DIGITAL IMAGE CLASSIFICATION OF LAND COVER OF PRE AND POST HURRICANE IRMA IN WEST PALM BEACH, FL: A COMPARISION BETWEEN ISODATA CLASSIFICATION AND OBJECT BASED IMAGE ANALYSIS

FINAL PROJECT FOR THE COURSE

GIS 5033C Digital Image Analysis

Submitted by

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INTRODUCTION

Hurricanes are considered as the one of the most major natural disaster that disturbs the ecosystem close to the coasts. In particular the south eastern parts of the United States are mostly porn to the damages that caused by the hurricanes. Florida coast is one of those parts in United States that hit by hurricanes which has been causing the damages to the wetlands, infrastructure and also the coastal ecosystems. The assessment of the land cover changes following the storms is an important emergency response which helps to plan recovery operations.

Hurricane Irma was considered as the most powerful Atlantic hurricane in recorded history. It was a Category 5 storm when it made landfall on Barbuda on September 6, 2017. Its winds were 185 miles per hour for almost 37 hours. Tropical storm-force winds extended 185 miles from the center. Its coastal storm surges were 20 feet above normal tide levels. Above-average ocean temperatures of 86 degrees Fahrenheit sustained the storm. These temperatures are worsening due to global warming. Its force was so powerful that earthquake seismometers recorded it. It generated the most accumulated cyclone energy in a 24-hour period. Irma's attack was the first time in 100 years that two storms (Hurricane Irma and Harvey) Category 4 or larger hit the U.S. mainland in the same year.

The field survey as soon after the hurricane is not accessible, so the remote sensing data will provide the firsthand knowledge about the emergency management and also information about the damage of the land covers. The changes of the land cover during the hurricanes is also depends on the pre storm conditions of the region (Angnuureng et al., 2017; Yates et al., 2009). The damage chances will be high when there is lack in the precautionary measures. The importance of the updates on the hurricanes is important especially when the storms last longer than usual or are slow moving or occur in rapid succession like Hurricane Mathew in 2016 *Stewart, 2017) or

Hurricane Irma (in 2017 or El Nino of 2015-16 (Barnard et al., 2017). The quantitative analysis of the post hurricane conditions is important to evaluate the damage happened during the hurricane. Previous utility of the lidar images for the assessment of hurricane response has been studied previously (Brock et al., 2002; Stockdon, et al., 2009). The classification of the images is important to see the changes in the land cover.

Land cover is described as the state of the land surface. The categories that are included in the land-cover are referred as state of vegetation, forest/grass cover, wetlands, roads, urbanized areas. The land cover map is obtained by dividing the geographic area of interest into a finite set of map units with a distinct label of each of these classes. The land cover maps are often derived from the satellite remotely sensed data. The land cover is considered as what covers the surface of the earth (Nerd, 2004). There are two primary methods to capture the information on land cover, which include the filed survey and form the analysis of remotely sensed imagery (Comber et al., 2005).

Remote sensed data has an important role in identifying the land cover and classification of different features of the land surface from the satellite or airborne sensors. The applications of the remote sensing data for land cover and land use maps and its changes has an importance in many applications like environment, forestry, agriculture, geology etc. The acquired information from the remotely sensed images is an important tool for many applications such as damage assessments, wetland classification, allotted forest stands, to classify plant species, agriculture crops etc. The classification in the remote sensing includes the clustering of an image to set of classes in which the pixels in the same class have the same properties. The classification depends on the different signatures for the land cover classes.

