Desertification of Sudan during El Nino Years Assessed using Remote Sensing

Cole Vickers, Grand Valley State University, Allendale, Michigan

Introduction

One of the largest issues facing Sudan is desertification; the degradation of land from climate and human forcing's causing it to become more arid. It is such a large and pressing issue that there is a major undertaking being attempted to create a wall of trees that stretches the width of Africa to stem the tide of desert into the Sahel. The changing climate has drastically increased the amount of desertification across Africa. The more arid climate is exacerbated during El Nino years. El Nino years occur every 3 to 7 years and are produced by changes in ocean circulation in the Southern Ocean. These changes effect air masses which in turn effect the climate. In Africa, El Nino years are marked by a more warmer and more arid climate. We are currently in an El Nino year and it is predicted that El Nino events will become longer and more intense as the climate changes. Thus it is important to see how these climate events effect places such as Sudan.

This research aims to see how the changing climate has effected an area in Sudan over time. I used two Landsat images from two different El Nino years (June of 1999 and 2015) to see how this area has been effected by desertification through time. I conducted an unsupervised classification of these images to more clearly compare the land types present in the study area. If desertification where present in the area one would predict that the amount of area classified as "Sand" would be increasing and "Vegetation" and "Water" would be decreasing. Remote Sensing is a useful tool for assessing land degradation over time because it allows for a detailed analysis of land types which then allows for changes over time to be seen.

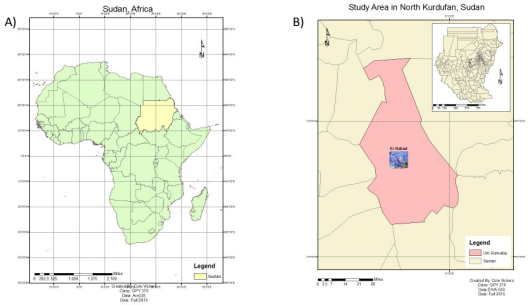

Figure 1: Map showing the study area within Sudan, Africa. A) The continent of Africa with Sudan highlighted and B) the area within Sudan where the study area is located.

Methods

- Data: Landsat data was downloaded using GloVis. The 1999 image was taken by Landsat 7. The 2015 image was taken by Landsat 8.

- 1999 and 2015 Landsat Processing: The Landsat images where combined using the ERDAS 2013's image stacking process. This combined the different bands provided by Landat into a single composite image for each year.

- Subsetting Images: The images provided by Landsat covered more of an area than I required for this project. I created a subset image of a smaller area that I decided would provide a clear representation of desertification. To create a subset image I used the Inquire Box function to select an area. I then used the image subset function to create the subset image and chose the "inquire box" option to create the subset of the area I chose to use. I then recorded the coordinates for the corners of the image so a subset image of the other image could be made to the same size.

- Unsupervised Classification: I performed an unsupervised classification of the subset images for both 2015 and 1999. The area, which is already very arid, only had five main land types. These include 1) Bare land; which I considered any land that had no vegetation but was not covered in sand. 2) Vegetation; any land that had vegetation (found using False color images). 3) Infrastructure; which I considered any building, road, or concrete structure. 4) Water, and 5) Sand, which I considered any area that was apart of the sand dunes which can be seen on the larger Lansat images. I recoded the images using the recode function so that the classification would be compiled.

- Accuracy Assessment: I performed an accuracy assessment on both recoded classified images using the recode function.

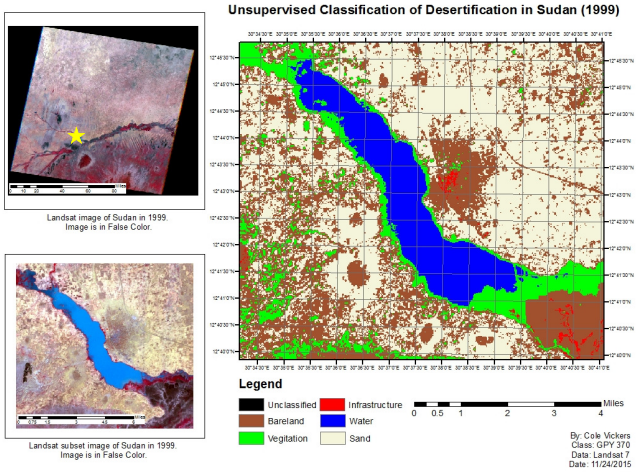

Figure 2. Map showing unclassified image of the study area in 1999. The map has the original subset image and the original stacked Lansat image for reference. Study area is marked by a yellow star on the stacked image.

