University of Puerto Rico

Mayagüez Campus

Faculty of Arts and Science

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Final Written Report: Using satellite-based indices for impact of volcanic activity on vegetation using spatial analysis

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INTRODUCTION

This research is done to determine if the change in vegetation can be observed in the June 2018 eruption in the Fuego volcano in Guatemala by using the satellite-based vegetation indices. The convergence of the Caribbean plate with the Cocos plate generates a subduction zone, in Central America this formed the Guatemalan Volcanic Front (Carr et al., 2007). It is composed of a belt of stratovolcanoes (Carr et al., 2007). The Fuego stratovolcano is located at 14.47°N, 90.88°W, and its summit is at 3,763 m asl (http://volcano.si.edu/volcano.cfm?vn=342090). The Fuego volcano on June 3rd, 2018 had a paroxysmal eruption that involved explosions that lifted thick columns of ash, pyroclastic flows that went toward towns by going through the drainages ("Barrancas"; mainly Seca, Cenizas, and Las Lajas), and tephra falls (INSIMUMEH, 2018a; 2018b). It was the most powerful eruption in the last decade that had the most human impact (INSIVUMEH, 2018b; Naismith et al., 2019). Barranca Las Lajas is where most of the volume of pyroclastic flows have been observed (INSIVUMEH, 2018a; 2018b; 2018c). A pyroclastic flow is a current of volcanic rock fragments and gas traveling down a slope (Vallance et al., 2001).

For the scientific significance, this can aid to further describe and characterize the deposits in the volcano. Also, this can support hazard monitoring and evacuation plans. The constant studying of the deposits and geochemistry of the volcano should be maintained and even increased if possible. In the flanks of the Fuego volcano there is strong agricultural and other human activities growing, and a great number of human settlements such as cities, towns, and communities. The flanks where people are the most vulnerable are the SouthWest and SouthEast. In the economic, social, and environmental point of view people will be greatly affected even if lives can be saved. This occurs as they heavily depend on the human activities to sustain themselves. People generally have accepted the volcanic rick and there a moderate local organization, this occurs as people have adjusted with time to the volcanic activity. Some citizens do not consider the warnings and do not

prepare for any event. This a serious situation because if there is an alert of evacuation people will not respond with time. This is important because it will bolster the importance of studying the site as there are a lot of people living near the volcano. This information was taken from Romano, 2019.

OBJECTIVES

Obtaining Landsat images after and before the eruption in the GoogleEarth data base. The software ArcMap will be used to create maps with the Normalized Difference Vegetation Index (NDVI), the Soil Adjusted Vegetation Index (SAVI), and the Normalized Burn Ratio (NBR) applied or calculated. This is essential as it defines how the vegetation health was before and after the eruption, and to see if the recovery rate is slow or fast and its shape. In addition, see if the climate also had a role in the vegetation changes before and after the eruption.

METHODS

Schutter et al, 2015 and Fallas et al.,2018 were utilized as models to calculate the vegetation indices. Schutter et al, 2015 employed satellite data to assess ash impact on vegetation and people by the Oldoinyo Lengai volcano eruption from 2007 to 2008. It was done creating maps, time series of vegetation indices, interpolated rainfall data, linear temporal trend analysis and Principal Component Analysis. They correlated the recovery rate with ash fall deposit thickness, in the field they observed a circumferential pattern. In addition, they confirmed that for areas were field work is not possible the data can give a good estimate of ash fallout impact and intensity as in areas where field work is possible the data associated with the amount of damage. Fallas et al.,2018 utilized the indices on Landsat 8 images to analyze the behavior of the Turrialba Volcano volcanic system from 2014 to 2017 as it affected vegetation, fauna, and population centers. It was done creating maps, histograms of vegetation indices, and surface coverage diagrams. This aided in the

hazard assessment plan as the changes were able to be examined. The changes of vegetation indices on both papers were correlated to increase of volcanic activity.

In the ArcMap program, the Normalized Difference Vegetation Index is calculated by dividing the subtraction of the near-infrared band with the red band, with the sum of the near-infrared band with the red band. The Soil Adjusted Vegetation Index formula is SAVI = ((1 + L) (NIR + red)) / (NIR + red + L). The Normalized Burn ratio is calculated by dividing the subtraction of the fifth (near-infrared) band by the seventh (short wave infrared) band, with the sum of the fifth band (infrared) with the seventh band (short wave infrared). The previous formula is for Landsat 8 images and is found in an USGS website (https://www.usgs.gov/core-science-systems/nli/landsat/landsat-normalized-burn-ratio).