There are many different approaches in classifying the images. The two different of classification includes pixel based classification (unsupervised classification used for this project) and object bases image analysis (segmentation used for this project). The unsupervised the algorithm is chosen which will take the remotely sensed data set to find the pre-specified number of statistical clusters in the multispectral data. These cluster are not always equivalent to actual classes of land cover; however this method can be used even without having the prior knowledge of the study area (Nie et al., 2001). The pixels in the sample area/spectral signatures of a multispectral data from spectral library are used to train the classification algorithm (Kamaruzaman et al., 2009). The ISODATA utility repeats the clustering of the image until either a maximum number of iterations have been performed, or a maximum percentage of unchanged pixels have been reached between two iterations. Performing an unsupervised classification is simpler than a supervised classification because the signatures are automatically generated by the ISODATA algorithm. However, as stated before, the analyst must have ground truth information and knowledge of the terrain, or ancillary high resolution data if this approach is to be successful. The trained algorithm is then applied to the entire image and a final classification image obtained. The pixel based classification has the limitations like the typical objects in an image are characterized in different texture of colors rather than classifying by similarly. At the same time, the same color can be part of two different objects. To overcome these limitations a new image analysis technique is adopted which is an object oriented way of data assessment which is OBIA (Object based Image Analysis) eCognition method (Baatz et al., 2000). In the OBIA analysis segmentation is done which is a aggregation process based on image statistics and thresholds defined by the analyst produces the homogeneous clusters or objects.

OBJECTIVE OF THE PROJECT

The study area for the project is chooses as West Palm beach, Florida east coast of the United States. The hurricane Irma did have the huge damage to the coastal regions causing damage to the not just infrastructure but also huge damage to the coastal ecosystems like wetlands. The project focuses on the land cover data before and after the hurricane using two prominent classification methods the ISODATA (Iterative Self-Organizing Data Analysis Technique) (pixel based classification) and eCognition (Object based analysis). The difference in analyzing the hurricane damage assessment in the study area using the pixel based (ISODATA clustering) method is presented in this project. Additionally the object bases classification method is provided for the same pre and post hurricane data sets. The similarities and differences in both methods are addressed along with the damage assessment happened after hurricane in the study area is discussed.

LITERATURE REVIEW

The use of remote sensing techniques on assessing the before and after results of natural disaster has occurring since many years and more widely used in recent times. The image classification techniques for the land use and land cover play an important role in doing the assessment. Several studies have focused on using the various classifications to obtain the land cover maps for the natural disaster assessment.

Different types of classification approaches are used in various fields like pre and post forest burn assessments etc. The differences of different types of classifications were also previously done many of the past research studies. In this project the comparison of the pixel based and object based analysis is observed in analyzing the changes of land cover features before and after the hurricane. Most of the previous studies has focused on the difference between the supervised and unsupervised classifications in various fields to see the changes in vegetations,

forest covers etc. Some of the few researches that focus on the comparison between pixel based and the object based analysis which includes classification itself like for agriculture filed classifications (Manakos et al., 2000) but not much past researches has focused on discussing the comparisons of pixel and object based classifications related to the time series data.

Few of the other studies performed in the past have focused on the various othe remote sensing tools. The other research works include the object based analysis to improve the forest management and monitoring using the eCognition (Masami and Itaya, 2006). The study in the article focuses on the forest management and monitoring the datasets but have not included in any comparison to the pixel based or any other classification. However the research work sated includes the time series analysis.

The other research work also includes the classification of land cover data using the different approaches like decision tree (Fisette et al., 2012), supervised classifications etc. The past work on the project related area shows few of the work on comparing the pixel based ISODATA analysis with the object based image analysis using eCognition with relation the time series data like natural disaster assessment for the before and after hurricane changes on land cover features.

DATA SOURCES

The data for the project used is Landsat 8 Level 1 images downloaded from USGS Earth Explorer (https://earthexplorer.usgs.gov/). Landsat collection 1 level 1 data products are based on data quality and level of processing in the Landsat Tiers inventory. The data used for the project is Tier 1 (T1) which contains highest quality Level 1 Precision Terrain(L1TP) which is considered suitable for time series analysis. As the project is to see the land cover changes for before and after hurricane this data is considered suitable for the study. Landsat 8 Level 1 data products typically include data from both the OLI (Operational Land Imager) and TIRS (Thermal

Infrared sensor). The pixel size of the multi spectral bands is 30 meters. The data includes the Landsat image obtained on August 22nd, 2017 for the pre Irma datasets and October 9th, 2017 for the post Irma datasets. The region of the datasets includes eastern part of the Florida (Figure 1) from which the West palm Beach study region is clipped using the mask in data management analysis. The output clipped file is saved as Tiff file (Figure 2) which is used for the further classification.

