Enhancement and Combining Multispectral Image for Vegetation Analysis

Akakporo Rukevwe Gabriel, Xuewen Ding
School of Electronic Information Engineering, Tianjin University of Technology and Education, China

Abstract

The purpose of this paper is to evaluate the potential of multispectral image for better analysis for vegetation. Vegetation commonly appear greenish to the human eye but can be way much more accentuated outside the visible spectrum. Vegetation respond to several bands of the electromagnetic spectrum differently, choosing the appropriate spectrum and processing the images for this spectrum and combining the image to best reveal vegetation is a core point in the analysis of vegetation. With respect these core points this paper proposed some spectrum, processes and combination that reveals vegetation seemingly real to the human eye (in the nonvisible spectrum) and a false color to actually accentuate the health of vegetation. Firstly the image is obtained from Landsat 7 EM+ and the spectrum within the photosynthetically active radiation are processed and analysed as actual vegetation, then these were processed also in the nonvisible spectrum were the level of vegetation health was much more accentuated

Keywords: Very near infrared, Short wave Infrared.

1. Introduction

Vegetation being the chief manufacturer of oxygen and the role it plays in checking global warming, monitoring it cannot be over emphasised, though visual interpretation using visual elements of tone, shape, size, pattern, texture, shadow, and association is often a part of our daily lives, whether we are conscious of it or not, yet we lose some information when viewing a two-dimensional image, observing the differences between targets and their backgrounds, therefore processing the image to accentuate the color level helps in bringing out these differences.

To determine the density of green on a patch of land, it is important that one do observe the distinct colours (wavelengths) difference in the visible and near-infrared sunlight reflected by the plants. As can be seen through a prism, many different wavelengths make up the spectrum of sunlight. When sunlight strikes objects, certain wavelengths of this spectrum are absorbed and other wavelengths are reflected. The pigment in plant leaves, chlorophyll, strongly absorbs visible light within the photosynthetically active radiation range (from 0.4 to 0.7 μm) for use in photosynthesis. The cell structure of the leaves, on the other hand, strongly reflects near-infrared light (from 0.7 to 1.1 μm). The more leaves a plant has, the more these wavelengths of light are affected, respectively [1].

Analysing vegetation using remotely sensed data requires knowledge of the structure and function of vegetation and its reflectance properties. This knowledge enables you to link vegetative structures and their condition to their reflectance behaviour in an ecological system of interest. Vegetation reflectance properties are used to derive vegetation indices (VIs). The VIs are used to analyse various ecologies. VIs are constructed from reflectance measurements in two or more wavelengths to analyse specific characteristics of vegetation, such as total leaf area and water content [2]. Plant foliage, one of the general categories of vegetation, including leaves, needles, and other green materials, often look similar to the casual observer, but they vary widely in both shape and chemical composition. The chemical composition of leaves can often be estimated using VIs, but doing so requires some knowledge of the basic composition of leaves and how they change under different environmental conditions. The most important leaf components that affect their spectral properties are pigments water carbon and nitrogen, and the pigment chlorophyll in most vegetation cell shows to be more reflective in the electromagnetic spectrum though when there is chlorophyll breakdown other pigment surface more telling an analyst the vegetation is poor, but the lack rich green chlorophyll for good plant health can be more noticeable in the nonvisible range of the electromagnetic spectrum.

A significant advance in sensor technology stemmed from subdividing spectral ranges of radiation into bands (intervals of continuous wavelengths), allowing sensors in several bands to form multispectral images, and this help provide appropriate image to be processed[4].

2. Multispectral Images

A multispectral image consists of several bands of data. For visual display, each band of the image may be displayed one band at a time as a grey scale image, or in combination of three bands at a time as a colour composite image. Interpretation of a multispectral color composite image will require the knowledge of the spectral reflectance signature of the targets in the scene. For any given material, the amount of solar radiation that reflects, absorbs, or transmits varies with wavelength. This important property of matter makes it possible to identify different substances or classes and separate them by their spectral signatures (spectral curves), as shown in the figure below.

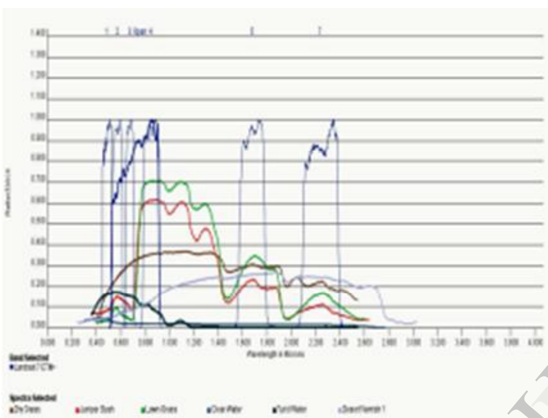

Figure 1Spectral Signature

2.1. Remote Image acquisition

The image for my study was acquired remotely with the aid of USGS Landsat 7 [3]. Remote sensing offers an efficient way to estimate vegetation properties over large geographic areas. For the purpose of this study: Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording the radiated, reflected or emitted energy then processing, analysing, and applying that information. With the sun as a main source of energy and several satellites, for my study Landsat 7, launched to receive radiated, emitted and reflected energy I am able to get my data from Ground Receiving Station (GRS). Remote sensing data is gotten via the means of airborne or spaceborne as stated above and sent to a ground station were they are available for research and other purposes.

