

Remote sensing and digital image processing for analysing the impact of forest fires in Ocongate, Cuzco, Peru

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Abstract—This article describes the digital image processing process, from initial image acquisition to segmentation and feature extraction. It is focused on the forest fires in the Peruvian Andes that occurred in the department of Ocongate, Cuzco, Peru on August 2020. This report also includes remote sensing, since it is based on the data set of satellite images provided by the European Space Agency ESA from the Copernicus Open Access Hub program and the Copernicus satellite platform.

// **Index Terms**—Normalized difference vegetation index, European Space Agency, Red Green Blue color model, Infrared spectre, Near-infrared spectre, Remote Sensing, Digital Image Processing

I. INTRODUCTION

Forest fires in Peru are more common than most Peruvians believe. In 2019 alone, 37,617 heat sources were identified on the vegetation that indicate agricultural burns, mostly, in addition to forest fires [1]. There is a specific government entity called the National Forest and Wildlife Service (SERFOR for its acronym in Spanish) which is the national authority, created by the Ministry of Agriculture, to ensure the sustainable management of the country's wild flora and fauna.

In this sense, this sub-unit of the ministry works actively to prevent forest fires in the national territory, which in turn (for the most part) are caused by agricultural burns. Elvira Gómez Rivero, general director of Information and Forest and Wildlife Management at SERFOR commented that in her experience “fires do not appear spontaneously in a massive way, but are caused because there is a culture of ‘cut down and burn’ to enable cultivation or farming farms. dispose of waste in rural areas”.

These fires result in a significant threat to the diversity of species and natural resources in Peru. Among the main effects of the fires are the death of wildlife, the contamination of nearby bodies of water, the increase of pollutants in the air and the destruction of vegetation. [1]

The present work focuses mainly on analyzing the impact of this last effect. It is proposed to use remote sensing in addition to digital image processing techniques to measure the impact of forest fires in highland areas, specifically in the mountains

of the Ccatca district, in the Quispicanchi province of Cusco, Peru.

II. THEORETICAL FRAMEWORK

Before carrying out the work, the information presented by Torres, Quiroz and Juscamaita was taken as a reference. In this work, the grassland burning process was carried out under a controlled environment in the department of Junín, Peru and the effects on the microbial population were studied. The highlight of this work is that it is indicated that the reason why “burns” of these high Andean pastures are carried out periodically in order to allow the use of the ground vegetation by sheep, and outbreaks by cattle. And that are carried out mainly in the dry season which is from June to September. The most important result that we take as prior information is that two weeks after burning, the recovery of the grasses was quite good and within two months the grasses had abundant regrowth.[2] This will be taken into account for the analysis by dates that we will carry out below.

III. METHODOLOGY

The main indicator used for this work is the Normalized Difference Vegetation Index . It is a simple indicator of photosynthetically active biomass or, in simple terms, an estimate of vegetation health. Simply put, NDVI helps to differentiate vegetation from other types of (artificial) land cover and to determine its general condition. It also allows the definition and visualization of vegetated areas on the map, as well as detecting abnormal changes in the growth process. the NDVI of each date is calculated. Using the formula:

$$NDVI = (NIRband - Redband)/(NIRband + Redband) \quad (1)$$

And as a result is obtained the Fig. 1.

A. Acquisition

We start searching on SERFOR a fire between a time and zone suitable to a image investigation. This led us to select the Ocongate Fire in August 2020 as the chosen one for our investigation because we can observe its evolution one