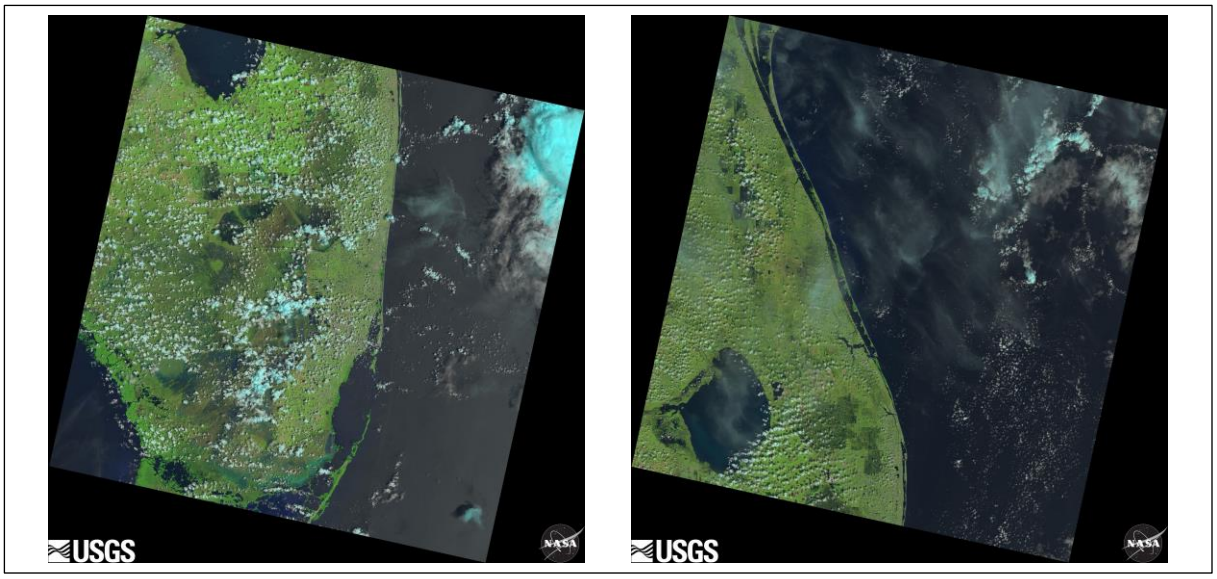

Figure 1: Landsat 8 L1TP images of before (left) and after (right) hurricane in Florida region downloaded from USGS earth explorer.