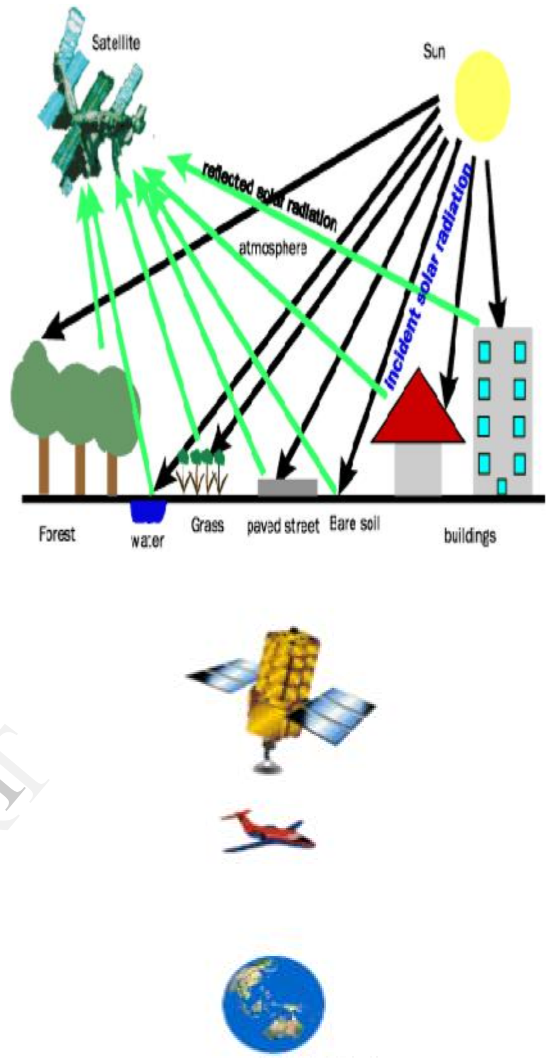

Figure 1Image Acquisition

3. Colour Composite Images

The subdivided spectral ranges of radiation into intervals of continuous wavelengths help in separating the colours in spectrum and of these are the primary red, green and blue which are more notable to the human eye. Putting these different colours together makes up a colour composite image.

In displaying a colour composite image, the three primary colours (red, green and blue) are used. When these three colours are combined in various proportions, they produce different colours in the visible spectrum. Associating to a separate primary color each spectral band (not necessarily a visible band) results in a color composite image. Many colours can be formed by combining the three primary colours (Red, Green, and Blue) in various proportions.

4. Vegetation and Its Reflectance Properties

Vegetation can be distinguished using remote sensing data from most other (mainly inorganic) materials by virtue of its notable absorption in the red and blue segments of the visible spectrum, its higher green reflectance and especially its very strong reflectance in the near-IR.

Analysing vegetation using remotely sensed data requires knowledge of the structure and function of vegetation and its reflectance properties. This knowledge enables to link vegetative structures and their condition to their reflectance behaviour in an ecological system of interest. With the aid of reflectance properties of vegetation the vegetation indices (VIs) can be derived. Vegetation Indices (VIs) are combinations of surface reflectance at two or more wavelengths designed to highlight a particular property of vegetation.

Photosynthetically active radiation (PAR) is the spectral range from 400-700nm that is used by plants in photosynthesis. Precipitation and temperature are two of the major factors that determine the proportion of PAR absorbed by plants. Fraction of PAR is an important parameter in measuring biomass production because vegetation development is related to the rate at which radiant energy is absorbed by vegetation. The fraction of PAR (fPAR) can be measured on the ground with handheld instruments or inferred from satellite imagery over large spatial scales.

