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Surface Temperature and NDVI Generation and Relation between Them: Application of Remote Sensing

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ABSTRACT

Temperature is one of the most important climatic parameters and there are many methods to estimate the surface temperature distribution. The aim of this study is to analyze the surface temperature and develop a relationship between surface temperature, land cover and NDVI using satellite image. In this research band no 6 from Landsat TM satellite image was used to estimate surface temperature and NDVI. Remote sensing is an effective tool for classification of landcover and NDVI. Also regression analysis is an effective statistical tool by which the relationship between land cover, surface temperature and NDVI can be identify. In this paper statistical analysis, Geographic Information system and Remote sensing – all are used to identify the relationship between three of them. And in result, it is found that the temperature is comparatively low in vegetation area and in non vegetation area temperature is high. The correlation between both of them is found 35% and also regression value is found 0.17. The paper will regard as one of most effective methodologies to generate surface temperature with consideration of various geographical phenomena and also a relationship between them.

Keywords: Remote Sensing, Satellite Image, Surface Temperature, NDVI, GIS.

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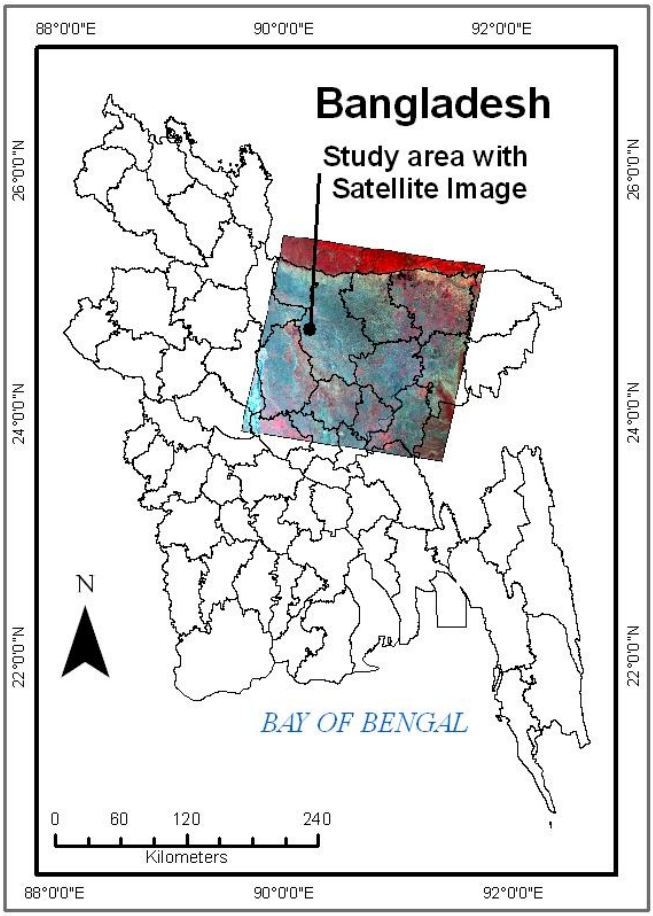
1. INTRODUCTION

Bangladesh is a developing country and it is urbanizing rapidly. So to develop urban for fast growing population we need proper urban planning as well as also need rural planning. But most of the time we fail to develop a sustainable planning with concern of global climate change as well as local micro-climate change due to lack of proper climatic parameters model. Temperature is one of the most important climatic parameters which should consider during planning. In this research a temperature model will be tried to develop with help of geographic information system and Remote sensing so that we can easily calculate the variation of temperature between Rural and urban for sustainable development. And the surface temperature varies for various geographical phenomena. GIS (Geographic Information System) and remote sensing are modern research techniques to analyze the surface variation of temperature and NDVI. Griend(1993) analyzed distribution of temperature depending on status of surface with correlative analysis between NDVI and surface temperature using Landsat TM images. According to Klysik and Fortuniak(1999), urban heat island is a phenomenon, which temperature is distinctly going up, because of the increasing buildings in cities. The cities are non vegetative area and other land are vegetative area except waterbodies and bareland. The main aim of this research is to estimate surface temperature from satellite images and develop the most effective model through the comparing land cover, NDVI (Normalization Difference Vegetation index) and surface temperature.

In this research, the study area was selected as a full strip image of Landsat TM satellite where all the bands were available. The extent of the image was top 820100 bottom 609830 right 683410 left 460360 at Transverse Mercator Projection where Brahamanbaria, Dhaka, Gazipur, Jamalpur, Kishoreganj, Manikganj, Mymensingh, Narayanganj, Narsingdi, Netrakona, Sherpur, Tangail, Habiganj and Sunamganj- 14 districts are situated. A study area map is shown in map 01.