RESULTS AND DISCUSSION

Images were found for the November and December of 2017, January and March of 2019. Also, for January, March, June, and November of 2018. A total of 24 maps were created using the satellite images, each month has a map created for each vegetation index (**Fig. 1-24**). Observing all the maps in general qualitatively, it can be seen that in November 2017 volcanic activity was recent and then in January 2018 it can be seen recovery of the vegetation. Later in March of 2018 volcanic activity started again and then there is a stronger increase in June of 2018 as a powerful eruption occurred on the 3rd. Gradual vegetation growth is later seen to March 2019. The increase of activity can be tied to vegetation loss as the color gradient of maps show how to vegetation covers the area of the volcano spatially. There are no maps of the months in between those chosen as clouds covered most of the image or the volcano. The rainfall aided in the recovery rate by looking at the average monthly rainfall in the Guatemala in https://weather-and-climate.com/average-monthly-precipitation-Rainfall-inches,guatemala,Guatemala.

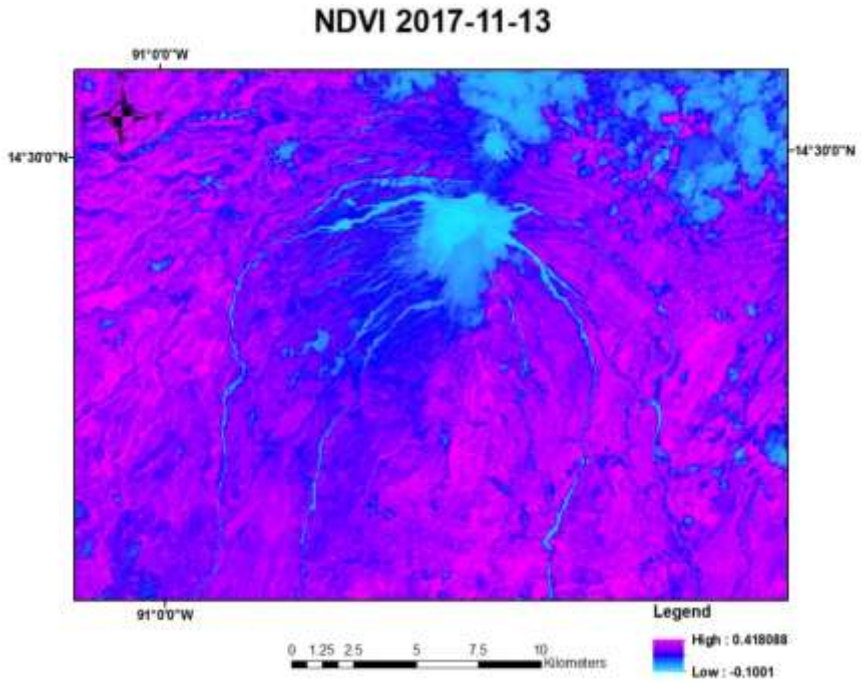

Figure 1 – Map of the Fuego volcano realized with an image of November of 2017, it has the NDVI calculated.

