CLASSIFY AND ANALYSIS OF FIRE IN THE FOREST GREECE USING REMOTE SENSING

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Abstract—In this paper has been used satellite Sentinel-2A imagery, this satellite is a polar-orbiting, multispectral high-resolution to cover Athens, Greece that located at latitude 37° 58′ 46″ N, 23° 42′ 58″ E. the paper aims to study the wildfires (natural resources) before and after fire break out that occurred in forests of Athens in Greece for a year 2007, 2018 and analysis the damage caused by these fires and their impact on soil and environment by classify the satellite images for the interested region before and after wildfires for a year 2007 and 2018, and Discuss methods that compute the area covered of each class and reduce or limit the wildfires damage. The classification using moment's features extraction with K-Means clustering algorithm in remote sensing. The classification results show five different classes (water, trees, buildings with tree, buildings without tree, bare lands) where, it can be notice that the area covered by each class before and after wildfires and the changed pixels for all classes. The experimental resulted of classification technique shows that the good performance accuracy with a good classification and result analysis about the damages resulted from the fires in the forest Greece for a year 2007, 2018.

Index Terms : Remote sensing, Wildfires, Moment feature, K-Means, Sentinel satellite.

I. INTRODUCTION

Remote sensing technology has been used during the last few decades to survey land cover and earth observation to study the distribution quantity of natural planet resources. Remote Sensing has been developed in spatial, spectral and temporal resolution to use satellite images for selecting region, understanding, mapping, evaluation, error modulation, and accuracy computation of image [1]. Image classification is one of a good technique in digital image processing for land-cover data extraction and using the information contained in remotely sensed images. Where, the classes are identified into a defined thematic class (water, trees, building with trees, buildings without trees, and bare-lands) [2]. Satellite image classification is widely used for extracting the spectral features from satellite images and analyze land-cover map of the region selected [3]. Where, the classification techniques can be defined as a two major types: supervised and unsupervised classification [4]. The study area chosen for research is cover the area of Athens in Greece taken by Sentinel-2 (Optical) with a resolution 10 meters shown in Figure (1).

Figure (1): The position of Study area (Athens region in Greece).

So that, moment feature clustering technique is used in this paper as unsupervised classification for the Athens region in Greece to classify the serious

damages, fires and threats that occur in that area. The rest sections of paper are as follows: in Section 2 presents a brief related works in satellite image classification. In section 3 illustrates the problem statement. Section 4 illustrates methodology about image classification techniques. A section 5, 6 describes the experimental results and analysis of result.

Finally, the conclusions within future suggestions are given in Section 7.

II. Relative Work

In fact, there are a lot of works that have studied the processing of satellite images and know the details and take advantage of the enormous information that the images [5]. This information is used to predict future environmental disasters or changes in climatic conditions and many other things in many areas of life. Here are some of the works that have been studied and researched in this field.

In [6], show the size damages and threats in Turkey especially over Aegean and Mediterranean Regions caused by Forest fires. Several digital image processing methods used to study the fire classification and compute the fire affected on the burned areas.

In [7], show that an object-based classification to develop a classification procedure for burned area mapping and study the series damages of fires that occurred during the summers of 2007 and 2009 in Greece. Where, Système pour l'Observation de la Terre (SPOT)-4 HRVIR images are introduced.

In [10], present a classify of satellite image environment using an innovative method called Reflection Based Phenology Method (RBPM) . Where, the Landsat 8 datasets has been used which keep imagery in multispectral. The basis of band reflection values are used in the classification process. The classification accuracy of the PRBM method used overall accuracy, confused matrix, and kappa coefficient as a quality measurement.

In [11], State a classification technique used to find the classes of land cover in satellite images. In this paper, the classification techniques that used are supervised classification, unsupervised classification and Object oriented classification.

III. PROBLEM STATEMENT

One of the most important factors of using the region of Athens in Greece are the wildfires causing huge damages in this region and having five types of land (classes) and being used as support for the interpretation. These types of classes are rivers, agriculture area, Buildings with trees, Buildings without trees, and bare lands. Where, the areas in which fires occur are determined by using techniques to classify it and discuss the effect of fires on each area covered by each class. Satellite image of that area was taken by Sentinel-2 (Optical) with resolution 10 meters. The classified images before and after the fire are analyst and studied to calculate the amount of fires and damaged buildings occurring in the forests of Greece for a year 2007 and 2018.