5. True Colour Composite Image

In a multispectral image that consists of the three visual primary colour bands (red, green and blue), the three bands may be combined to produce a "true colour" image. For my research, the bands 3 (red band), 2 (green band) and 1 (blue band) of a LANDSAT 7 EMT+ multispectral image of the Niger Delta of Nigeria was assigned respectively to the R, G, and B array for display. In this way, the colours of the resulting colour composite image resemble closely what would be observed by the human eyes though the composite image will need to be enhanced to reflect what the human visual system actually interpret when observed by the human visual system (hvs)

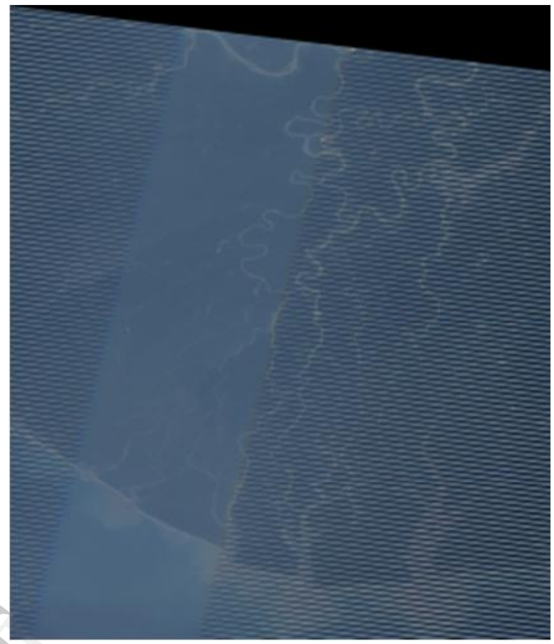

Figure 3True color Composite Image

6. Enhancing the Image

Often raw images do not highlight the particular features or processes that we wish to understand. For better analysis it is needful to improve the appearance of the image to assist in visual interpretation and analysis. A composite image of true color was constructed from a multispectral image from Landsat 7 bands by “picking” out the spectra that falls within the photo synthetically active radiation of the spectral range of 400-700nm that is also in the range of the visible ray Red (620–750 nm), Green (495–570 nm) and Blue (450–495 nm) respectively. Image enhancement is the mathematically manipulation of the digital number of the image (processing) to reveal features in the image that best show the target of interest, though enhancement of one characteristic is often accomplished at the expense of other image characteristics and in the case of my study the target is vegetation therefore other features may be supressed to reveal vegetation more distinctly.

6.1 Radiometric Enhancement

This is processes designed to improve the visual quality of an image making useful information more apparent, it is a point operation mapping a single input image into a single output image such that each output pixel's gray

value, k', depends only on the gray value, k, of the corresponding input pixel: linear contrast is one process of enhancing the radiometric characteristics of an image.
Contrast: The difference in brightness between two adjacent regions of an image.

$k'(x,y) = m * [\ k(x,y) - k_o\ ]$

k_o, m = constants,

Scaled so that

$k'_{min} = 0 \qquad k'_{max} = 255$

$m = 255 / (kf - k_o)$

$k_{out} = (k_{in} - k_o) * m$

Linear contrast enhancement, as mathematically expressed above, also referred to as a contrast stretching, linearly expands the original digital values of the remotely sensed data into a new distribution. The DN values of the image are systematically expanded so as to adjust the contrast to broaden the image expression of differences in spectral reflectance.

The histogram of the bands that makes up the composite image shows that the remotely sensed image is with Gaussian or near-Gaussian histograms, meaning, all the brightness values fall within a narrow range of the histogram and only one mode is apparent, therefore DN that falls within the values of 0 to 64 and 91 to 255 for the red band and of 0 to 64 and 91 to 255 for the green band 0 to 110 and 129 to 255 for green band are not displayed, as shown in figure 4a,4b and 4c, thereby reducing important spectral differences that can be detected. Therefore a minimum-maximum linear contrast stretch was applied to expand the original minimum and maximum values of the data assigned to a newly specified set of values that utilize the full range of available brightness values, in this case from 0 to 255. The linear stretching did not show much for better analysis, figure 4d, though several water path can be seen as water generally reflect high in the visible spectrum, however, clearer water has less reflectance than turbid water since turbid water give more backscatter. And the reason why the green colour which is an indicative of vegetation is not really visible in this linear stretched image is as a result of high