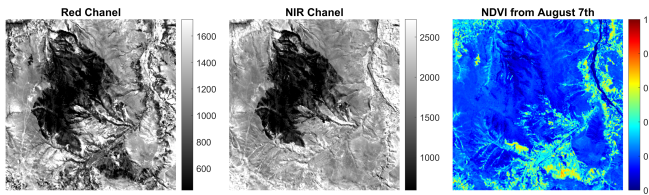


Fig. 1. RED Channel, NIR, Channel and NDVI From the Fire

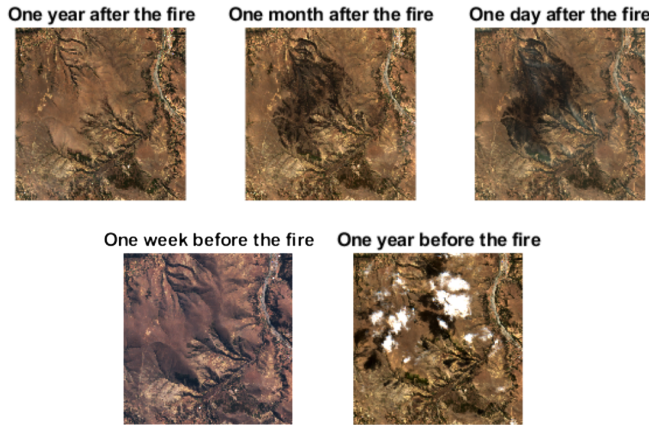


Fig. 2. Land affected by fire on different periods of time

year after the incident and was a knowledge news in the highlands of Cuzco. Satellite images were pulled from the Copernicus Hub repository. Process begins with the download of all the requested layers. In this part of the process, it is possible to filter the results by satellite, by layer quality level and cloudiness level. The images provided by the Copernicus Hub platform give us the images broken down into their respective spectral components, both for the colors of the visible electromagnetic spectrum and for some later ones, such as Infrared and Near Infrared until the total composition of image.

The first phase of the process is the collection of images, and a total of 3-band satellite images (Red, infrared and TIC) of 5 relevant dates around the fire that occurred on August 6, 2020 were extracted on the following list and presented in Fig. 1.:

- 1) August 7, 2021 (1 Year after the fire)
- 2) September 6, 2020 (1 Month after the fire)
- 3) August 7, 2020 (1 day later)
- 4) July 28, 2020 (1 Week before the fire)
- 5) August 3, 2019 (1 year before the fire)

B. Pre - processing

There is 5 levels of processing available on Copernicus platform. Our acquisition scope are the free downloads from sentinel' Satellites 1 2, that are level 1C and 2A. Level 2A is the result of a correction of meteorological effects applied to a layer of level 1C, this application called SEN2COR that is processed using STEP software owned by the same European

TABLE I
NDVI RANGES

NDVI range	Description
]0 , 0.14]	Inanimate Objects (barren rock, sand, snow, clouds)
[0.14 , 0.5]	Sparse Vegetation
[0.5 , 1[Dense Vegetation

Space Agency, is the level with the highest processing and is the one that we have used in this project [3]. The images extracted from copernicus, being Level 2A, already have a layer enhancement preprocessing. Subsequently, the area of interest that is the mountain in the district of Ccatca was located in each of them. The desired area is measured and the 15 collected images are cropped using the same dimensions. With the help of the Red and Infrared bands

C. Segmentation and Description

Eventually is necessary to measure the vegetation index on the material from databases. So, researchers indicate that Grassland loss is measured by contrasting the Normalized Vegetation Index. This index reflects the life cycle of plant cells, which have evolved to disperse solar radiation in the near infrared spectral region and absorb that located in the visible spectrum (for each particular plant) in their periods of vitality, once that begins to wither. The radio changes to the detriment of the amount of reflected infrared, each time it absorbs more infrared rays with the consequence of storing heat. This effect on the life cycle of plants creates the optimal conditions for the spread of forest fires, whether caused or spontaneous. For the calculation of the vegetation indices, the information found in the red and infrared bands of the electromagnetic spectrum is necessary [4].

IV. EXPERIMENTATION AND RESULTS

We focus mainly on understanding the behavior of the fire, validating its interpretation and observing its evolution over time. In this way we can validate not how the fire acts, but how it interacts with its environment

A. NDVI distribution

In the first place, to understand the behavior of the fire outside of the descriptive images, one option was to know the dispersion of the data and understand the presence of outliers and how they appear in the different stages of the fire. Later to know the main characteristics of the values that vegetation index takes for each pixel of the image, we made a box-and-whisker diagram:

It can be observed in Fig. 3 that the distribution of vegetation index it is concentrated on 0.2. And we can reach some point until 0.8 on th majority of days. Also a interesting view is the behavior of the boxplot on the day of the fire. On these day vegetation index higher than 0.8 disappear and the appearance of data become lower in the extremities. What dirves to the figure to have the data more concentrated in the middle.

