Relationship between NDVI with Tasseled cap Indices: A Remote Sensing based Analysis

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Abstract- **Green cover removal is a crucial factor in urbanization scenario. These changes can be clearly observed and estimated by using Geographic Information System (GIS) technologies and satellite images. The Normalized Difference Vegetation Index (NDVI) is a general tool which is used in decision making regarding remote sensing based land cover and land-use related studies. Tasseled cap indices provide more detailed description on separate land features such as vegetation, water and bare land. Kelaniya is an important city with higher population density and infra-structure development which is very closer to capital city of Sri Lanka. The main objective of this study was to find out the relationship between tasseled cap transformation indices and NDVI. An image from Landsat 8 was used for the analysis while ArcGIS 10.1 was using as the software. From the image analysis process, NDVI and Tasseled cap transformation (TCT) maps were derived for the study area. A strong positive relationship was identified between NDVI and Tasseled cap greenness index. Tasseled cap indices enable to provide much more detail interpretations for the judgments made based on NDVI values**

Index Terms- **GIS, Land-use/Land-cover, NDVI, Remote Sensing, Tasseled cap transformation**

I. INTRODUCTION

Remote sensing is a technique, which can be used to detect and quantify the spatial changes on the earth. Satellite images are, one of the main data sources used in remote sensing. With the time when population increase, the soft land cover on the earth is removed gradually and it replaced with hard low reflective materials [1]. These changes can be observed clearly by the changes of vegetation indices and tasseled cap indices. Normalized Difference Vegetation Index (NDVI) is standard vegetation index which enable us to derive an image for interpret the relative biomass in an image area [2]. The chlorophyll absorption in band red (RED) and relatively high reflectance of vegetation in Near Infrared band (NIR) are using for calculating NDVI [3]. Derived output of NDVI method provides a single-band dataset which only shows greenery. NDVI value is varying between -1 to +1. Values that are exceeded +0.1 represent vegetation and values which are closer to zero represent rock and bare soil [4]. Negative NDVI values represent water, snow and clouds. Increase in the positive NDVI value means greener the vegetation .This method was developed by the NASA scientist [3]and it popularized as Normalized Difference Vegetation Index (NDVI).

The Tasseled Cap transformation was developed to map and evaluate urban and vegetation changes detected by different satellites. The name “Tasseled Cap” was given because of the shape developed after the graphical distribution of plotted data [5]. By Tasseled Cap Transformation, it converts the readings from set of channels into composite values. The weights are assigned to separate channels and the weighted sum of each channel was taken. These weighted sums are measured the brightness of each pixel in the scene. Other composite values are the linear combination of the separate channels. Some of these weights are negative and some are positive. Three bands are commonly used in tasseled cap transformation based analysis. Band one which is correspondence with image “brightness” gives a measure of soil brightness that used to develop brightness index. Band two is correspondence with “greenness”or photo synthetically-active vegetation to derive greenness index. The third tasseled-cap band is usually interpreted as an index of “wetness” in which describes the interrelationship of soil and canopy moisture [6].

II. STUDY AREA

Kelaniya DS division (around 20km^2 in area) which is having a tropical monsoon climate was selected as the study area for this research. Western province is the highest industrialized and the urbanized region in Sri Lanka. Colombo is the main city in Western Province as well as the capital city in Sri Lanka. Next to Colombo, Kelaniya is leading to have a rapid infrastructure development as well as for the population expansion [7].