IV. METHODOLOGY

The features of the homogeneous regions in an image can be classified by using the elements of visual interpretation. The classification method can be supervised or unsupervised to be assigned into a predefined classes based on the number of observed features extraction related to that image [11]. The satellite image contains one or more features, such as spectral region in remote sensing case. Each of these features belongs to distinct class [12]. In supervised classification, the classes are specified by providing the sample set of data by analyst to supervise [8]. In this paper, the K-means clustering algorithm based on moments are used to extract features and classify satellite images. Figure (2) describe the concepts of the proposed technique for classification.

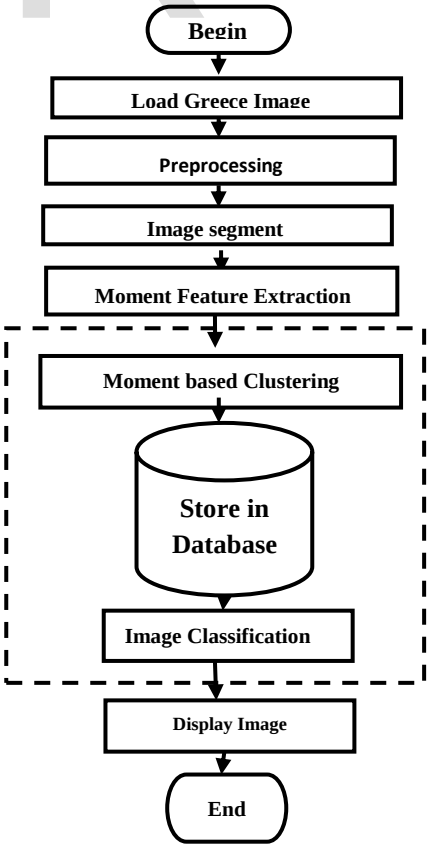


Figure 2: Block diagram of classification Technique.

A. Satellite Images of Greece

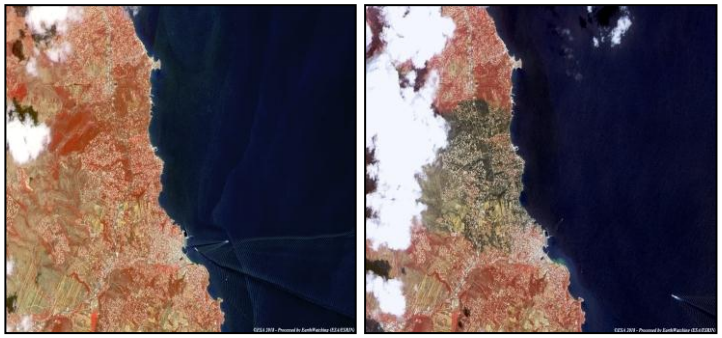
Satellite Sentinel-2A imagery is a polar-orbiting, multispectral high-resolution to cover Athens, Greece that located at latitude 37° 58′ 46″ N, 23° 42′ 58″ E. The Greece image was captured by Sentinel-2 (Optical) with resolution 10 meters. It covers the wildfires (natural resources) before and after fire break out that occurred in forests for a year 2007, 2018. Table (1) shows the technical information of original image, and the original satellite image of Greece before and after the fire for a year 2007, 2018 are shown in figure 3, 4 respectively.

Table (1) Technical information of original image.

Product	Geo Tiff format
Satellite/Sensor	Sentinel-2 (Optical)
Resolution	10 meters
Acq. Date:	20 July 2018 & 30 July 2018
Band Combination used to create this image:	4, 3, 2 (R-G-B) Visible color & 8,4,2 (R-G-B) False color layers

a. Mati-Greece- before Fires- b. Mati-Greece- after Fires

Figure 3: The images represent Mati-Greece before and after Wildfires for a year 2007.



b. Mati-Greece- before Fires c. Mati-Greece- after Fires

Figure 4: The images represent Mati-Greece before and after Wildfires for a year 2018.