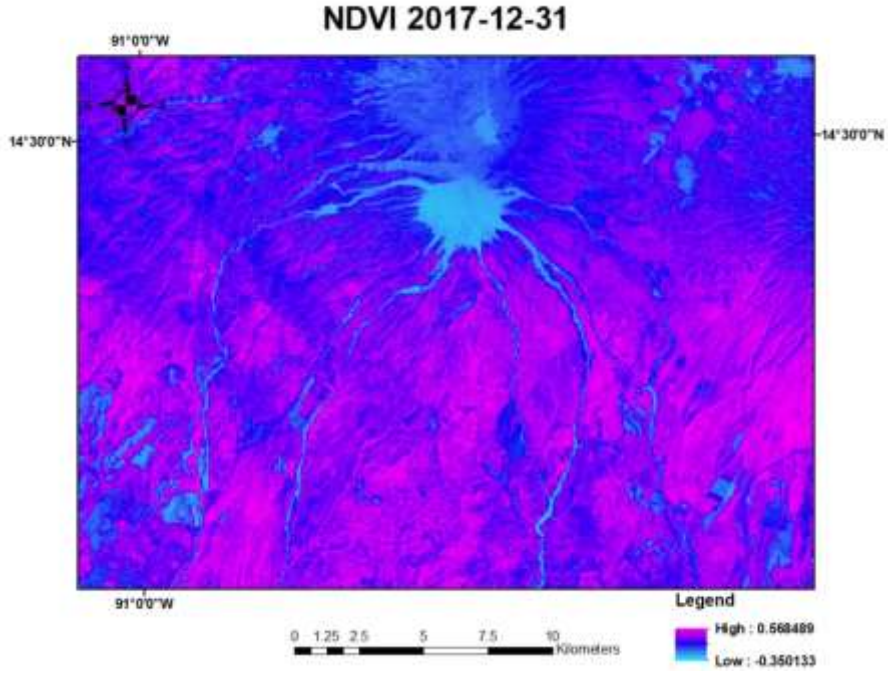

Figure 2 – Map of the Fuego volcano realized with an image of December of 2017, it has the NDVI calculated.

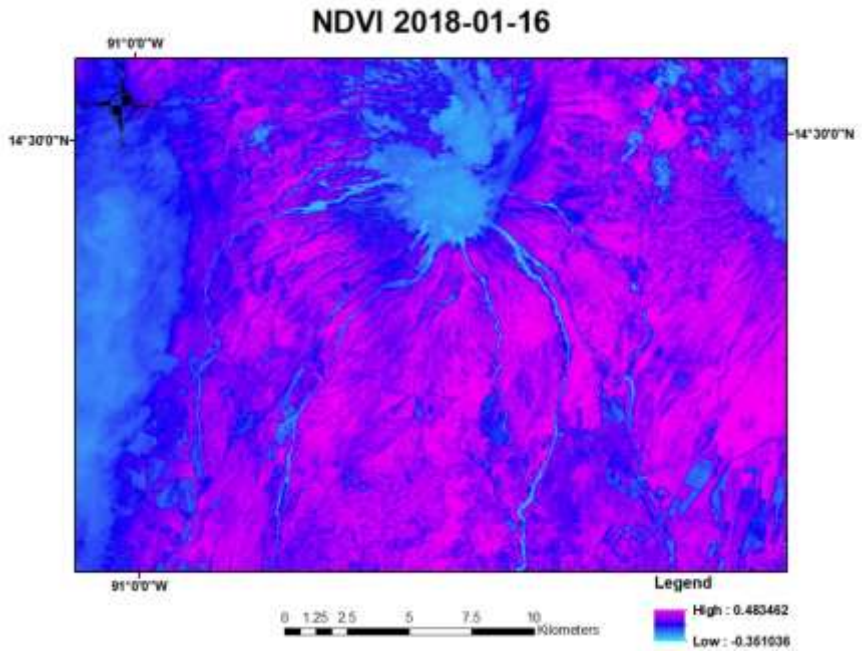

Figure 3 – Map of the Fuego volcano realized with an image of January of 2018, it has the NDVI calculated.