Map 01: Study area map with satellite image

Materials and Methods

In this research a multispectral Landsat TM (30 January 2010) image was taken. The spatial resolution of the image is 30mX30m and 8 bit image. Band 6 which is a thermal band was used for surface temperature and NDVI generation. The wave length of band 6 is 10.40-12.50 micrometers. The minimum and maximum DN value of the image was 113 and 159 with 3.111 standard deviation and mean 130.347. The histogram of the image is given in fig 01. Four steps were taken to do the research and the processes are described below. The projection parameters of the image are given in fig 02.

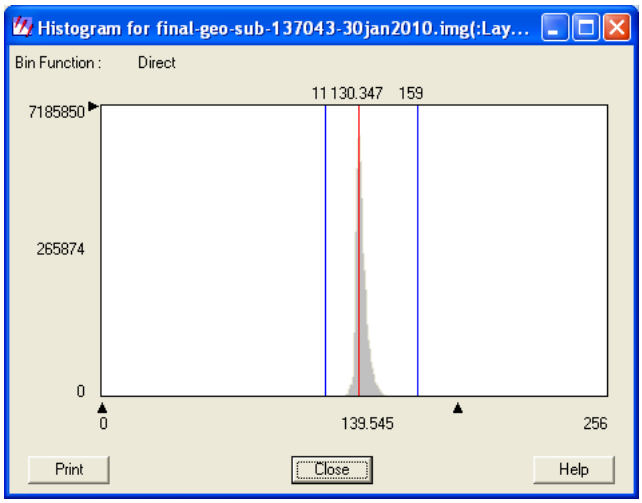


Fig 01: Histogram of Band 6 of Landsat TM image

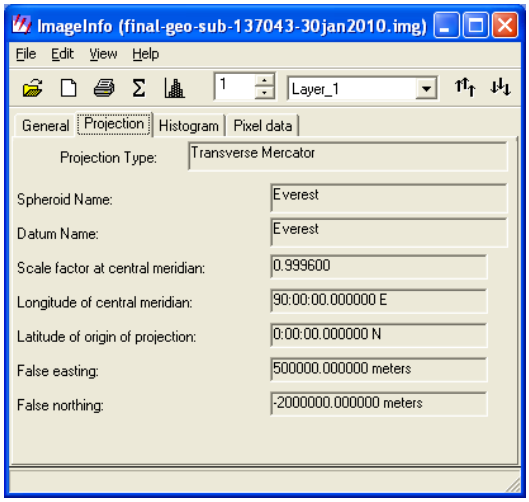


Fig 02: Projection Parameters of the image

1. Surface temperature Analysis using DN value of Landsat TM band 6:

To analyze the surface temperature variations with band 6 of landsat TM image, the following formulas were used to determine the temperature. To do so three steps were carried out to generate the temperature from (Digital Number) DN values of image. And a model was developed at Erdas Imagine software.

Step1. Conversion of the Digital Number (DN) to Spectral Radiance (L)

L = LMIN+ (LMAX-LMIN) * DN/ 255

Where

L = Spectral radiance

LMIN= 1.238 (Spectral radiance of DNvalue 1)

LMAX= 15.600 (Spectral radiance of DNvalue 255)

DN= Digital Number

Step2. Conversion of Spectral Radiance to Temperature in Kelvin

$$T_B = \frac{K_2}{\ln\left(\frac{K_1}{L} + 1\right)}$$

Where

K1= Calibration Constant 1 (607.76)

K2 = Calibration Constant 2 (1260.56)

TB= Surface Temperature

Step3. Conversion of Kelvin to Celsius

T= TB-273

2. landcover classification map:

A supervised classification process carried out from the satellite image with Erdas Imagine software and found 11 classes. And the classes were Agricultural Land, Bareland, Chars, Deep Forest, Forest, Haor, River, Settlement, Shallow Waterbodies, Urban and Vegetation Cover.

3. Extraction of NDVI

In this research to generate NDVI with band 4 and band 3 of the image the following formula was used by model making at Erdas Imagine software.

$$\frac{NIR - IR}{NIR + IR}$$

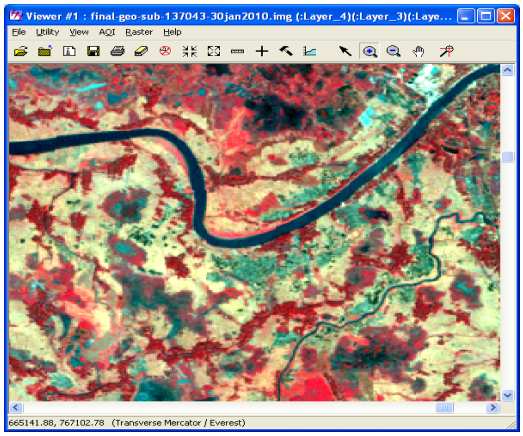


Fig 03: Supervised Classification of Landsat TM for landcover mapping

Where NIR is Band 4 and IR is band 3. Normally NDVI have the value of -1(Min) ~ 1(Max) through Equation of NDVI extraction.