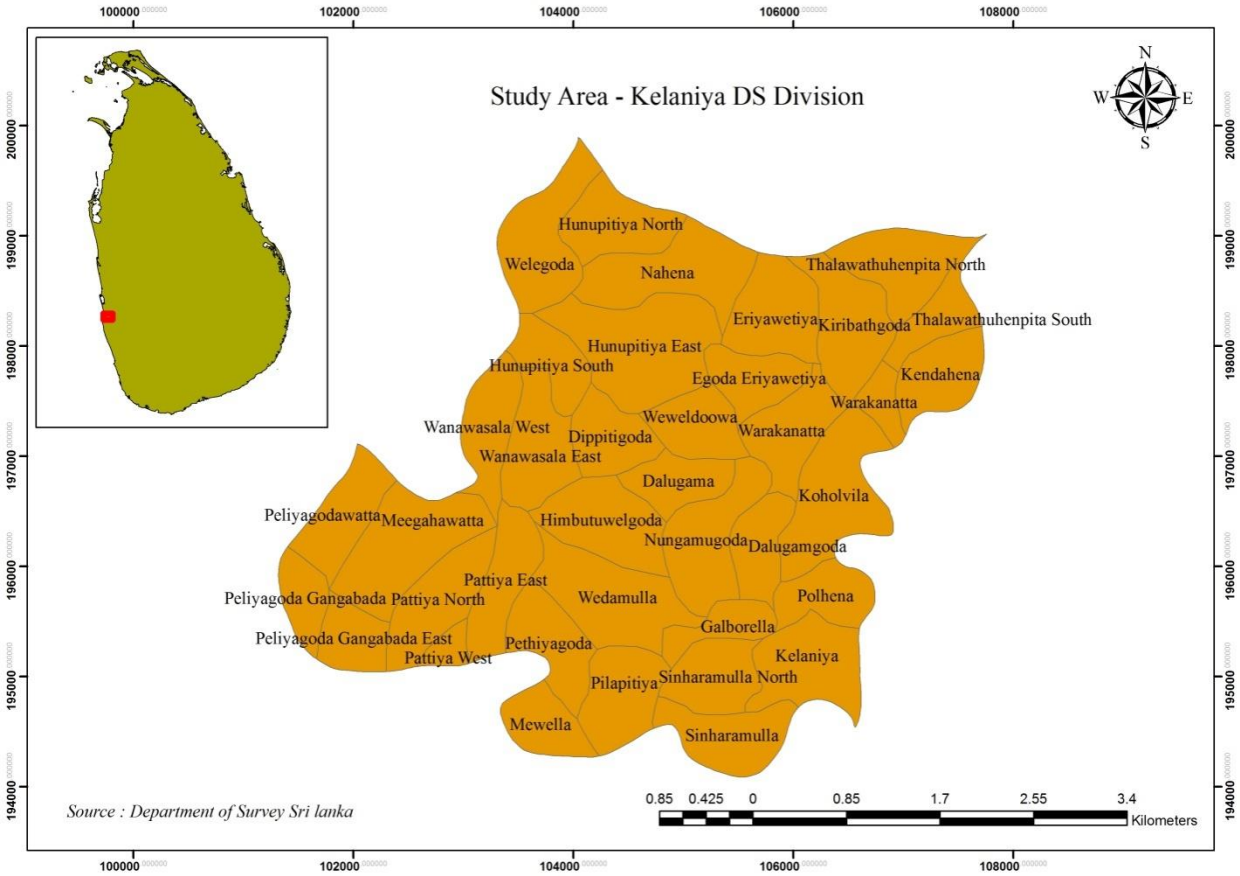


Figure 01 Study area – Kelaniya DS Division [1]

III. OBJECTIVES

Main objective of this study is to find out the relationship between TCT indices and NDVI. There are two other specific objectives; to derive NDVI and NDBI maps in the study area and to derive separate greenness, brightness and wetness tasseled cap index maps of the study area.

IV. DATA AND SOFTWARE

Clear digital images were acquired in year 2014 by using Landsat 8 satellite, which are with less than 10% in cloud cover (image ID = LC81410552014021LGN00). Arc GIS 10.1 software was used in image analysis.

V. METHODOLOGY

***Pre preparation of the satellite images* [8]**

Before applying the image analysis functions for the selected satellite image, it should be pre prepared. Radiance values in the selected bands (band number 2 to band number 7) of the satellite image should be converted to Top of Atmosphere (TOA) planetary reflectance values by using reflectance rescaling coefficients available in the metadata file of the image.

