blue and red coefficients, 6 and 7.5, minimize residual aerosol variations. The EVI is more functional on NIR reflectance than on Red absorption, and therefore it does not ”saturate" as rapidly as NDVI in dense vegetation, and it has been shown to be highly correlated with photosynthesis and plant transpiration [3]. The EVI is one of the two VIs available from the MODIS sensors and it is increasingly used in phenological, productivity and evapotranspiration (ET) studies.

The Advanced Very High Resolution Radiometer is the instrument that was first used, and still is most commonly used, to calculate NDVI. The sensor has five channels that are capable of providing day and night time information about ice, snow, vegetation, clouds and the sea surface.

	CH-1	CH-2	CH-3	CH-4	CH-5	CH-6
Spectral Range (micrometers)	0.58-0.68	0.725-1.1	1.58-1.64	3.55-3.95	10.3-11.3	11.5-12.5
Detector type	Si	Si	InGaAs	InSb	HgCdTe	HgCdTe
Resolution (km) Nadir	1.1	1.1	1.1	1.1	1.1	1.1
IFOV	1.3	1.3	1.3	1.3	1.3	1.3
Physical Variables associated	Visible red light Used for NDVI and Daytime cloud and surface mapping	Near Infrared. Used for NDVI and Land-water boundaries	Thermal Infrared. Snow and Ice detection	Thermal Infrared. Night cloud mapping, sea and surface temperature	Thermal Infrared. Night cloud mapping, sea surface temperature	Thermal Infrared. Seas surface temperatures

Table 1: Characteristics of the NOAA polar orbiter AVHRR instrument.

This data is obtained on a daily basis, free of cost and covers a vast area of earth surface in a single pass of satellite. In this study NOA-AVHRR images obtained from Bangladesh Space Research and Remote Sensing Organization (SPARRSO) has been used to derive NDVI for three months for the year 2005.

1.1 The Study Area

In this work, the study area is the geographical area of Bangladesh which is located between 20°34′ to 26°38′ north latitude and 88°01′ to 92°42′ east longitude.

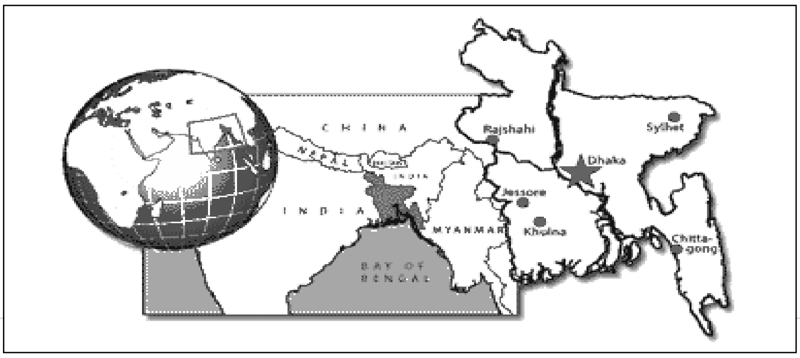


Figure-1 Map showing the study area.

1.2 Material Used

The source of remote sensing data that has been used for this study is near polar sun-synchronous satellite of NOAA K-L-M-N series. In this study particularly NOAA-16(L) and NOAA-17(M) imagery has been used. The data are captured by the NOAA satellite ground station that is situated at SPARRSO (Space Research and Remote Sensing Organization) in Agargaon, Bangladesh. The images are generated by Kongsberg Spacetec S.A. Ltd. Multimission Earth Observation System (MEOS).

2. Methodology

Satellite image processing is an integrated task. The whole work has been divided into the phases as shown in Fig.2.