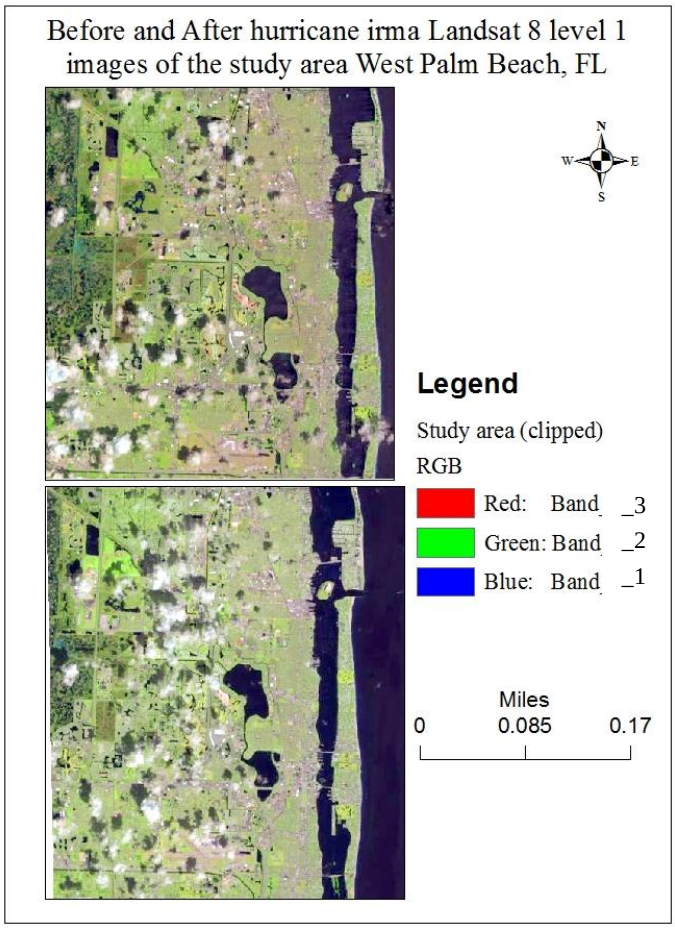

Figure 2: Clipped images of before (top) and after(below) hurricane Irma of the study area (West Palm Beach, FL.

ANALYSIS AND METHODOLOGY

ISODATA classification:

The images obtained after the clipping were loaded in ERDAS imagine to do the pixel based classification of the land cover in the study area. The images of both dates were used individually for the unsupervised classification. The unsupervised classification is done by selecting the unsupervised tab under raster tab and the input file is uploaded and output classified, and the signature files are requested for the classification. Number of classes selected were 15 and maximum iterations were given 20 with the convergence threshold at 0.95. The maximum iterations represent the number of times the ISODATA (Iterative Self-Organizing Data Analysis

Technique) utility will re-cluster the data which help to prevent the utility from running too long, or from getting stuck in a cycle without reaching the convergence threshold. Whereas the convergence threshold is the maximum percentage of pixels whose cluster assignments can go unchanged between iterations which prevents the ISODATA utility from running indefinitely. Once the options were selected as above the algorithm ran to provide the respective results which were then used to cluster identification. Using the create feature space image option total three combinations of the layers (Layer_1-Layer_2, Layer_1-Layer_3 and Layer_2-Layer_3) is used to obtain the output. The processing is done, and all the three obtained output is opened in a new 2D view. The signature file is loaded, and the respective 2D view is selected to label the clusters in the image which further helps to cluster the classes together. The unsupervised output file is opened along with the original image for reference to cluster the classes. Total 5 classes were classified namely forest preserve, grass land, urban, water and wetlands. The same process is applied for the post Irma image as well. Once the image is classified accuracy assessment was done using the accuracy assessment tab under the supervised tab in raster tab. The assessment was done for 30 points for both the classified images.

OBIA classification:

eCognition developer software is used to classify the object based segmentation of the datasets. In the process tree new amend is created with execute child algorithm followed by insert with multispectral segmentation algorithm with the following parameters (Image layer weights 1, 1, 1, scale parameter 10, shape 0.1 and compactness 0.5. The process is used for the dataset files. Each of the image has obtained three level segmented classification images included low (level 30) medium (level 60) and high (level 90). The best of the three outputs is used for the classification. Once the segmentation is done an algorithm in the eCognition was ran to classify

the segmented image. Samples were selected under the class hierarchy and nearest neighborhood process is used to classify the objects of each image. The class hierarchy was set to 5 classes which include forest preserves, grass land, urban, water and wetlands. The classified image is exported to the ArcMap to provide the final output.

RESULTS AND DISCUSSION

Results from ISODATA analysis:

Before comparing the pixel based classification and object based image analysis the difference between the pre and post Irma image are compared separately for the both the analysis. The unsupervised images classified from ISODATA is uploaded in ArcMap to see the classification difference between the before (August 22nd, 2017) and after (October 9th, 2017) hurricane Irma in West Palm Beach. The final images are shown in Figure 3. The image in the figure shows the changes in the land cover for before (top image in Figure 3) and after (bottom image in Figure 3) the hurricane. The land cover features in the image include forest preserve (dark green), grass land (apple green), urban (rose pink), water (blue) and wetlands (sienna). The image has the clouds and shadows of the clouds as can be seen in the Figure 1 and 2 the pixels for the clouds and shadows are cluster according to the region with grass land or water or urban. The post hurricane image shows the loss of vegetation in the back barrier region and also in few locations in the inland regions. The image also shows the loss of the wetlands after the hurricane in the backbarrier region at the backwaters and near the inlets. The accuracy assessment for both the images for the 30 points throughout the image has given kappa values 85% and 89% for the before and after classified images, respectively. The kappa values obtained from the assessment shows that the classification is good enough for the obtained land cover classified image.