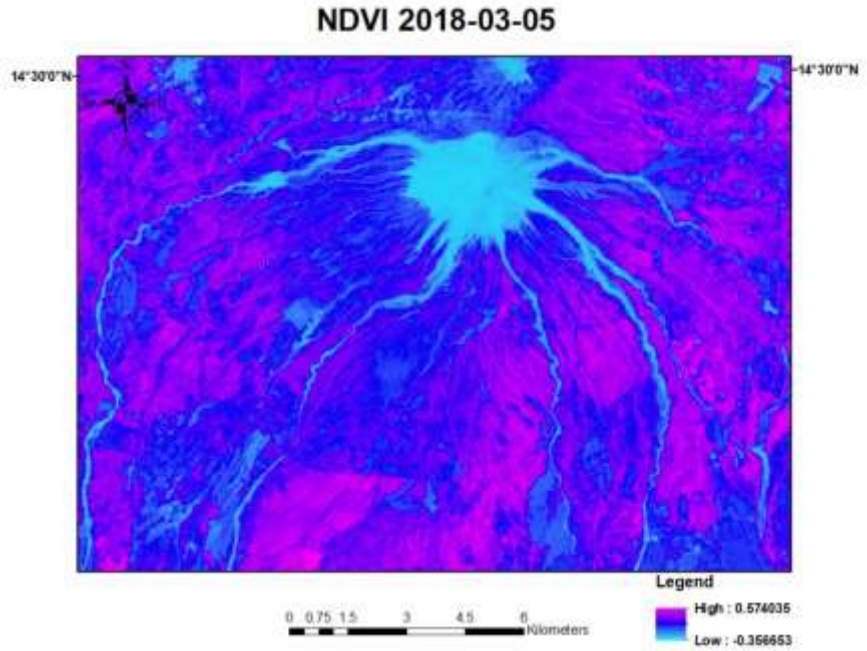

Figure 4 – Map of the Fuego volcano realized with an image of March of 2018, it has the NDVI calculated.

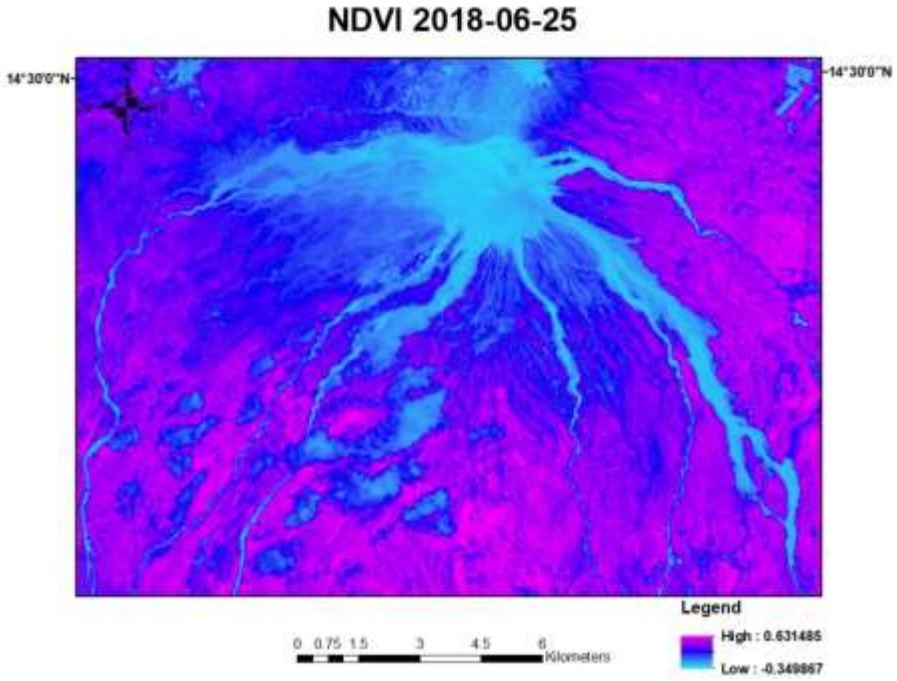

Figure 5 – Map of the Fuego volcano realized with an image of June of 2018, it has the NDVI calculated.