Conversion of Digital Numbers (DN) in to TOA reflectance values

Following equation was used to convert Digital Numbers (DN) in to TOA reflectance

$$\rho\lambda = M\rho * Q\,cal + A\rho \qquad \text{Eq. 01}$$

Where,

$\rho\lambda$= TOA planetary reflectance, without correction for solar angle.

$M\rho$= Band-specific multiplicative rescaling factor

$A\rho$ = Band-specific additive rescaling factor

Q cal = pixel values (DN).

Correcting the Reflectance value with the Sun angle

Resulted TOA reflectance values were not calibrated according to the Sun angle at the time of image acquisition. Following equation was used to correct resulted reflectance values with the Sun angle.

$P\lambda corrected = \rho\lambda / \sin \theta SE$ Eq. 02

Where,

$P\lambda corrected$ = reflectance values after sun angle correction

$\rho\lambda$ = TOA planetary reflectance

θSE = Local sun elevation angle (sun angle).

Deriving NDVI map[3]

Band 4 and Band 5 from the Pre prepared bands of the selected image was used for the analysis. Following equation was used to derive NDVI map. Raster calculator was the tool which was used in this analysis in Arc GIS software.

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

Eq. 03

Where,

NIR = Near Infrared Band

RED = RED Band

Above equation was modified according to the corresponding band numbers as follows,

$$NDVI = \frac{Band\ 5 - Band\ 4}{Band\ 5 + Band\ 4}$$

Eq. 04

Deriving Tasseled Cap Indices[6]

Tasseled cap indices provide a measure of Greenness, Brightness and Wetness of each pixel. It utilizes a linear combination of Landsat bands (From band 2 to band 7). Tasseled cap indices were calculated by using the following equation.

$$Tas\_cap\ i = (coeff_2 * band2) + (coeff_3 * band3) + (coeff_4 * band4) + (coeff_5 * band5) ++(coeff_6 * band6) + (coeff_7 * band7)$$

Eq. 05

Where,

Tas_cap i = Calculated tasseled cap index (Greenness, Brightness or Wetness)

Coeff = Corresponding co efficient values for each band

Band = Pre prepared bands

Coefficient values for each band for each index was applied according to the table below

Table 1. Coefficients of the Tasseled Cap transformation applied to Landsat 8

Index	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7
Brightness	0.3029	0.2786	0.4733	0.5599	0.508	0.1872
Greenness	−0.2941	−0.243	−0.5424	0.7276	0.0713	−0.1608
Wetness	0.1511	0.1973	0.3283	0.3407	−0.7117	−0.4559

Estimate the Relationship between NDVI and Tasseled cap indices.

Pixel values of NDVI and three different tasseled cap indices were extracted separately by using pre created 200 random points. Then the extracted brightness, greenness and wetness values of the each location (random point) were plotted in a scatter plot against corresponding NDVI value of the location.

VI. RESULTS AND DISCUSSION

NDVI map extraction

Derived NDVI map was shown in figure 02. Dark red color area represent low NDVI values while dark green color represent high NDVI values. NDVI value of the study area varies among 0.82 and -0.40.

Tasseled cap brightness index map extraction

Derived Tasseled cap brightness index map was displayed in figure 03. Dark red color area represent high brightness values while blue colors represent low brightness values. Tasseled cap brightness index in the study area vary among 1.16 and 0.10.

Tasseled cap greenness index map extraction

Derived Tasseled cap greenness index map was expressed in figure 04. Dark green color area represent high greenness values while purple colors represent

low greenness values. Tasseled cap greenness index in the study area vary among 0.32 and -0.19.