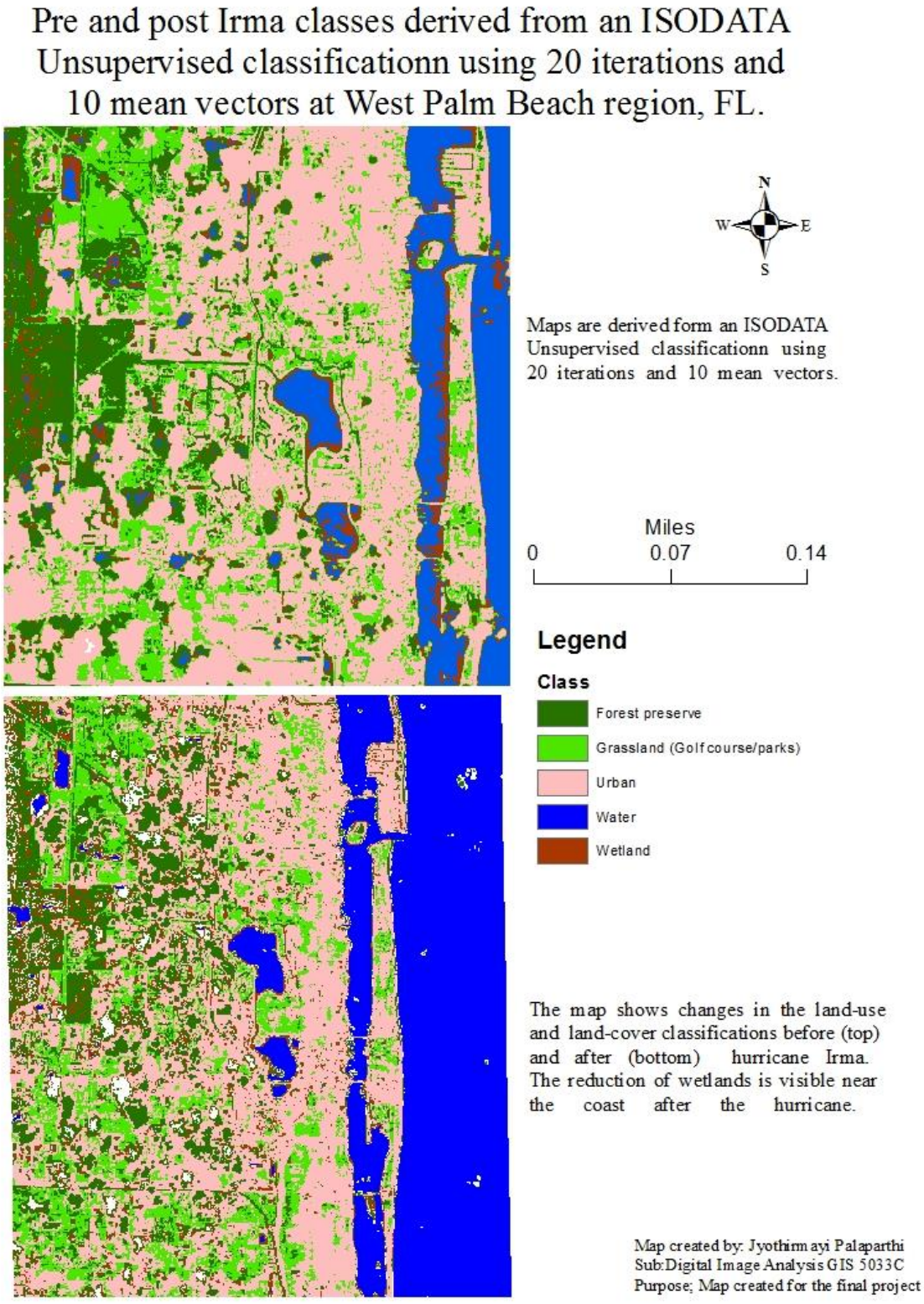

Figure 3: The pre and post land cover maps created using ISODATA unsupervised classification.