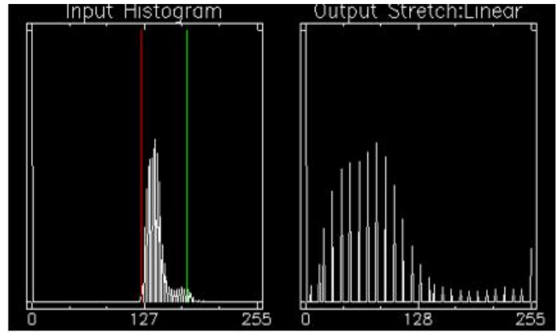

Figure 4a Red Band Histogram

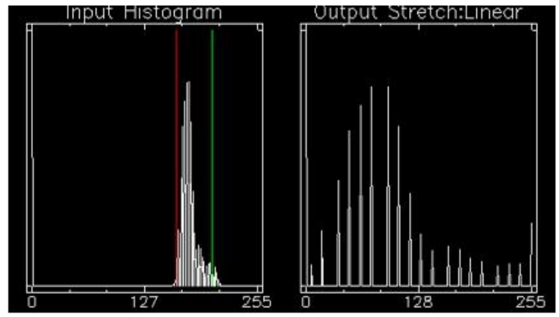

Figure 4b Green Band Histogram

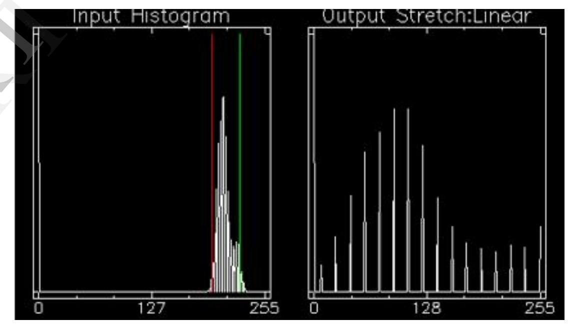

Figure 4c Blue Band Histogram

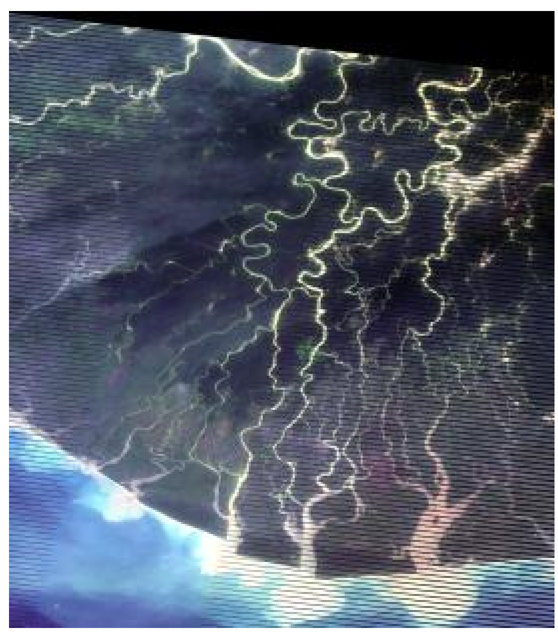
Figure 4d Linear Stretched Bands

correlation between the red and blue colour pixels, figure 5, making the image seem not to have red pixels with very poor green display. A spectral plot is a graphical technique for examining cyclic structure in the frequency domain. It is a smoothed Fourier transform of the autocovariance function. Scatter plots are used to plot data points on a horizontal and a vertical axis in the attempt to show how much one variable is affected by another. Using 2D Scatter Plots of two bands of image data Red with Blue, figure 5b also show the correlation.

Decorrelation is a general term for any process that is used to reduce autocorrelation within a signal, or cross-correlation within a set of signals, while preserving other aspects of the signal. In image processing decorrelation stretching enhances the color separation of an image with significant band-band correlation. The exaggerated colours improve visual interpretation and make feature discrimination easier. With the aid of image processing software, ENVI, the image was decorrelated. The enhanced image shows more of the different available colours. The spectral reflectance is based on the chlorophyll and water absorption in the leaf. Needles have a darker response than leaves. There will be various shades of vegetation based on type, leaf structure, moisture content and health of the plant.

Some of the coloration in the enhanced image is indication of manmade activities as concrete and asphalt, with which houses and roads are built; both display spectral curves that generally increase from the visible through the Near IR and Mid-IR regions, however as concrete ages it becomes darker and as asphalt ages it becomes lighter with soil with less or no vegetation showing color different from the tropical rain forest. The delta being an area of land with much river braches flowing towards a larger water body, in the case of my study the Atlantic Ocean, helps in transporting these inorganic material and these in turn have a negative effect on the vegetation. Increasing amounts of dissolved inorganic materials in water bodies tend to shift the peak of visible reflectance toward the red region from the green region (clearer water) of the spectrum, figure 5c. Some of the