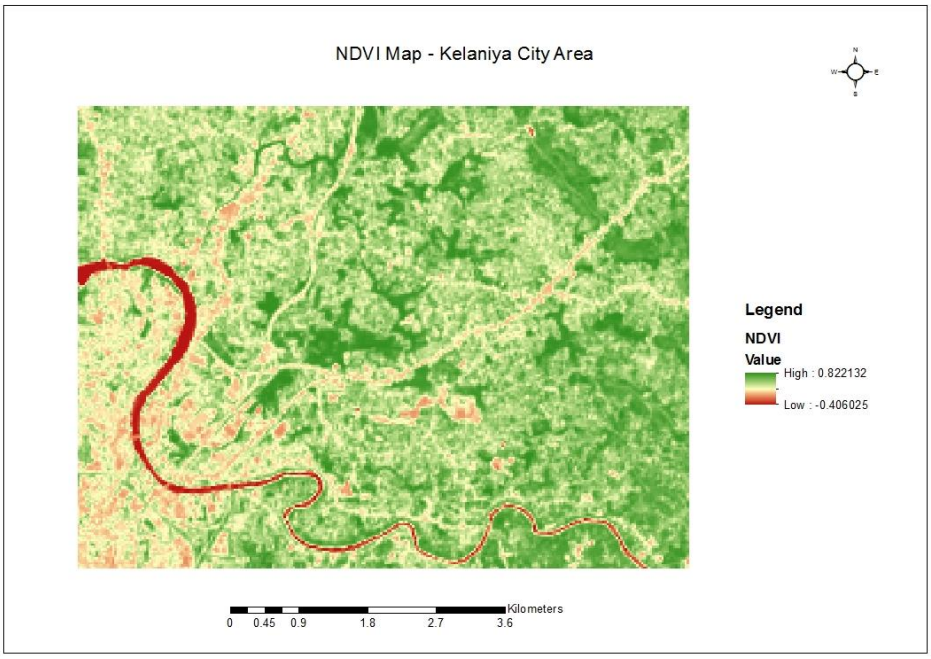
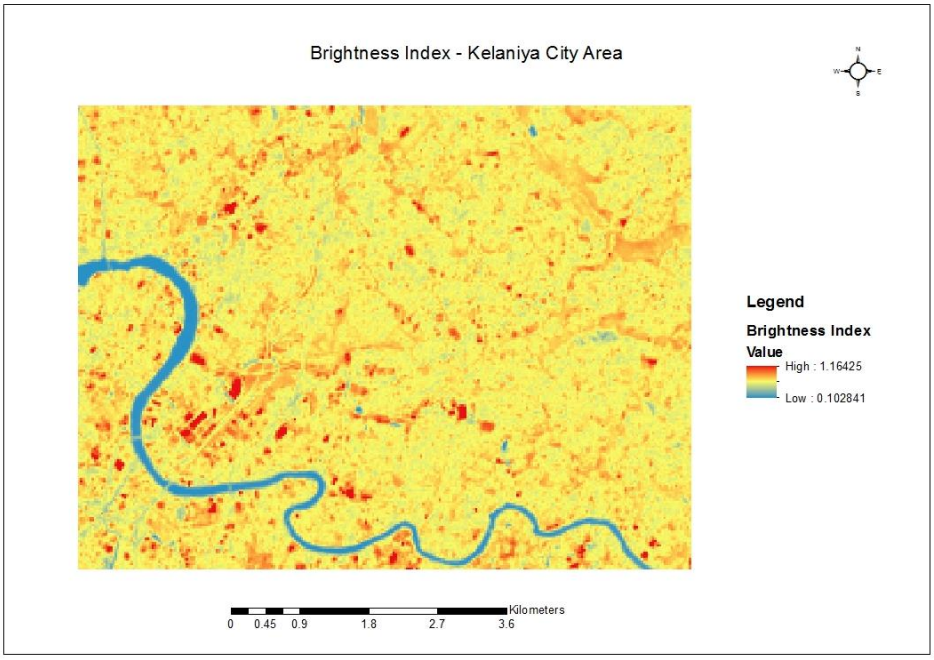