Results form OBIA analysis

Using OBIA three levels were created as discussed in the methodology. Out of three level 30 is considered for the analysis. As the levels increasing further some of the features are clustered with the other features and was difficult to identify more classes. The Object based image segmentation is used to classify the before and after hurricane of the study area (West Palam Beach) and the segmented image is exported in the ArcMap and the final image is shown in Figure 4. The image shows the before (top image of the Figure 4) and after (below image in Figure 4). The image classified using the OBIA techniques has more homogeneous and the objects are identified clearly. The image is segmented as five land cover classes includes forest preserve (dark green), grass land (apple green), urban (rose pink), water (blue) and wetlands (sienna). The classification of the images through the OBIA analysis also shows that loss of vegetation/grass land (apple green) and the loss of the wetlands (sienna). Due to the classification of the classes is made on the nearest neighbor algorithm in eCognition the classes have slightly miss classified at few of the locations where the water is classified as wetlands and the cloud shadows are classified as water and clouds are classified as urban areas. The images show the loss of vegetation near the backwaters of the back barrier and loss of vegetation on the dune environments and on the backbarrier.

Comparison of pixel based classification and object based classification:

The land cover classification of the images for the pre and post Irma using the pixel based ISODATA analysis and object based image analysis eCognition were compared. In both the images near the clouds and the shadow of the clouds were classified as urban (due to light colored pixels) and water (due to dark colored pixels). But the object based analysis showing the more homogeneous classification compared to the pixel based classification.