4. Statistical Analysis of Temperature and NDVI

Temperature data acquired at the point of 50 different locations. Where various numbers of points were taken from various landused categories. The distribution of points at different category is given below:

Sl No	Category	Number	Sl No	Category	Number
1	Agricultural Land	3	7	River	5
2	Bareland	1	8	Settlement	6
3	Chars	2	9	Shallow Waterbodies	8
4	Deep Forest	7	10	Urban	3
5	Forest	3	11	Vegetation Cover	7
6	Haor	5			
Grand Total			**50**		

Table 01: Distribution of observation points among different landuse categories.

Finally temperature and NDVI values were extracted of each points with spatial location methods by ArcGIS Spatial Analyst and regression line was drawn with these two variable where landuse categories were independent and temperature and NDVI were dependant variable. The figure 04 shows the prediction statistics of 50 observation points and validity.

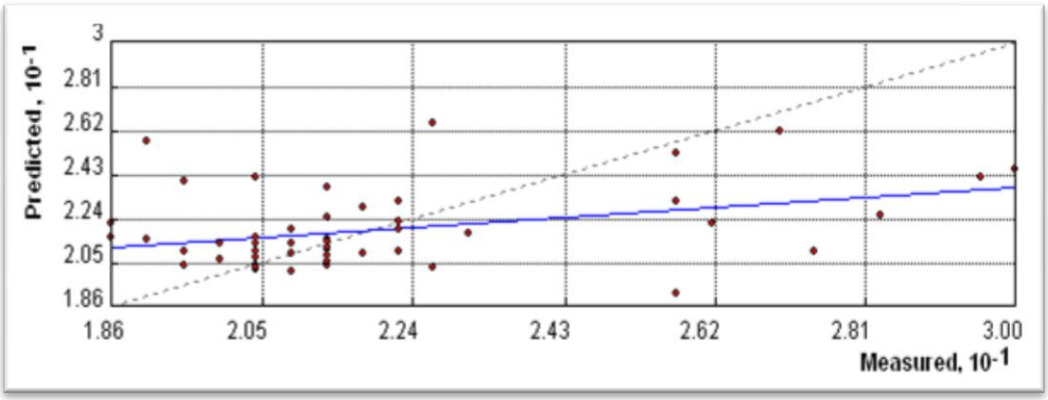


FIg 04: Prediction statistics of 50 observation point's temperature from Landsat TM band 6

Findings

After applying the above surface temperature generation formula, the average temperature of each landuse category were found and the following table shows the value. The lowest temperature found in River (18.58^0 C) and the highest temperature in Urban and that is 29.97^0 C. Also the highest NDVI value found in Deep forest and forest (0.25) and the lowest value is 0.0 in various categories and these are Bareland, Chars, River and Urban where generally physically no vegetation were found. Tbale 02 shows the individual average value of temperature and NDVI.

Class	Avg Temp(⁰ C)	NDVI Value
Agri Land	23.48	0.08
Bareland	27.01	0.00
Chars	26.57	0.00
Deep Forest	21.37	0.25
Forest	22.00	0.25
Haor	20.04	0.03
River	18.95	0.00
Settlement	22.41	0.18
Shallow Waterbodies	21.51	0.00
Urban	26.11	0.00
Vegetation Cover	20.85	0.27

Table 02: Landcover classification, average Surface temperature and NDVI

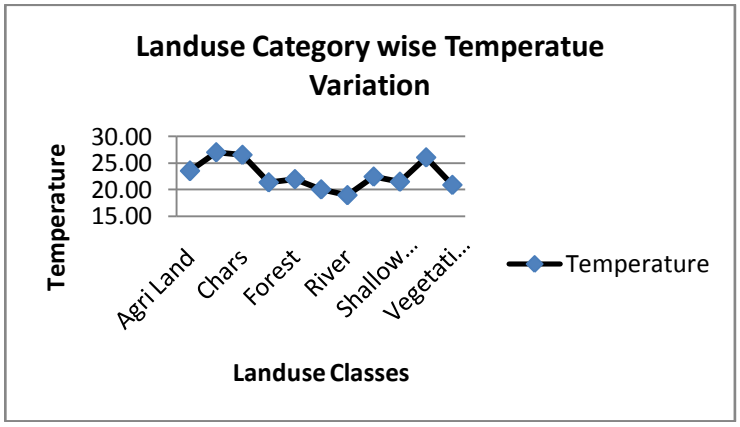


Fig 05: Landuse category wise graphical presentation of temperature.