Figure 02 NDVI Map – Kelaniya



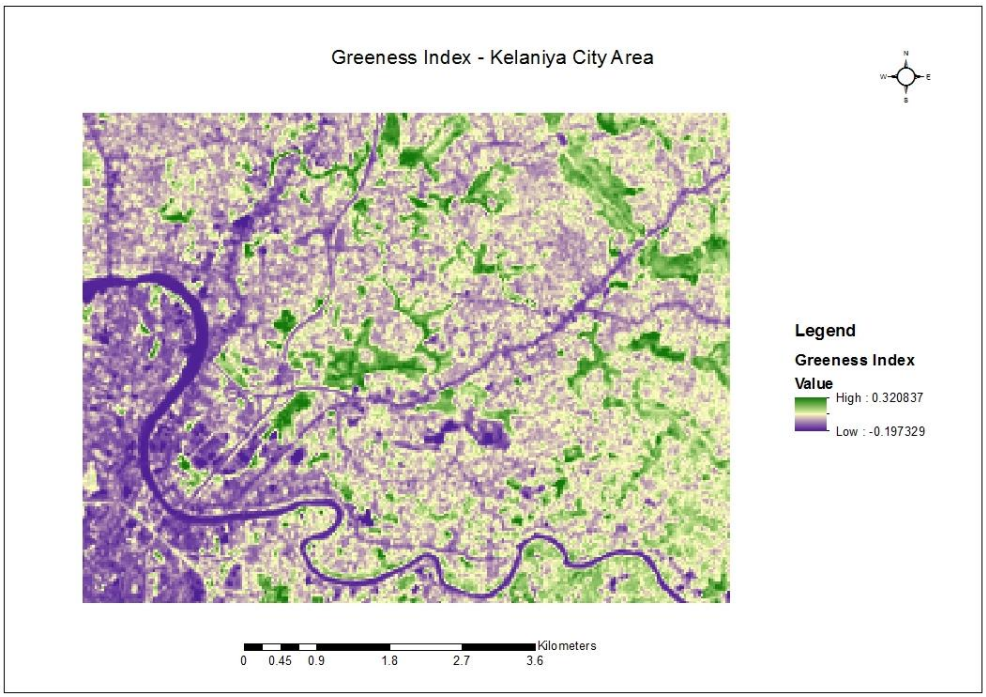


Figure 04 Greenness index Map – Kelaniya

Tasseled cap wetness index map extraction

Derived Tasseled cap wetness index map was shown in figure 05. Dark blue color area represent low wetness values while blue colors represent high wetness values. Tasseled cap wetness index in the study area vary among 0.13and -0.35.