B. Preprocessing

A preprocessing is used in this paper to enhance the visual appearance of the image under consideration. This stage is depends on the intensity of each pixel without effecting of the correlation of adjacent pixels. To improve the distinguishing between image features apply the following relation on the image [9]:

$$C_e(k,z)=\text{round}[(C_o(k,z) - H)/(H-L)*255] \quad \dots (1)$$

Where, $C_e(x,y)$ refers to the new image enhanced, $C_o(x,y)$ represents to the original image, and k, and z are refer to the indices of the pixel in the image. H refers to the top 1% of pixels values of original image, and L refers to the bottom 1% of pixels values of original image [13].

C. Greece Image Segmentation

The segmentation of image can be defined as a process of dividing it into square blocks of uniform size. This process is not concerned with the spectral distribution of the image; it is just geometrical partition. In this paper, the size of each block is 4×4 where, it depends on the amount of image spatial resolution. It is taken into account that low resolution image is separated into a number of blocks is less than that of higher resolution image. This is for credit enough information is containing in each block.

D. Extract Moment Feature

The moments can be used to differentiate images as measurement that based on their features of color [12]. The Moment features can be described as a specific quantitative measure that used to extract the information set in each image block. Where, the mass refers to a set distribution of pixels, the first-ordered moment given in equation (2) is used to extract the moment features.

$$M = r \times F_P \quad \dots (2)$$

Where, the pixel of block can be represented as the applied force (F_P) and r refers to the distance from the center of block to the applied force. So that, the pixel value is observed as the meant force, and the distance is computed depends on the quarter in which the pixel is located (In first, second, third, or fourth quarters) Figure (5) describe how to compute

moment feature of each block depends on the location of pixels by apply following steps [2, 3]:

1. determine the distance (D_s) between each pixel in specific block and the center of block depends on the location of pixel by using the following process:

   a. In the First quarter the *distance* (D_{s1}) is determined by using the relation:

   b.

$$D_{s1} = \sqrt{(|i - i_o| - 0.5)^2 + (|j - j_o| - 0.5)^2} \quad \dots (3)$$

   c. In the Second quarter the distance (D_{s2}) is determined using the following equation:

   d.

$$D_{s2} = \sqrt{(|i - i_o| - 0.5)^2 + (|j - j_o| + 0.5)^2} \dots (4)$$

   e. In the Third quarter the distance (D_{s3}) is determined by using the following relation:

   f.

$$D_{s3} = \sqrt{(|i - i_o| + 0.5)^2 + (|j - j_o| - 0.5)^2} \dots (5)$$

   g. Finally, in the Fourth quarter the distance (D_{s4}) can be computed by the following relation:

$$D_{s4} = \sqrt{(|i - i_o| + 0.5)^2 + (|j - j_o| + 0.5)^2} \quad \dots (6)$$

   Where, i,j are indices of pixel in a block and i_0, j_0 refers to the indices of the center block.

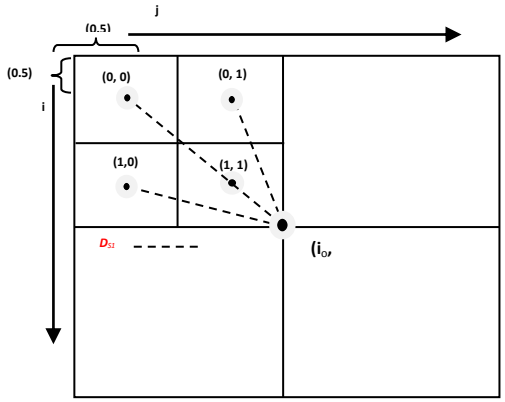
2. Calculate the feature moment of pixel FM_p *(x,y)* in a specific block in the image by applying the following equation:

$$FM_p(x,y) = F_P(x, y) \times D_s \quad \dots (7)$$

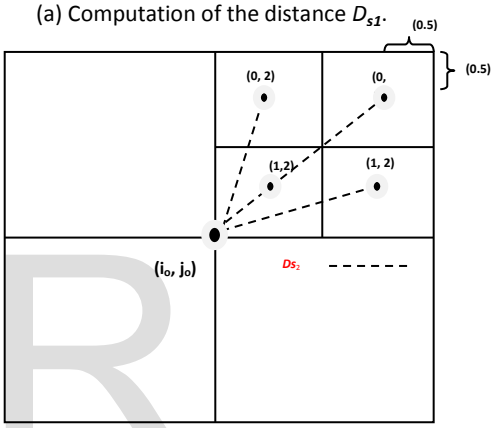
3. The moment features of a specific block (*MB*) in the image can be determined by using the following equation:

$$MB(I, j) = \frac{1}{B_h \times B_w} \sum_{i=0}^{B_h} \sum_{j=0}^{B_w} M_p(i,j) \quad \dots (8)$$

   Where, B_w refers to the width of block, and B_h refers to the height of block, and F_P (*x*,y) refers the pixel value of the selected block. *x*, and *y* are indices of the pixel in selected block of image.