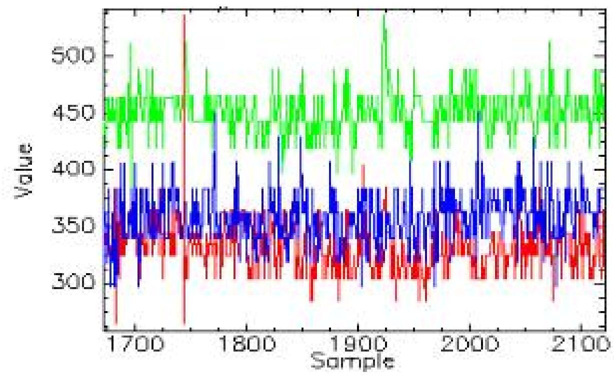

Figure 5a Spectral Plot

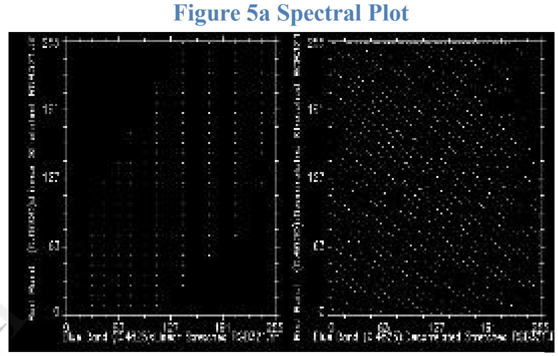

Figure 5b Scatter plots of Linear Stretched and decorrelated Red and Blue Band

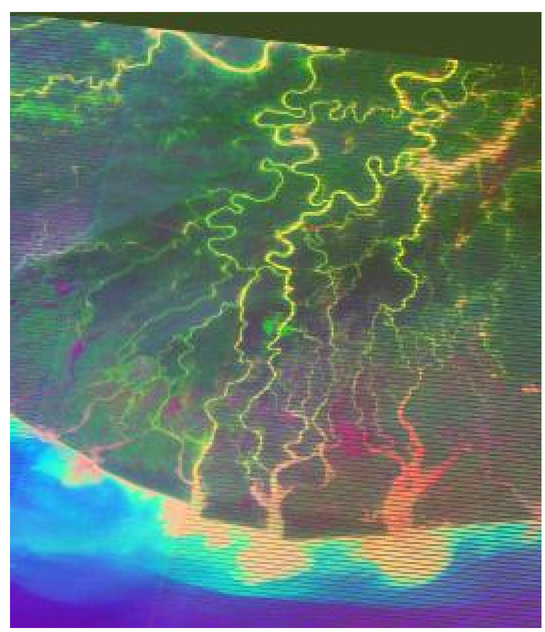

Figure 5c Decorrelated Stretched

coloration still tells unhealthiness of vegetation as carotenoid and xanthophyll in the leaves reflecting colour ranging from pale yellow through bright orange to deep red yellow may be reflecting also. They are organic pigments that are found in the chloroplasts of plants and some other photosynthetic organisms like algae, some bacteria, and some fungi. Therefore this coloration can also be as result of breakdown of green chlorophyll, which unmasks the already-present orange, yellow, and red pigments of carotenoids and xanthophyll, my study accentuate this more in processing the image in other spectrum.

7. False Color Composite Image

A false-color image is an image that depicts an object in colours that differ from those a photograph (a "true-color" image) would show. False-color image can be created using solely the visual spectrum to accentuate color differences, typically some or all data used is from electromagnetic radiation (EM) outside the visual spectrum (e.g. infrared, ultraviolet or X-ray). The choice of spectral bands is governed by the physical properties of the object under investigation. In my research vegetation is the object of investigation, though the green reflectance which is prominent in vegetation, due to chlorophyll, is easier to discern by the human eye yet it is much more evident in the nonvisible spectrum. Therefore processing the image in color infrared with the Very near Infra-Red band four, the Red band three and green band two of Landsat 7 with micrometres wavelength 0.82500, 0.66000 and 0.56500 spectrum respectively figure [10].

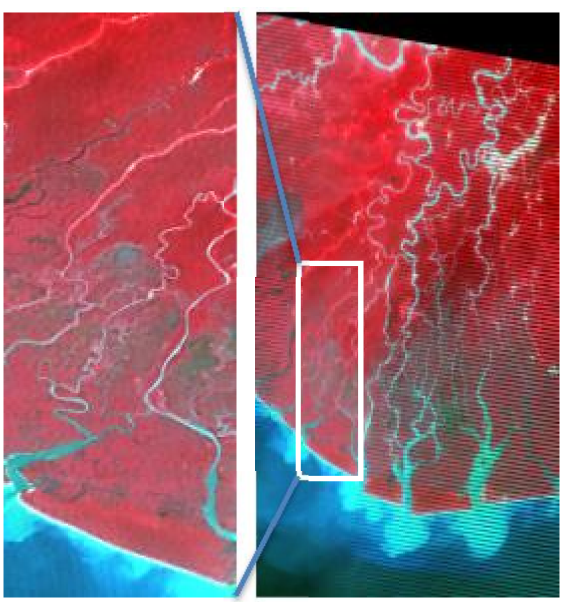

Figure 6 Composite of VNIR (4) - red (3) - green (2)

Much of the image appearance is due to the fact that healthy chlorophyll-rich vegetation, which is predominant in this area, has a high reflectance in the near infrared and the NIR band is mapped to the red channel in the composite image thereby causing any area with a high vegetation density to appears red in the in the image. A frame on the left from figure [6] shows though the Niger delta is rich in vegetation there is still area with poor vegetation. Though in the CIR image, water features are very dark and green vegetation appears red, most water in the image still appear blue green due to the turbidity and having sediment or foreign particles stirred up or suspended increasing the backscatter of the blue short visible ray or the spectrum.

