In the Aftermath: Detecting Change From Natural Disasters Using Satellite Imagery

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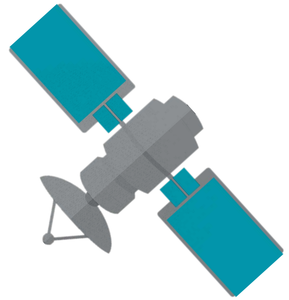

Abstract

The 2004 tsunami had devastating impacts on many nations surrounding the Indian Ocean, but none faced loses as devastating as the Aceh province on the island of Sumatra in Indonesia. Through the comparison of unsupervised classifications of imagery taken before and after the tsunami struck, this report examines the changes in land use as result of the tsunami. Landsat 5 data was collected and filtered to improve clarity of image, then classified using an ISODATA unsupervised classification to place pixels in one of eight categories. These classifications were then compared using an MAT to show changes from one class to another before and after the tsunami struck. Area reports and an area cross-tabulation were done to give quantitative measurements and analysis of the correlation between the two images.

Introduction

With the increasing availability of remotely sensed data, over a variety of spatial, temporal, radiometric, and spectral resolutions, satellite imagery is coming to be used in more and more areas of study. With the availability of imagery over a variety of time periods, it is now possible to determine changes in land cover and use. This study utilized change detection based on unsupervised classifications between two time periods to determine the changes caused by the 2004 tsunami in Aceh, Indonesia. Image classifications are commonly used in remote sensing as a way of classifying land and showing change. Studies have shown that it is possible to detect a nation's vulnerability to tsunami through remotely sensed data, but until the 2004 tsunami, there had been few change detections done to determine tsunami impact. After the 2004 tsunami however, image analysis to find damage done by tsunami became more common. This study utilized unsupervised land classifications and change detection analysis to determine changes in land use because of the 2004 tsunami.

Methods

The area under observation in this study is located in the Aceh province on the island of Sumatra in Indonesia. This area of the Indian Ocean was one of the closest to the tsunami earthquake epicenters, and so was one of the first locations impacted by the seismic sea waves, with little to no warning for those in the area. USGS data was collected through EarthExplorer and then downloaded, corrected for atmospheric interference, and analyzed using unsupervised classification to identify the land use in each image. These images were then compared to detect change using an MAT and statistically analyzed with area reports.

Stock media courtesy of NASA and Canva Layouts

Visual Analysis

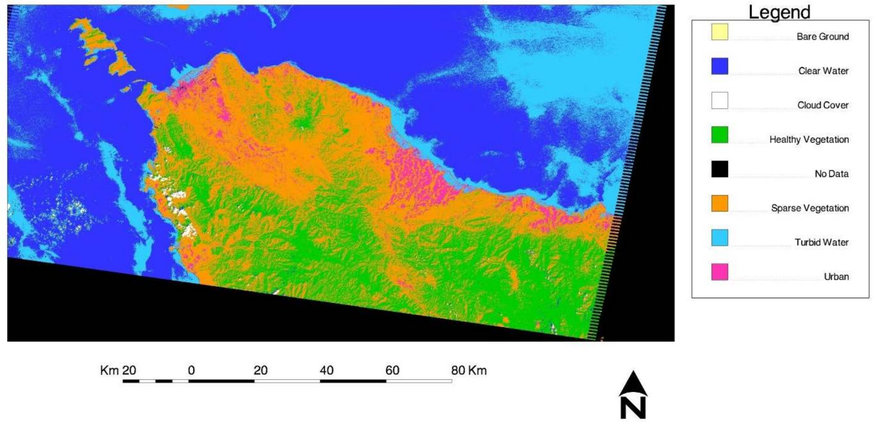

Figure 1: Map Showing an Unsupervised Classification of Aceh, Indonesia Before the Tsunami