From the NDVI generation it is found that the following values which shows the vegetation intensity of the observation points. The average value is given in table 02 also in a graph (fig 06).

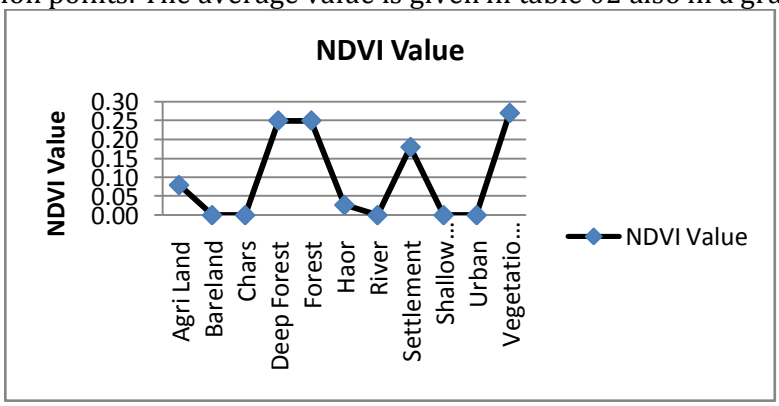
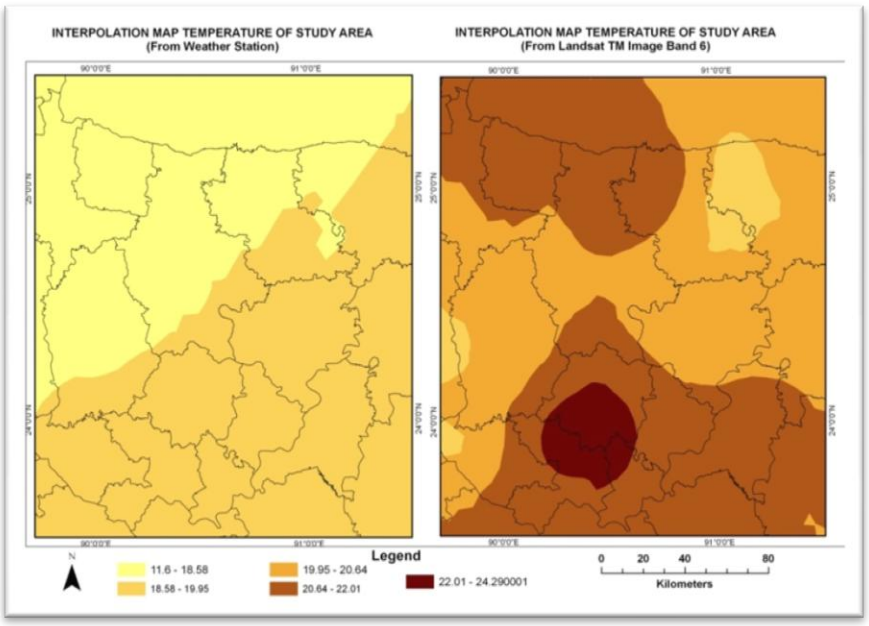


Fig 06: Landuse category wise graphical presentation of NDVI.

After generating both temperature and NDVI indexes data of 50 different observation points a regression analysis was done to find out the relationship between two variables and found that Multiple R is 0.17 and R2 is 0.028. Also the correlation between two variables is 35%.

After generating the surface temperature from Landsat TM satellite image Band 6, the temperature distribution map was prepared by GIS software where geostatistical method was used. A distribution map was prepared from data of local meteorological observation stations. From both map it is found that the map from satellite image shows the more accurate and actual distribution. As we know temperature varies with various geographical landuse classes and land types. And many temperature classes were found. The map 02 shows the comparism of both maps.



Map 02: Comparism of prepared maps between two methods.

Conclusion

In this research 50 observation points were selected and calculated Pearson correlation coefficient(R) between surface temperature and NDVI for to study distribution of temperature in green area and non-green area and found that the value is 0.16. Regression analysis between two variables shows that the multiple R is 0.17. Also the correlation between surface temperature and NDVI is 35% which indicates the vegetation covers having low temperature and non vegetation covers having high temperature. the result shows that the Urban area have high temperature and the waterbodies and also the forest area have comparatively low temperature. Generally many other interpolation methods like Inverse distance weighted (IDW), Kriging or Spline are used for analyzing surface temperature and also distribution of temperature. But there the geographical phenomena were not considered so that the surface temperature distribution is not properly analyzed. The Satellite Image like Landsat TM is more useful to analyze the surface temperature and also NDVI.

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