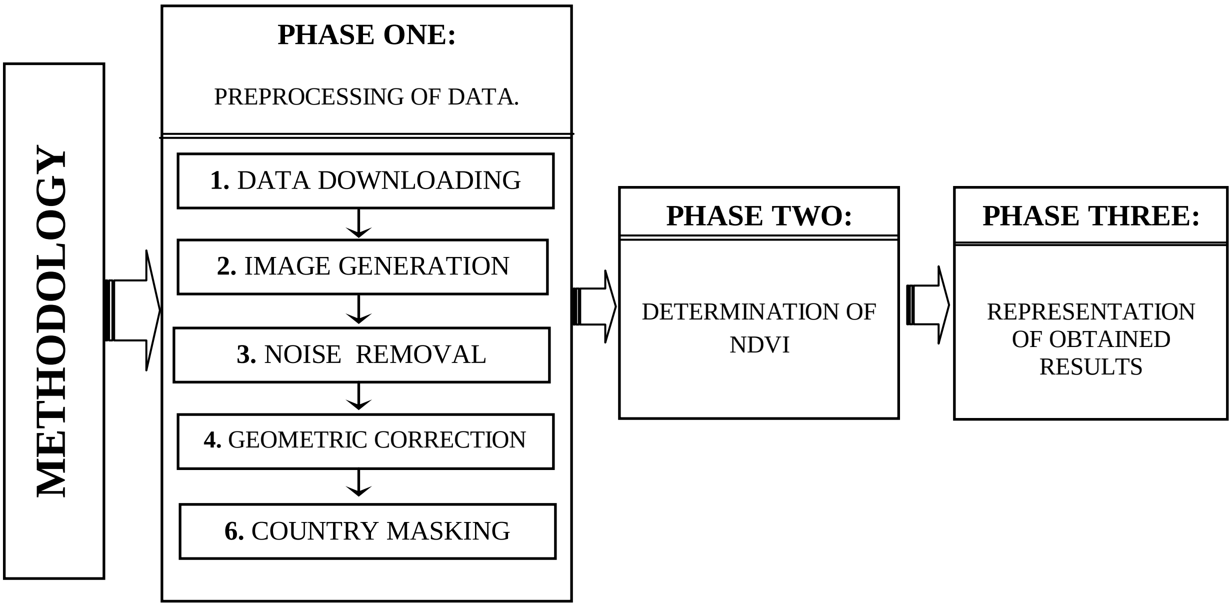


Figure 2: Flow diagram of the methodology of satellite image processing to determine NDVI using NOAA-AVHRR data.

2.1 Preprocessing

The fundamental aim of preprocessing is to correct the distorted or degraded image data to create a more faithful representation of the real scene. In this study, in the first step of preprocessing, NOAA AVHRR/3 1.1km data are downloaded by the 1.2m L-band satellite antenna. This antenna is sensitive at the frequency of 1695-1710 MHz and is a continuous tracking antenna. The transmission of data from satellite to ground station is happened by the format called High Resolution Picture Format (HRPT). The multi-band color image is generated from various channels and its composition has been carried out by the software named MEOS. In the next step, the HRPT data format is converted into HDF format (.hdf) by the image processing software ERDAS IMAGINE. After then the HDF format is converted into image format (.img) which is known as raster data.

NOAA AVHRR data suffers various types of noise such as badline, hole of pixel, scattered of pixel etc. In this study images are inspected visually and the images that contain no line noise or systematic distortion and low cloud contamination are selected for next processing. The raw images generally contain geometric distortions due to its course resolution. In this study, a two-step procedure has been performed to correct this geometric distortion from the raw images. In the first step, a second order polynomial rectification process has been applied by selecting ground control points (GCP's) manually. A minimum of 20 GCPs are selected which are uniformly distributed over the image. In the second step, the images are resampled to a map projection system based on the location data generated by orbital model navigation and as well as geo-registered it with a pre-corrected reference image.

2.2 Determination of Vegetation Index

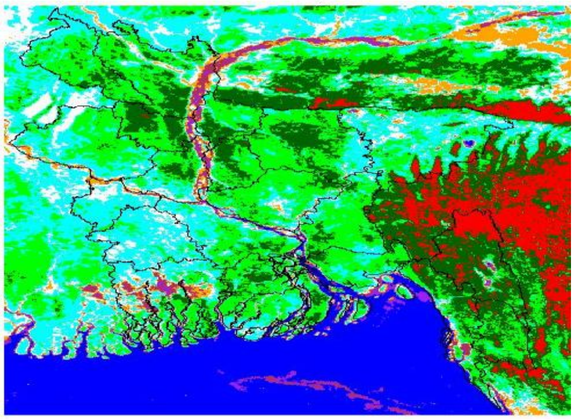
To derive NDVI, in this study, apparently cloud free images from three months for the year 2005 has been selected. In this process three images for December 6th, 7th and 8th; three images for April 12th, 15th and 21st; and one image for September 15th have been taken. The multi-date images of a month are used to form a single image applying a compositing process. All day-time images are taken, pixel values for a channel of one image are compared to the corresponding pixels of all other images for that month. The minimum values for each pixel thus obtained are retained. The resultant image will be the monthly composite image. As the monthly composite map contains data from different days and different weather and sun-target-sensor geometry, taking the minimum values for each pixel from the complex condition may reduce the effect of atmospheric intervention [7] [8]. NDVI for each composited image is then determined using Equation-2.