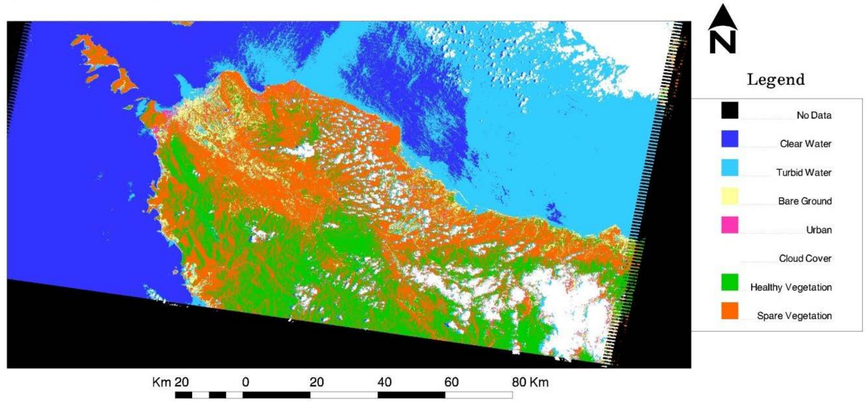

Figure 2: Map Showing an Unsupervised Classification of Aceh, Indonesia After the Tsunami

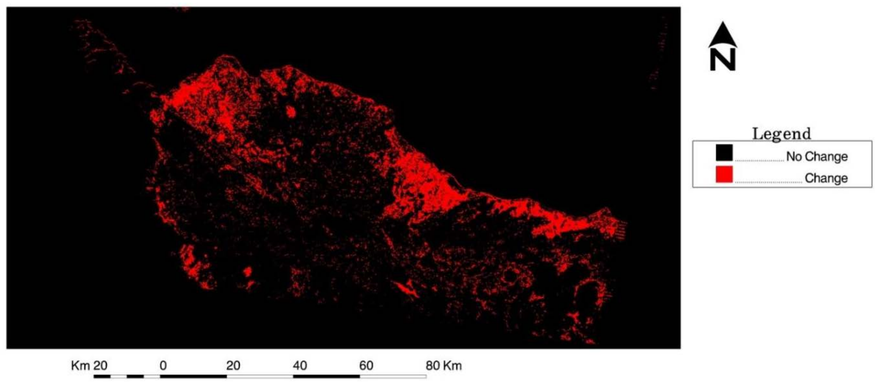

Figure 3: Map Showing Areas of Change Between the Before and After Tsunami Classifications of Aceh, Indonesia

Results

Changes were determined through an MAT comparison of the imagery before and after the tsunami. 25% of the pixels classified as urban before the tsunami were classified as bare ground after the tsunami, in addition to 4% of healthy vegetation and 9% of sparse vegetation. In the end, only 4% of the pixels classified as urban before the tsunami were still classified as such after. Much of the interior of the province was untouched by the tsunami, as 40% of healthy vegetation pixels, and 67% of sparse vegetation pixels remained classified as such in the post tsunami classification. An examination of the change detection map allows visualization of the areas of most significant change, which for the most part, were located along the coastline, and within the urban or bare ground pixel classes.

Discussion

Using MAT analysis to compare the before and after images of a region impacted by natural disaster can be an effective way of determining the changes that have occurred. While analysis was impacted by the changing cloud cover between images, some change can still be seen between them. The pixels that were changed from urban to bare ground are most likely the result of tsunami waves washing away human structures. Changes in healthy vegetation and spare vegetation to regions of bare soil may also be the results of wave action knocking down trees and washing them away. Changes in class from bare soil to the urban are probably the result of the migration of people from their former homes to the city after their homes were destroyed by the waves. There was also a large transformation from bare ground to sparse vegetation, but this is probably the results of debris pulled up by the waves, such as uprooted trees, covering previously bare regions and changing the reflectance of these areas spectrally.

Conclusions

Overall, this study finds that remotely sensed data can be used to show the damage done by natural disasters, such as a tsunami. This kind of research is especially important in considering the possible danger and difficulties of trying to produce field work in a region that has just experienced disaster. Future research in this area should focus on the collecting and inclusion of such field data, in addition to performing classification of the land whether supervised or unsupervised. Through this and other studies examining the changes before and after natural disasters, the possibility of using imagery to determine damages and areas most in need of assistance becomes clear. With the addition of ground truthing, more accurate determinations of damages could be made and could be more widely distributed through cloud-based data sharing, that would allow aid workers and residents to upload information on their circumstances to online GIS programs such as ArcOnline.