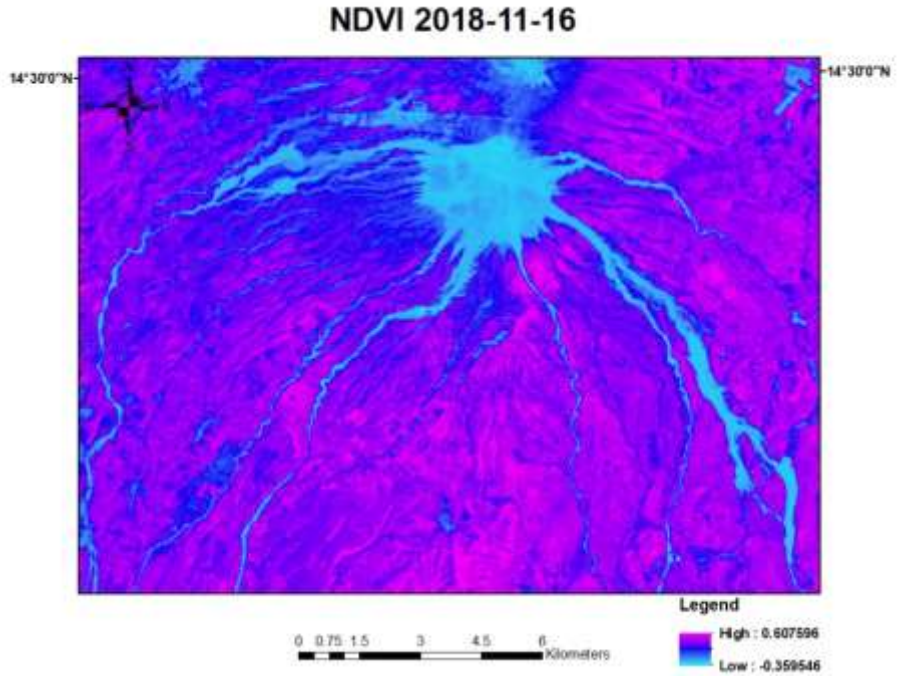

Figure 6 – Map of the Fuego volcano realized with an image of November of 2018, it has the NDVI calculated.

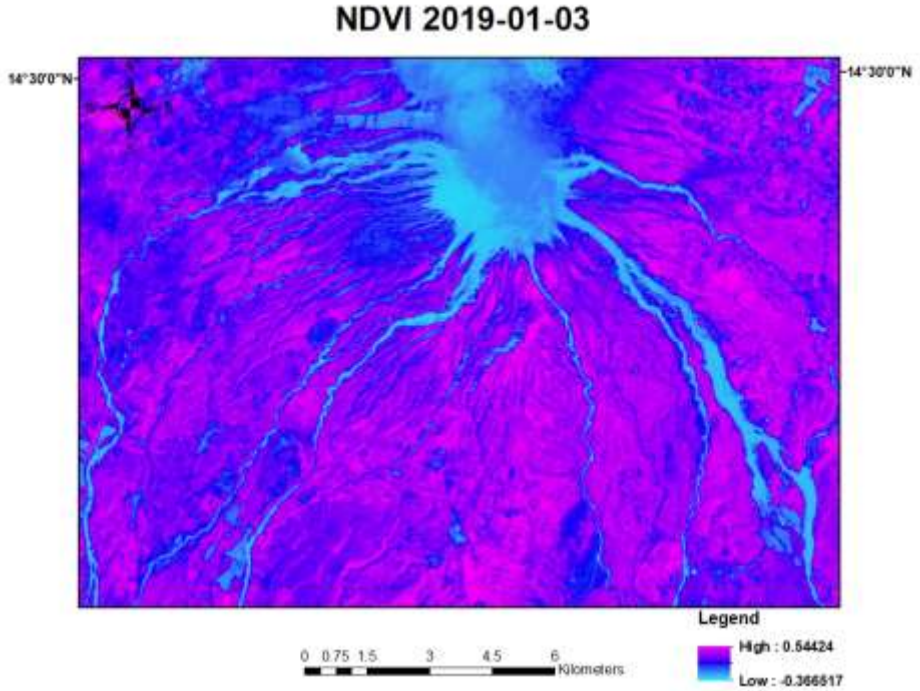

Figure 7 – Map of the Fuego volcano realized with an image of January of 2019, it has the NDVI calculated.