(a) Computation of the distance D_{s1}.



(b) the distance D_{s2} Computation.

Figure (5): Schematic description to the distance computation depends of the location of pixel.

E. Moment Based Clustering

In this phase, the implementation of K-Means algorithm is used by two input parameters, the first is the number of clusters (or classes) and the second is moment feature values of all blocks of image. The moment feature is extracted for each image block and stored in 2D array, and the K-Means algorithm is applied and grouping all these features to get the best features (centroids). Where, pixels value in the image belongs to each centroid are stored as a vector in database that used in the image classification.

F. Greece Classification

The Greece classification stage is done after the clustering of features and stored in database. The classification method depends on the comparison of

spectral value of each pixel with the established database, depending on the proximity for each pixel into the classes available in the database. Classification technique is carried out by determining the similarity measurement (S_K) between every pixel in the image F_{ij} and the mean μ by apply the equation (9). The maximum value of S_K represent to pixel of image belongs to any class [13].

$$S_k = 1 - |\mu - F_{ij}| \quad . \quad .. (9)$$

V. EXPERIMENTAL RESULTS

One of the most important factors of using the Athens region in Greece images having five types of land (classes) and being used as support for the interpretation. It made to discuss the differences between classes and study the area of that covered by each class. The images taken by Sentinel-2A satellite, this satellite is a polar-orbiting, multispectral high-resolution to cover Athens, Greece that located at latitude 37° 58′ 46″ N, 23° 42′ 58″. In this paper, the input images classified before and after the Wildfires for a year 2007, 2018. Where, the variations of the spectral features in these images give five classes: water, trees area, buildings with trees, buildings without trees, and bare lands. After apply the classify technique, the database contains moment feature values of image blocks corresponding to the final best centroids resulted from applying the K-Means on the image blocks as discussion in sections 4.4 and 4.5, where the number of iterations needed to get convergence and best centroids before and after Wildfires in the image of Greece shown in figure 3 (a, b) are 6, 2 respectively for a year 2007. The best five centroids represent a feature for a specific block in classified image. Tables (2, 3) represent the best centroids for the classified image before and after the Wildfires for a year 2007. While, the area covered by each class in classified images can be compute for a year 2007, 2018 by using the equation (9).

Area Covers (m^2) =No. Pixels * 10 … (9)

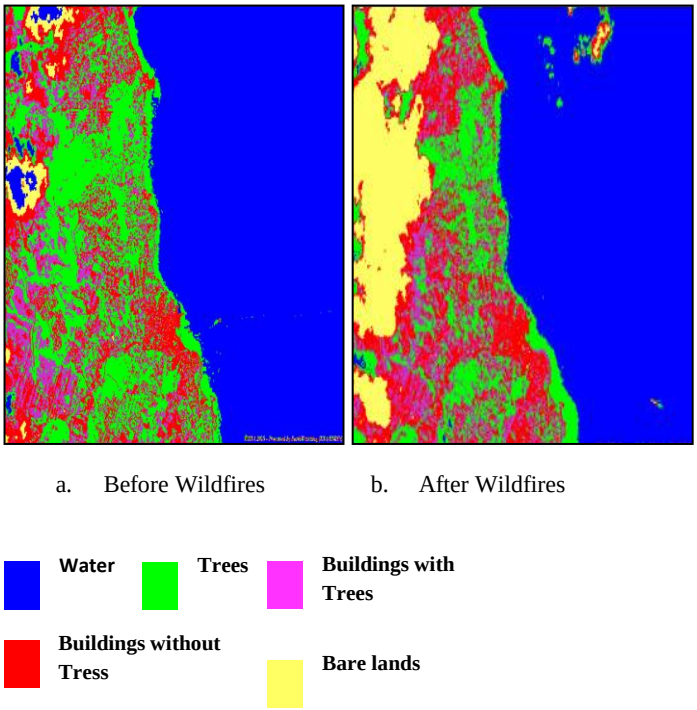
Table (2) Five classes with the best Centroids before fires in 2007.