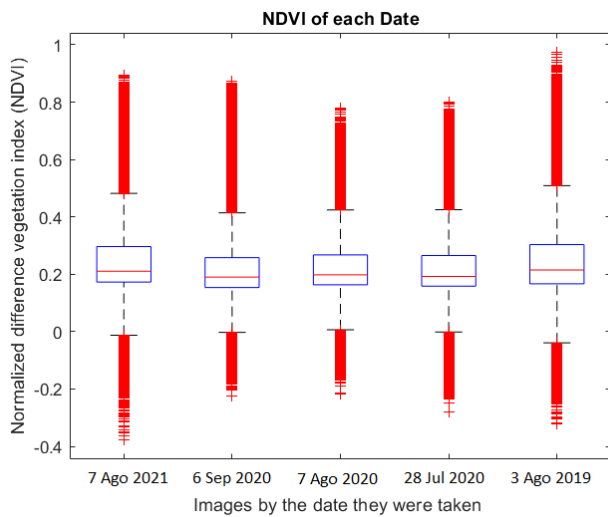


Fig. 3. NDVI distribution for the 5 dates

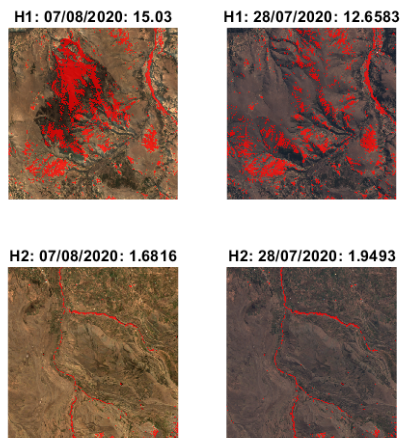


Fig. 4. Inert objects percentage between The mountain of study and a nearby one

Another study that is considered was the comparison of the land in the area in order to confirm that the decrease in vegetation is due to an external factor, but not to a seasonal factor. In this way we evaluate the percentage of inert objects that cover the earth in the same period of time with a neighboring hill no further than 15 hectares.

In Fig. 4 the nearby mountain have a higher vegetation with 12 percentage points less of inert objects index than the last week. Instead the mountain affected by the fire in study where it develop 20 percentage points more and appear a visible zone with inert objects where it's suppose the fire was.

B. Differences

In Fig. 5 the graph represent the difference in the state of the vegetation between three different dates against the fire Date. In this way, it is proposed to evaluate in the first place, against last week, the loss of vegetation caused by the fire. Second, against the following month the vegetation recovered

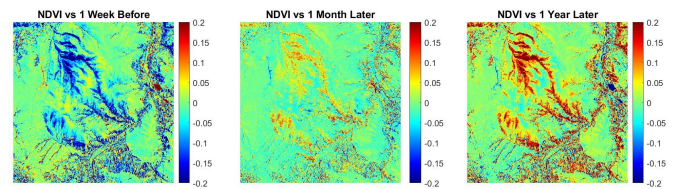


Fig. 5. NDVI vs Last week, Next month and Next Year

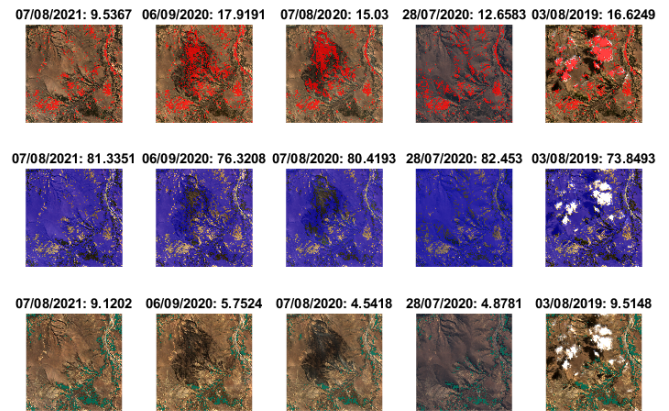


Fig. 6. inert objects, small vegetation and vegetation by Time Period

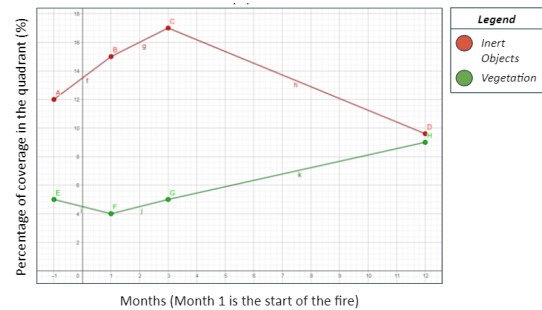


Fig. 7. Timeline of the evolution of the percentage of inert objects and vegetation in the study quadrant

in the short term. Finally in third place against next year, the vegetation recovered after the recovery process

We can observe how the land had a loss of vegetation index between the last week. But, it will have a continuous improve starting on the next month until to normalise when finally a year pass

C. Percentage of vegetation

Finally, from the 3 ranges previously determined, masks were created on the original images, likewise the percentage of the area that they covered of the total area studied was calculated on Fig. 6.

We identify also in Fig. 7 how the index evolve on the time line. We can observe a loss of vegetation index that finish with more vegetation compared to how it started

V. CONCLUSION

From the process followed and the results obtained, we can conclude that it is indeed possible to study forest fires in Peruvian territory. The analysis of the distribution of the NDVI values of each image suggests that after the fire it takes one year for the vegetation to recover its original state. Also we can clarify that it is the fire which affect many lands at the moment to compare the effects on nearby lands on the study.

VI. FUTURE WORK

It could be interesting to replicate the analysis in every month of the year to have a high precision on the moment which the land recovery his normal vegetation index.

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