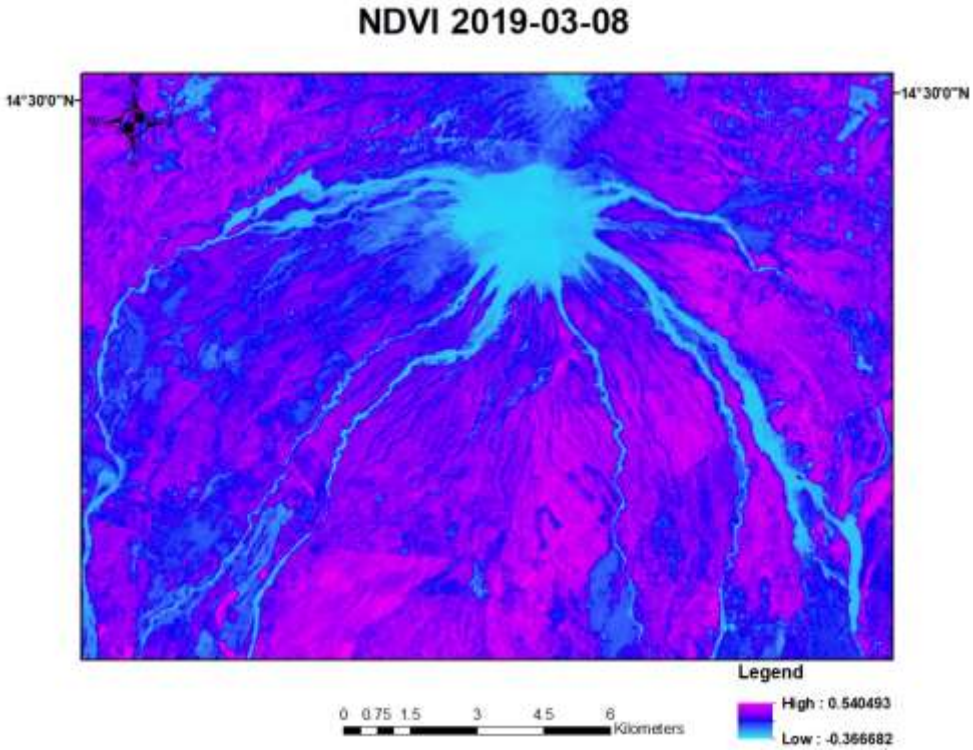

Figure 8 – Map of the Fuego volcano realized with an image of March of 2019, it has the NDVI calculated.

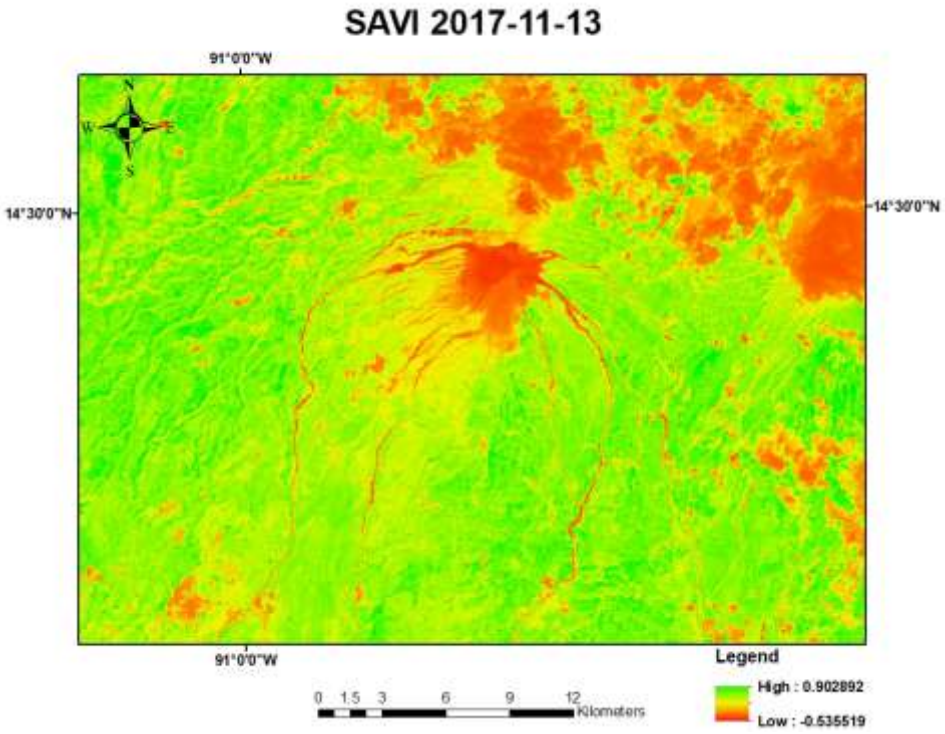

Figure 9 – Map of the Fuego volcano realized with an image of November of 2017, it has the SAVI calculated.