Classes	Best Centroids
Water	9
Tree area	74
Buildings with trees	121
Buildings without trees	164
bare lands	237

Table (3) Five classes with the best Centroids after fires in 2007.

Classes	Best Centroids
Water	8.342
Tree area	84.5
Buildings with trees	129.5407
Buildings without trees	171.03
bare lands	246.42

The classification results of images of Greece before and after Wildfires for a year 2007 are shown in figure 6: its notice there are five different classes.



a. Before Wildfires b. After Wildfires

Figure (6): The classified images of Greece before and after Wildfires for a year 2007.

The experimental results shown in Table (4, 5) explained the area covered by each class before and after Wildfires in Greece for a year 2007 was changed and detect the damage caused by these fires and their impact on soil and environment.

Table (4) No. of pixel with cover area for each class in classified image before fire in 2007.

Classes	No. Pixels	Area Covers (m^2) (No. Pixels *10)
Water	959576	9595760
Tree area	416892	4168920
Buildings with trees	213804	2138040
Buildings without trees	278292	2782920
Bare lands	29144	291440

Table (5) No. of pixel with cover area for each class in classified image after fire in 2007.

Classes	No. Pixels	Area Covers (m^2) (No. Pixels *10)
Water	962624	9626240
Tree area	213712	2137120
Buildings with trees	182572	1825720
Buildings without trees	230184	2301840
Bare lands	212400	2124000

In the other side, the number of iterations needed to get convergence and best centroids before and after Wildfires in the image of Greece shown in figure 4 (a, b) are 5, 6 respectively for a year 2018. Tables (6, 7) represent the best centroids for the classified image before and after the Wildfires for a year 2018. The experimental results shown in Table (8, 9) explained the area covered by each class before and after Wildfires in Greece for a year 2018 was changed and detect the damage caused by these fires and their impact on soil and environment.

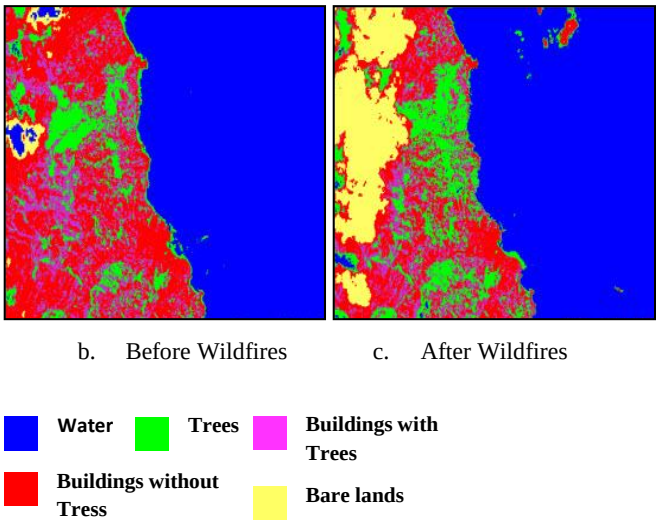
Table (6) Five classes with the best Centroids before fires in 2018.

Classes	Best Centroids
Water	7.6
Tree area	100
Buildings with trees	136
Buildings without trees	168.42
bare lands	236.7

Table (7) Five classes with the best Centroids after fires in 2018.

Classes	Best Centroids
Water	6.74
Tree area	82.99
Buildings with trees	128.63
Buildings without trees	168.5
bare lands	241.3

The classification results of images of Greece before and after Wildfires for a year 2018 are shown in figure 7: its notice there are five different classes.



b. Before Wildfires c. After Wildfires

Figure (7): The classified images of Greece before and after Wildfires for a year 2018.

Table (8) No. of pixel with cover area for each class in classified image before fire in 2018.