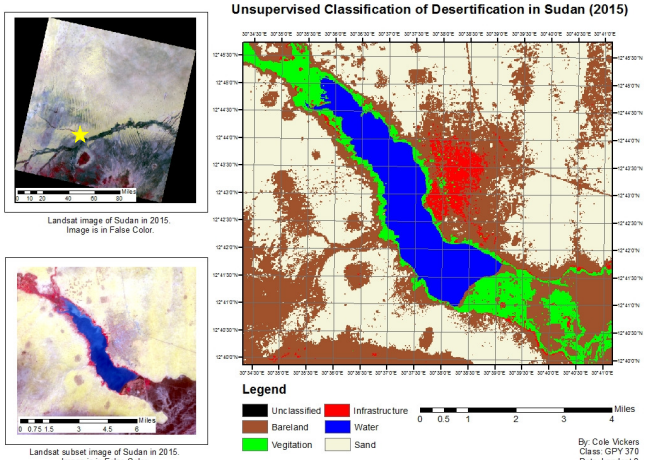

Figure 3. Map showing unclassified image of the study area in 2015. The map has the original subset image and the original stacked Landsat image for reference. Study area is marked by a yellow star on the stacked image.

1999					
Class Names	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Unclassified	0	0	0	---	---
Bareland	16	16	14	87.50%	87.50%
Vegetation	9	7	6	66.67%	85.71%
Infrastructure	4	4	3	75.00%	75.00%
Water	6	6	6	100.00%	100.00%
Sand	15	17	15	100.00%	88.24%

2015					
Class Names	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Unclassified	0	0	0	---	---
Bareland	13	17	13	100.00%	76.47%
Vegitation	6	6	6	100.00%	100.00%
Infrastructure	4	4	4	100.00%	100.00%
Water	5	5	5	100.00%	100.00%
Sand	22	18	18	81.82%	100.00%

Table 1: Accuracy assessments of the 1999 and 2015 images. The overall accuracy of the 1999 image is **88.00%** . The overall accuracy for the 2015 image is **92%.**

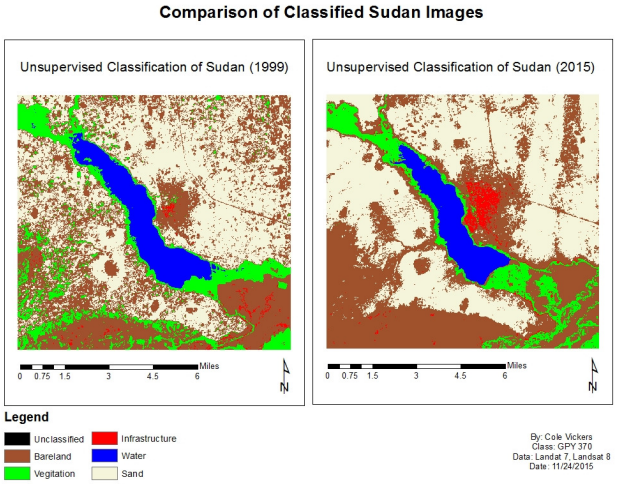

Figure 4. Map showing unclassified image of the study area in 1999 and 2015. Images are set side by side to compare the land cover change over the last 26 years.

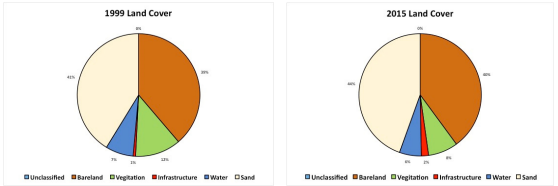

Figure 5. Pie graphs showing percentage of land cover for the 1999 and 2015 images.

Discussion

The classifications of each of the images show a majority of the land cover is either bare land or sand. The 1999 image, however, has a higher concentration of both water and vegetation when compared to the 2015 map (figure 2 and 3). The 2015 map has a higher concentration of infrastructure however (figure 3). The comparison of the two images show that over the last 16 years this area has experienced a high amount of desertification. The decrease in water and vegetation and increase in sand indicates a change to a more arid climate. This is the trend that is occurring in the Sudan so this is not surprising. What is surprising is the amount of change that is happening. There is a drastic increase in sand and even more drastic decrease in water and vegetation which has very negative impacts on the people and wildlife in that area . This can be seen in figure 5. The increase of sand and bare land is upwards of 6% and the decrease of vegetation and water is upwards of 5%. Over a large area this can be considered a significant difference. The accuracy of the images suggests that this was a useful way of understanding desertification in Sudan (table 1).

Acknowledgements

We would like to thank Dr. Sun for her insight into creating beautiful maps and Landsat for providing the images.

References

NASA Landsat Program, 2003, Landsat L7 ETM+ scene LE70220302015142EDC00 SLC-OFF L1 WMS ON-DEMAND, USGS, Sioux Falls, 10/26/2003.

Web. 1 Dec. 2015. <http://www.arcgis.com/home/item.html?id=16da193d9bcd4ae0b74febe39730658a>.

"Download Data by Country." *Download Data by Country*. Web. 1 Dec. 2015. <http://www.diva-gis.org/gdata>.