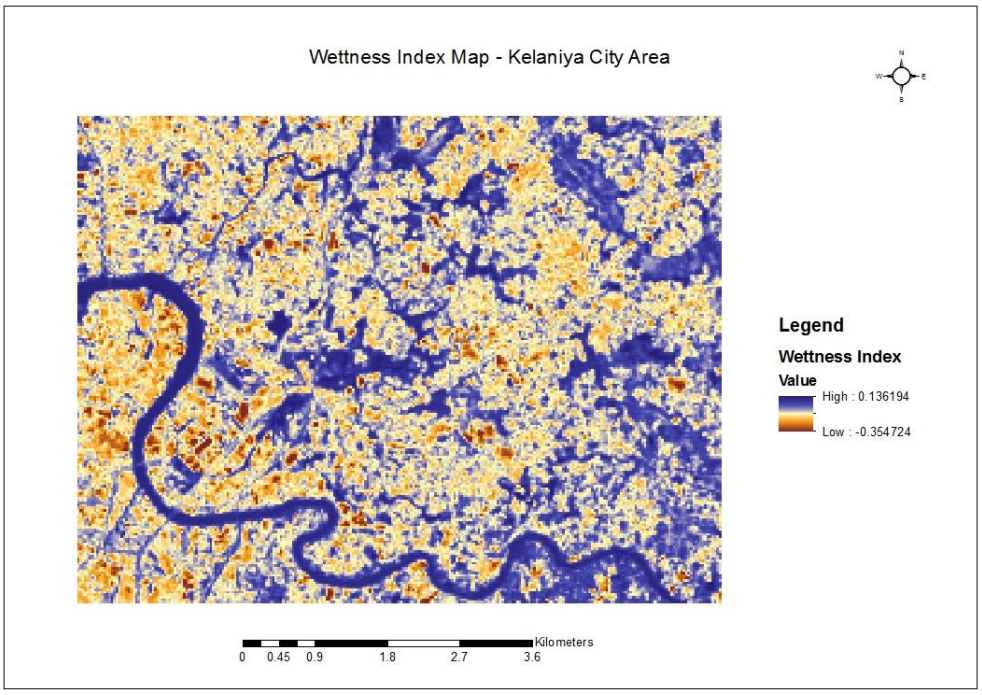


Figure 05 Wetness index Map – Kelaniya

Relationship between NDVI and Tasseled cap brightness index

Relationship between NDVI and Tasseled cap brightness index was displayed in figure 06. The graph expressed, there is a constant relationship between NDVI and Tasseled cap brightness index. According to the R^2 value (0.002) it explained the relationship between NDVI and Tasseled cap brightness index is very small.

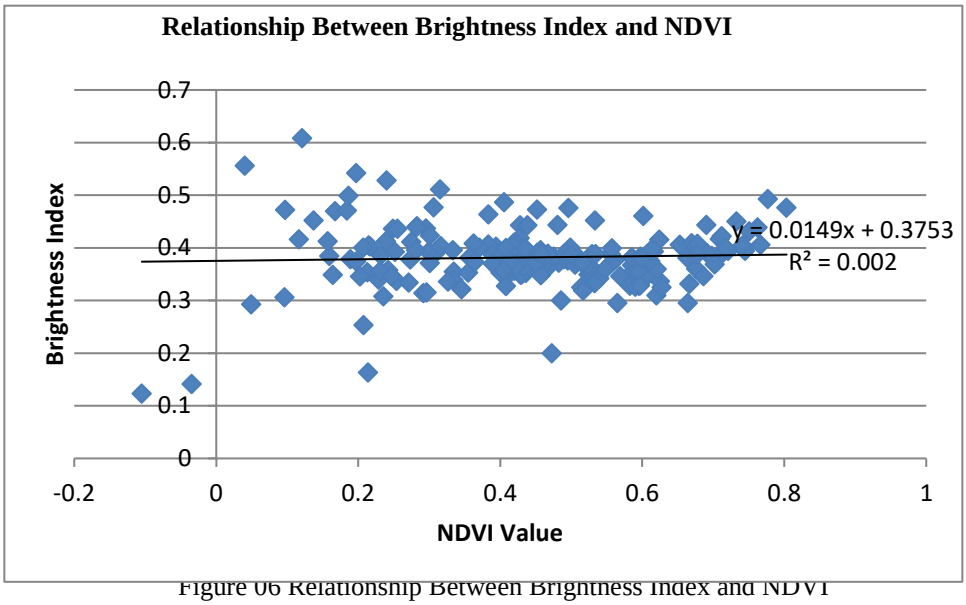


Figure 06 Relationship Between Brightness Index and NDVI

Relationship between NDVI and Tasseled cap greenness index

Relationship between NDVI and Tasseled cap greenness index was shown in figure 07. The graph explained that there is a positive relationship between NDVI and Tasseled cap greenness index. According to the R^2 value (0.91) it explained the relationship between NDVI and Tasseled cap brightness index is very strong.