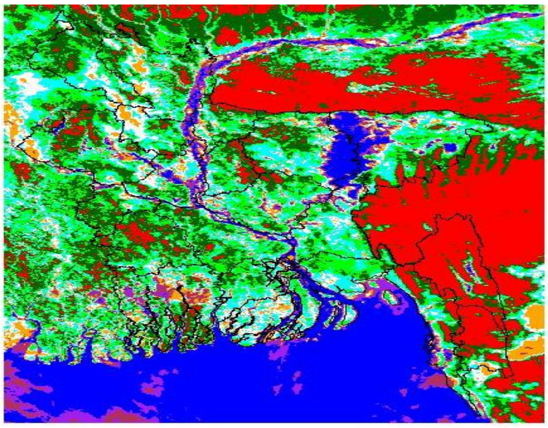
3. Result and Discussion

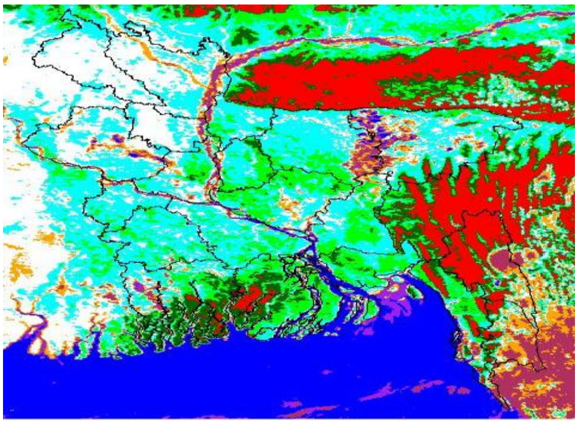
The false color composition (FCC) maps of NDVI values for Bangladesh are shown in Figure-3 for the months of April, September and December, 2005. For all the maps, a unique categorization scheme has been used to classify different NDVI levels based on the NDVI values covering the whole study period.

From the figures above it can be seen a significant variation of the vegetation index over the area of Bangladesh among the three periods. NDVI values less than 0 indicates non-vegetative surface areas such as water or cloudy pixels. Values from 0 to 0.1 indicate non-vegetative lands. Higher values of NDVI indicate the amount of vegetation present and its greenness.

In April, for most of the areas of Bangladesh NDVI values are seen to vary from 0.2 to 0.4. Highest NDVI values (0.4 to 0.6) are observed in the southeastern hilly areas (Rangamati, Chittagong, Khagrasory) whereas the lowest values (0.1 to 0.2) are seen in the mid-western and south-western parts. Green color for most of the surface areas are may due to the growing crops throughout the country.







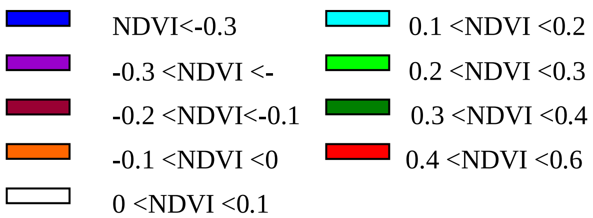


Figure-3.
NDVI maps of three main seasonal periods of Bangladesh. Upper left is for April (Summer); upper right is for September (Monson); lower left is for December (Winter).

In September mixed values of NDVI are observed throughout the country. In this month no completely cloud-free images are obtained. As a result the map contains some cloud. Also some water areas are seen in the greater Mymensing, Sylhet and Khulna regions and some other regions. Except some small scattered areas having high level of NDVI, the overall NDVI values for the country are seen relatively lower than that of April. September is the last part of Monsoon period and soils for all areas are wet. Since the wet soil have relatively higher absorption in channel-2, the resultant NDVI values become small.

In December lower level of NDVI values are observed for the country. No vegetation or very negligible vegetation (NDVI value from 0 to 0.1) is seen for large areas of the north-western part of the country. The highest level of NDVI (0.4 to 0.6) is seen for the hilly areas of the Chittagong division. For all other areas low level of NDVI (0.1 to 0.2) are observed.

4. Conclusion

In this study NDVI maps for the whole Bangladesh have been prepared from the freely obtainable USA based NOAA-AVHRR satellite images. The maps clearly indicate the vegetation conditions throughout the country for the study period. The method used in this study thus can be utilized to construct the NDVI maps for longer periods (10 to 15 years) over the country. These maps may be a valuable resource for studying in the changes of vegetation patterns, soil characteristics and effect of environmental changes.

Acknowledgement

The authors gratefully acknowledge the administrative support and remote sensing image provided by the Bangladesh Space Research and Remote Sensing Organization (SPARRSO), Dhaka.

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