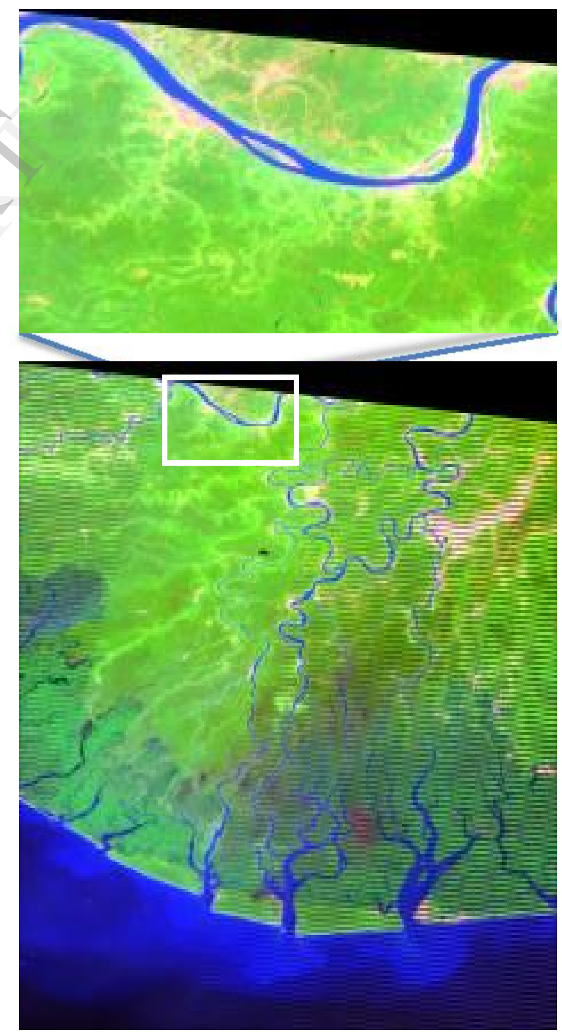

Figure7 Composite of SWIR (7) - VNIR (4) - green (2)

Again combining the short wave infrared band seven, Infra-Red band four and green band two of Landsat 7 with micrometers wavelength 2.22000, 0.82500 and 0.56500 respectively. This band combination shows the vegetation in various green shades because band four (high reflectance of vegetation) is presented in the colour green. This false color composite reveals more of the vegetation characteristic as band seven is sensitive to variations in moisture content and especially detects this in hydrous minerals in geologic settings (such as clays which is common in this area). The enhanced false color composite image showed more for better analysis than the composite of true colors. In this false color image the pixels with more of purple close to red color are much clearer and these depict soil and locals buildings while the orange yellow around the purple are lawn grasses in those community and the different level of blue for water tells the different depth of water to the deep blue ocean, also with the different available levels of green in the vegetation yet this can be distinct further with more processes.

8. Vegetation Stress

The stress in vegetation can be determined by processing the image to determine the density of green on the patch of land, by observing the distinct colours (wavelengths) of visible and near-infrared sunlight reflected by the plants in the processed image.

8.1Normalized Difference Vegetation Index (NDVI)

It is a Vegetation Index in which bands sensitive to chlorophyll absorption and cell wall reflectance are treated by simple mathematical ratio of individual band differences and sums to accentuate recognition of and variation within types and densities of growing forests, fields, and crops. As can be seen through a prism, many different wavelengths make up the spectrum of sunlight. When sunlight strikes objects, certain wavelengths of this spectrum are absorbed and other wavelengths are reflected. The pigment in plant leaves, chlorophyll, strongly absorbs visible light (from 0.4 to 0.7 µm) for use in photosynthesis. The cell structure of the leaves, on the other hand, strongly reflects near-infrared light (from 0.7 to 1.1 µm). The more leaves a plant has, the more these wavelengths of light are affected, respectively. NDVI is calculated from the visible and near-infrared light reflected by vegetation. 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.