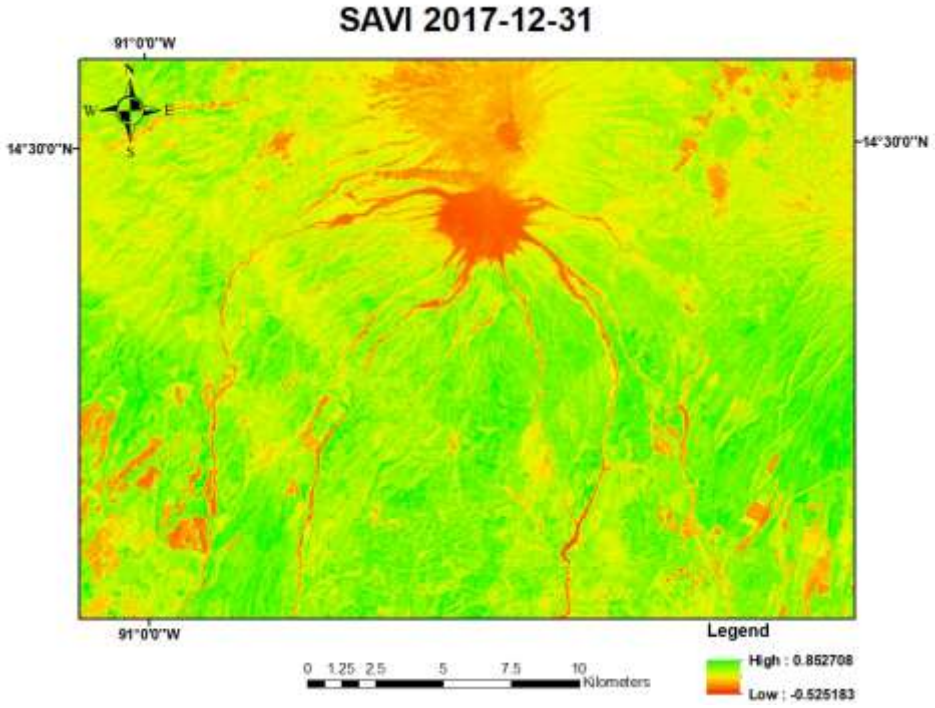

Figure 20 – Map of the Fuego volcano realized with an image of December of 2017, it has the SAVI calculated.

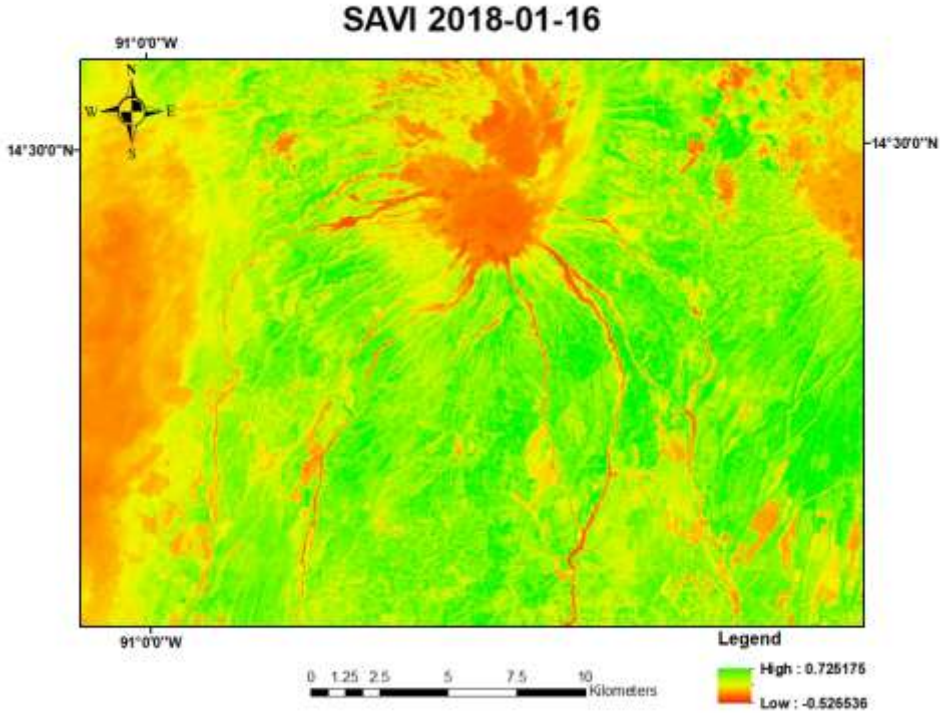

Figure 31 – Map of the Fuego volcano realized with an image of January of 2018, it has the SAVI calculated.