Classes	No. Pixels	Area Covers (m^2) (No. Pixels *10)
Water	976500	9765000
Tree area	164780	1647800
Buildings with trees	258928	2589280
Buildings without trees	427780	4277800
Bare lands	21612	216120

Table (9) No. of pixel with cover area for each class in classified image after fire in 2018.

Classes	No. Pixels	Area Covers (m^2) (No. Pixels *10)
Water	961896	9618960
Tree area	132647	1326470
Buildings with trees	184336	1843360
Buildings without trees	278648	2786480
Bare lands	242516	2425160

VI. RESULTS ANALYSIS

The experimental resulted of the proposed classification technique shows that the good performance accuracy of image classifies taken by Sentinel-2A satellite and give the good analysis results about the damages resulted from the fires in the forest Greece for a year 2007, 2018. In 2007 A.D. the tree class is covered the area (4168920 m^2) before Wildfires, while after the Wildfires it's covered the area (2137120 m^2). Otherwise, the building with trees class is covered the area (2138040 m^2) before Wildfires, while after Wildfires it's covered (1825720 m^2). Also, the bare lands class is covered the area (291440 m^2) before Wildfires, but after the Wildfires it's covered (2124000 m^2). Figure 8 display the natural images of Greece after Wildfires that refers to the huge damaged in the town Athena. After the Wildfires that happened in the Greece in 2007 and during the eleven years ago became the area covered by the class of trees in 2018 is (1647800 m^2), the area covered by the class of building with trees is (2859280 m^2), and the area covered by the class of bare lands is (216120 m^2).

Figure (8): The natural images of Greece after Wildfires.

The observed from the result analysis about the damages resulted from the fires in the forest Greece for a year 2007, 2018 where, the number of pixel for class (trees and building with tree) are increasing after wildfires in 2007 that refers the size of the development in culturing and reconstruction of buildings during 11 years ago to 2018 which means that the accuracy of proposed classification method is better for this study. Figure 9 shows the observation results and the differences in the number of pixels for each class before and after the Wildfires for a year 2007, 2018.

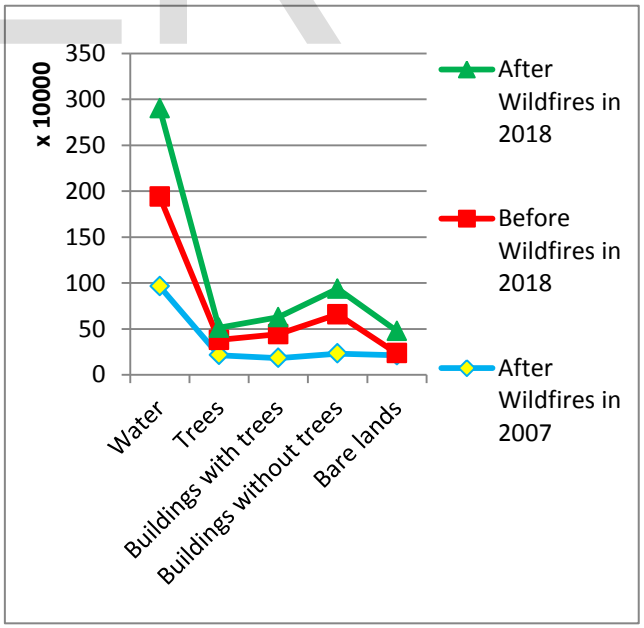


Figure (9): Behavior differences in number of pixels for each class.

VII. CONCLUSION AND FUTURE WORK

Satellite Sentinel-2A imagery, this satellite is a polar-orbiting, multispectral high-resolution to cover Athens, Greece that located at latitude 37° 58′ 46″ N, 23° 42′ 58″ E. In this paper, noticed the affected area, the burned areas. It observed the effect on each class before and after the fires that occurred in forests of Athens in Greece for a year 2007, 2018**.** The experimental resulted shows a good performance accuracy in classification with five different classes (water, trees, buildings with tree, buildings without tree, bare lands) and a good result analysis about the damages resulted from the fires in the forest Greece for a year 2007, 2018 where, the number of pixel for class (trees and building with tree) are increasing after wildfires in 2007 that refers the size of the development in culturing and reconstruction of buildings during 11 years ago to 2018 which means that the accuracy of proposed classification method is better for this study. For future work, use another landsat satellite image for the same area with SVM or genetic algorithm classification.

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