$NDVI = [(NIR - Red) / (NIR + Red)]$

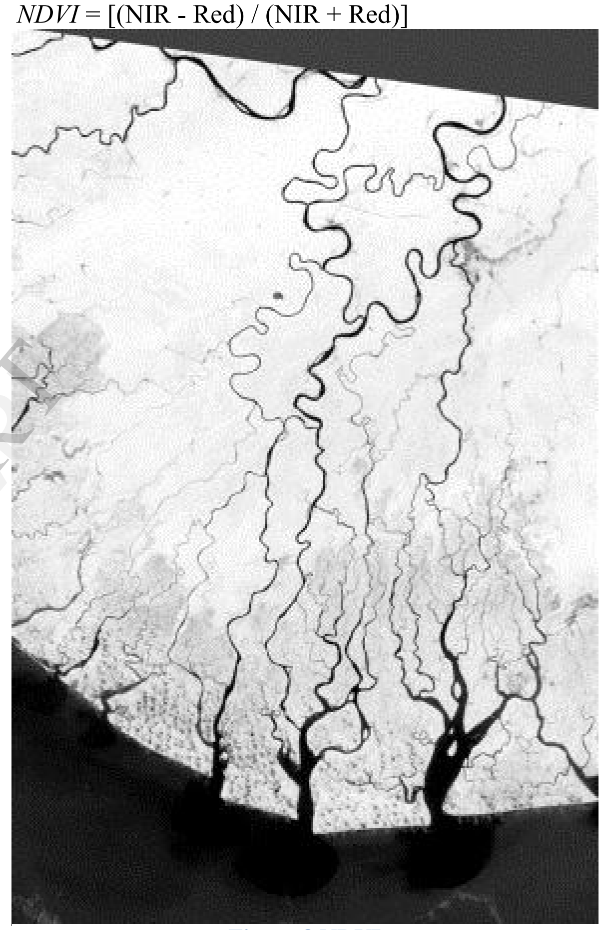

Figure 8 NDVI

The Normalized Difference Vegetation Index image, figure 8, show vegetation reflectance that really help accentuate the hue of the various vegetation level, and using the DN values reconstructing composite image with NDVI mapped to the green array and band seven which is sensitive to variations in moisture content mapped to the red array while the band two is mapped to the blue array, figure 9,. This indeed showed the various density of green color in the frame thereby telling the health of the vegetation.

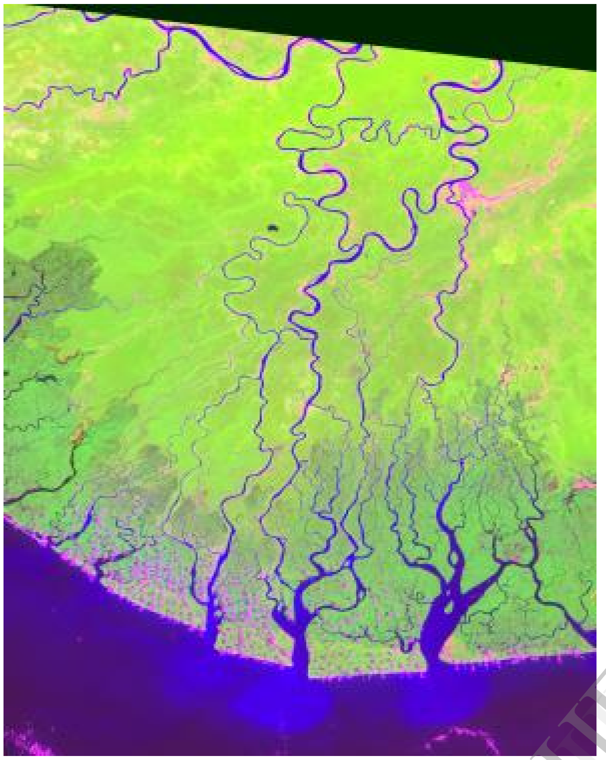

Figure 9 Composite of band7, NDVI and band2

Table 1 Colour representation

	Areas with no vegetation
	Loosing vegetation
	Poor vegetaion
	Rich vegetation

It also shows the bathymetry of the various water bodies with light blue to the deep blue ocean color, this is because longer wavelength visible and near infrared radiation is absorbed more by water than shorter visible wavelengths. Thus water typically looks blue or blue-green due to stronger reflectance at these shorter wavelengths, and darker if viewed at red or near infrared wavelengths as shown above in figure 7. If there is suspended sediment present in the upper layers of the water body, then this will allow better reflectivity and a brighter appearance of the water. The apparent colour of the water will show a slight shift to longer wavelengths. Suspended sediment (S) can be easily confused with shallow (but clear) water, since these two phenomena appear very similar. Chlorophyll in algae absorbs more of the blue wavelengths and reflects the green, making the water appear greener in colour when algae are present while the topography and the turbidity of the water surface also lead to varying coloration like the blue green in the VNIR image.

9. Discussion and conclusions

Remote sensed image if well processed can go a long way to help check vegetation. While the Sahel shows to be really gaining concern from researchers and others due to desert encroachment, I think it is still important to look at the coaster area and how vegetation stress seem to be showing up gradually into the main land.