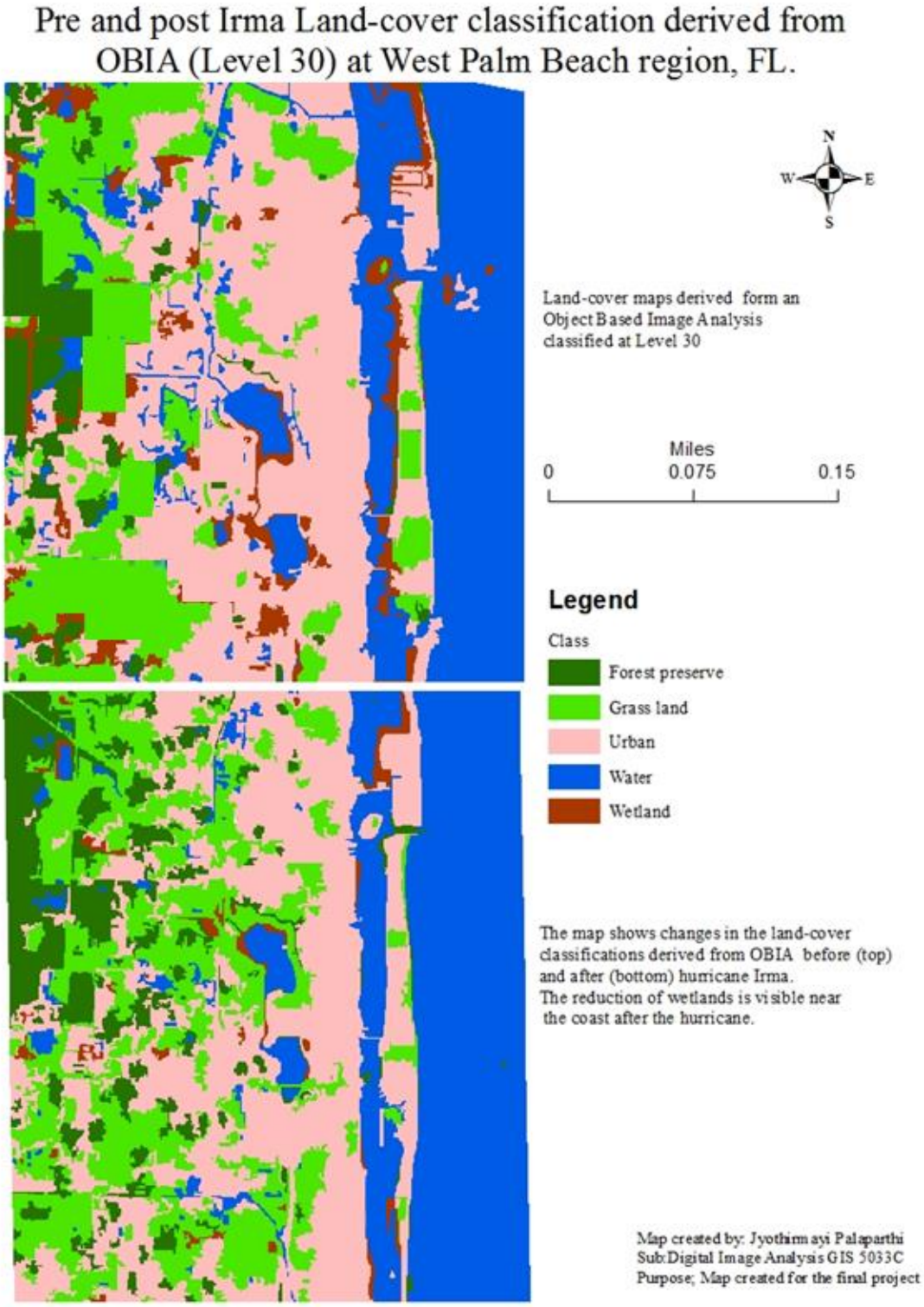

Figure 4: Pre and post Irma OBIA Land cover classification of West Palm Beach region.

The classification of the pixel based analysis showing the missing features that were not identified in both the images. Also, in the pixel based images the water canal is classified as forest preserve. Whereas in the OBIA the water canals are identified as water. The gaps in the data is clearly visible which shows the incomplete classification. But the purpose of comparing the time series data to analyze the pre and post hurricane land cover data in the study region is obtained. The kappa statics ranging between 85-90% which indicates 85-90% of the errors by which random classification would generate has been avoided during the classification process. Though the accuracy assessment showing the good classification the missing data and the heterogeneity of the classification shows slightly lower consideration compared to the OBIA classification.

The OBIA classification shows more homogeneous and completeness in the data classification. Also in the segmentation classification it was also able to classify more classes. For example the analysis was able to identify the beach as separate but was not included to keep the similarity between the two analyses. Level 30 is used for the classification because the chance of having more objects will help to classify more accurately. Though both the methods have their own limitations to have the more homogeneity in the land cove classification the object based analysis gives the more detailed images. Also, the datasets with even more high resolutions gives much more better land cover classification using OBIA.

The purpose of the classifying the images for this project is to see the changes of land cover features before and after hurricane Irma can be identifies better with the pixel based or object based analysis. When looking between the images it is clear that the same changes has been noticed which are the loss of vegetation/grass lands on the dune and backbarrier regions and loss of wetlands near the backwaters on the after hurricane images. However the pixel based classification showing the error in classifying the water canals as forest preserves. When comparing the post

hurricane images (October 19th, 2017) it can clearly see the loss of few features like grass lands and wetlands is visible in both classifications which shows that the purpose of the project is fulfilled. The pixel based image is showing more of slat pepper pattern whereas the OBIA is showing more smoother image classification.

CONCLUSIONS

To conclude ISODATA and OBIA classification methods managed to provide the image information into meaningful pixel aggregations. The pixel based and object based classification of the digital imagery are important tools to classify the image for the identification of land cover features like developed areas (urban), vegetation (grass land), forest areas, water, and wetlands. However there are both advantages and limitations with both the methods. The ISODATA analysis/unsupervised classification is anyway considered better at times compared to the supervised classification as it reduces the errors caused by the humans in the process of the supervised classification. However the object based classification will provide the analyst with the opportunity to choose the segmented objects at different levels allowing it to classify the image more accurately. Also, providing more homogeneous image with no gaps in identifying the features. Both classifications methods are considered as useful and are able to provide results that are useful in classifying the land cover in pre and post the disaster. However both the methods can give better display of the images with the better resolution images. Though the classifications derived from both the methods may not have most accurate display of images, but both the methods can be effectively used to see the before and after changes in the land cover features and to select one on above the other will depend on the further requirement of individual analysis.

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