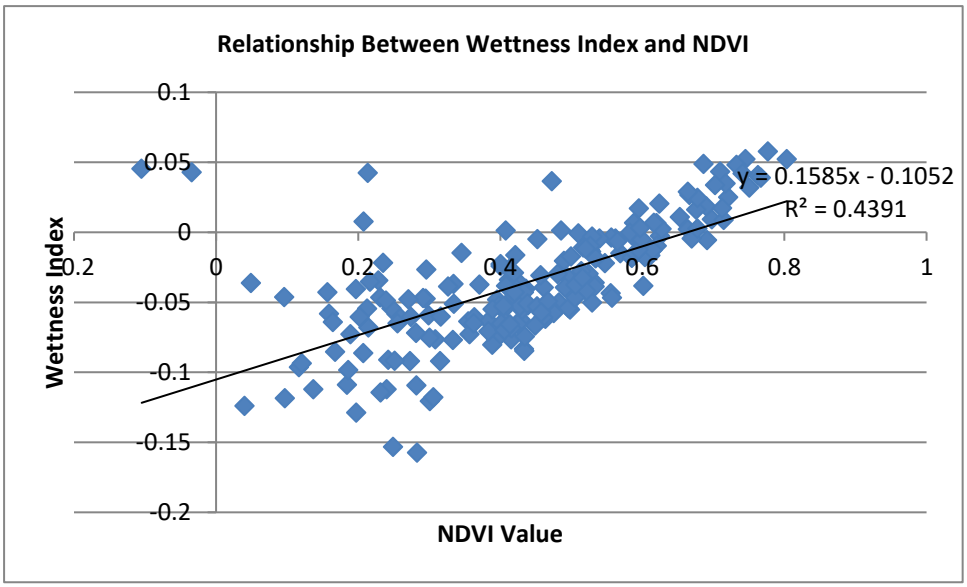


Figure 07 Relationship Between Wetness Index and NDVI

Relationship between NDVI and Tasseled cap wetness index

Relationship between NDVI and Tasseled cap wetness index was displayed in figure 08. The

graph expressed that there is a positive relationship between NDVI and Tasseled cap wetness index. According to the R^2 value (0.43) it explained the relationship between NDVI and Tasseled cap wetness index is not very strong.

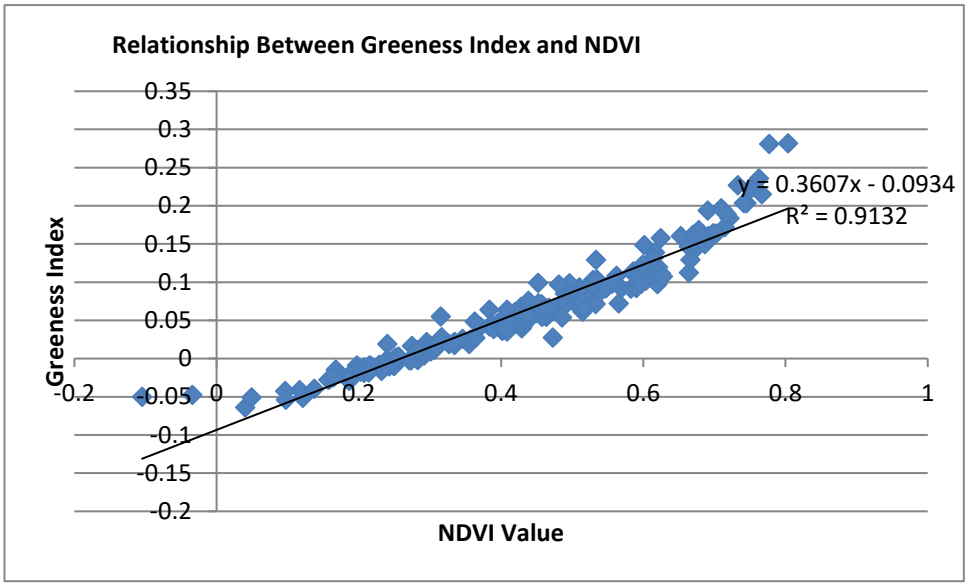


Figure 08 Relationship Between Greenness Index and NDVI

VII. CONCLUSIONS

Tasseled cap indices provide more detail information about the land-use and land-cover of the study area. NDVI map provides a general idea about a vegetation health and land cover. But the greenness index able to provide much more evidences to strengthen the judgment about the vegetation health in a particular area made by using NDVI values. Therefore Greenness index can be used as a substitute for NDVI when making decisions about vegetation health. The changes occurred in the areas in which soft land cover is removed is distinct in brightness index map. Wetness index map provides a detail description about the location where the water bodies are located.

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