My results highlight the levels of vegetation response to the distinct colours (wavelengths) in the electromagnetic spectrum thereby, with good proceeding, aiding analyst in determining vegetation stress in the tropical region of the Niger Delta. And the stress that has shown to be more in the down side closer to the ocean can be taken to be as a result of excessive water yet I consider this stress to be having a major manmade contribution as inorganic materials, like oil spillage which endemic in this area, flushing downstream also has some negative impact on the vegetation.

10. References

[1] http://earthobservatory.nasa.gov/Features/MeasuringVegetation/

[2] Gregory P. Asner: Biophysical and Biochemical Sources of Variability in Canopy Reflectance

[3] http://landsat.usgs.gov/index.php

[4] Nicholas M. Short, Sr: https://www.fas.org/irp/imint/docs/rst/Intro/Part2_11.html

A.B. Smith, C.D. Jones, and E.F. Roberts, “Article Title”, *Journal*, Publisher, Location, Date, pp. 1-10.

[5] Luis G. Montalvo: Spectral analysis of suspended material in coastal waters-A comparison between band math equations .

[6] E.H. Helmer, Thomas S. Ruzycki, Jay Benner, Shannon M. Voggesser, Barbara P. Scobie, Courtenay Park, David W. Fanning, Seepersad Ramnarinec: Detailed maps of tropical forest types are within reach: Forest tree communities for Trinidad and Tobago mapped with multiseason Landsat and multiseason fine-resolution imagery.

[7] Luis G. Montalvo: Spectral analysis of suspended material in coastal waters: A comparison between band math equations

[8] Donald M. Reed: Critical Methods In Wetland Delineation Vegetation.

[9] Philippe Colantoni, Nabil Boukala, Jérôme Da Rugna: Fast and Accurate Color Image Processing Using 3D Graphics Cards.

[10] S. Hese, C. Schmullius: High spatial resolution image object classification for terrestrial oil spill contamination mapping in West Siberia

[11] Guoxia Yu, Tanya Vladimirova, Martin N. Sweeting: Image compression systems on board satellites

[12] Ratiba Derfoul , Sebastien Da Veiga , Christian Gout , Carole Le Guyader , Elodie Tillier: Image processing tools for better incorporation of 4D seismic data into reservoir models

[13] Carlos A. Torres: Mineral Exploration Using GIS and Processed Aster Images

[14] Guo Haixiang , Liao Xiuwu , Zhu Kejun , Ding Chang , Gao Yanhui: Optimizing reservoir features in oil exploration management based on fusion of soft computing

[15] Yutaka Matsumi, Masahiro Kawasaki: Photolysis of Atmospheric Ozone in the Ultraviolet Region

[16] Henryk Sechman , Marek Dzieniewicz: The example of background determination and mathematical processing of data from surface geochemical survey for the purposes of petroleum exploration

[17] Sandro Rama Fiorini , Mara Abel , Claiton M.S. Scherer: Semantic image interpretation of gamma ray profiles in petroleum exploration

[18] C. C. OBER, R. A. OLDFIELD, D. E. WOMBLE AND J. VAN DYKE: Seismic Imaging on the Intel Paragon

[19] Klock BA (2003): Interface and usability assessment of imaging systems. IEEE AESS Syst. Mag 18(3):11–12

[20] Mr. Salem Saleh Al-amri , Dr. N.V. Kalyankar and Dr. Khamitkar S.D : A Comparative Study of Removal Noise from Remote Sensing Image. IJCSI International Journal of Computer Science Issues, Vol. 7, Issue. 1, No. 1, January 2010

[21] Yang Jinghui, Zhang Jixian, Li Haitao, Sun Yushan, Pu Pengxian: PIXEL LEVEL FUSION METHODS FOR REMOTE SENSING IMAGES: A CURRENT REVIEW

[22] S. A. Quadri and Othman Sidek: Pixel-Level Image Fusion using Kalman Algorithm, International Journal of Signal Processing, Image Processing and Pattern Recognition Vol. 6, No. 2, April, 2013

[23] Yang Jinghui, Zhang Jixian, Li Haitao, Sun Yushan, Pu Pengxian: PIXEL LEVEL FUSION METHODS FOR REMOTE SENSING IMAGES: A CURRENT REVIEW.

[24] Karin Allenbach: EnviroGRIDS remote sensing data use and integration guideline.

[25] Ratiba Derfoul , Sebastien Da Veiga , Christian Gout , Carole Le Guyader , Elodie Tillier: Image processing tools for better incorporation of 4D seismic data into reservoir models. Journal of Computational and Applied Mathematics 240 (2013) 111–122

[26] Katsuaki Koike, Shuichi Nagano, And Michito Ohmi: LINEAMENT ANALYSIS OF SATELLITE IMAGES USING A SEGMENT TRACING ALGORITHM (STA). Computers & Geosciences Vol. 21, No. 9, pp. 1091-I 104, 1995