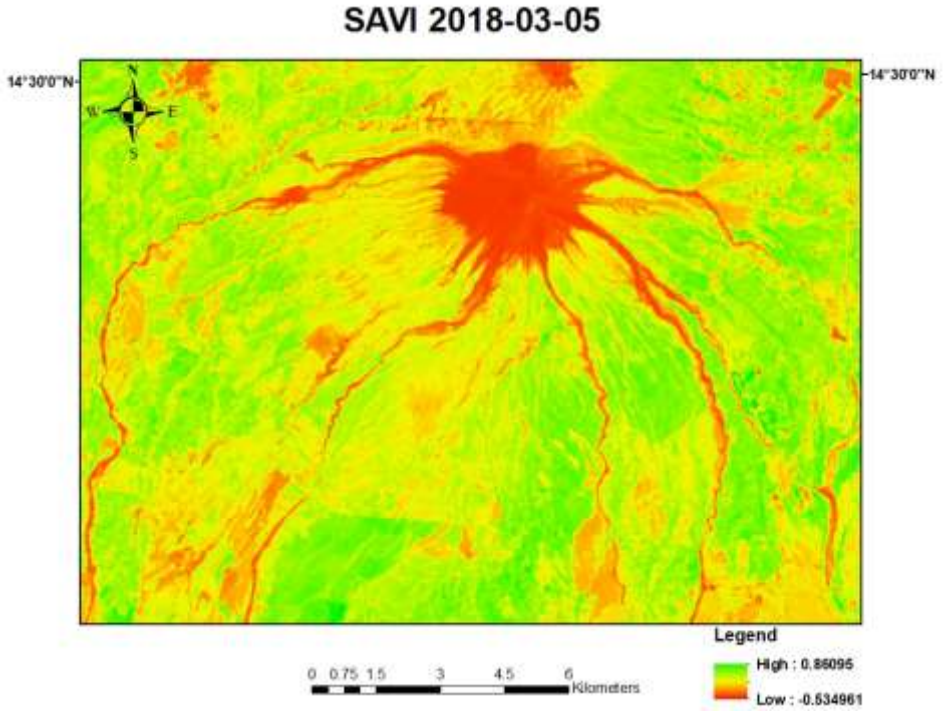

Figure 42 – Map of the Fuego volcano realized with an image of March of 2018, it has the SAVI calculated.

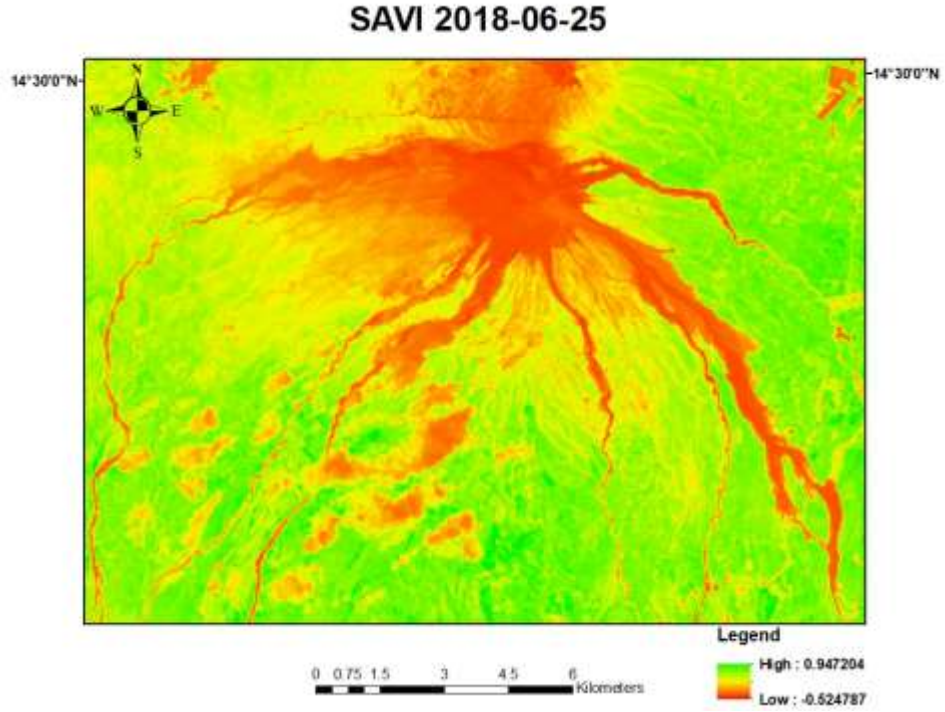

Figure 53 – Map of the Fuego volcano realized with an image of June of 2018, it has the SAVI calculated.

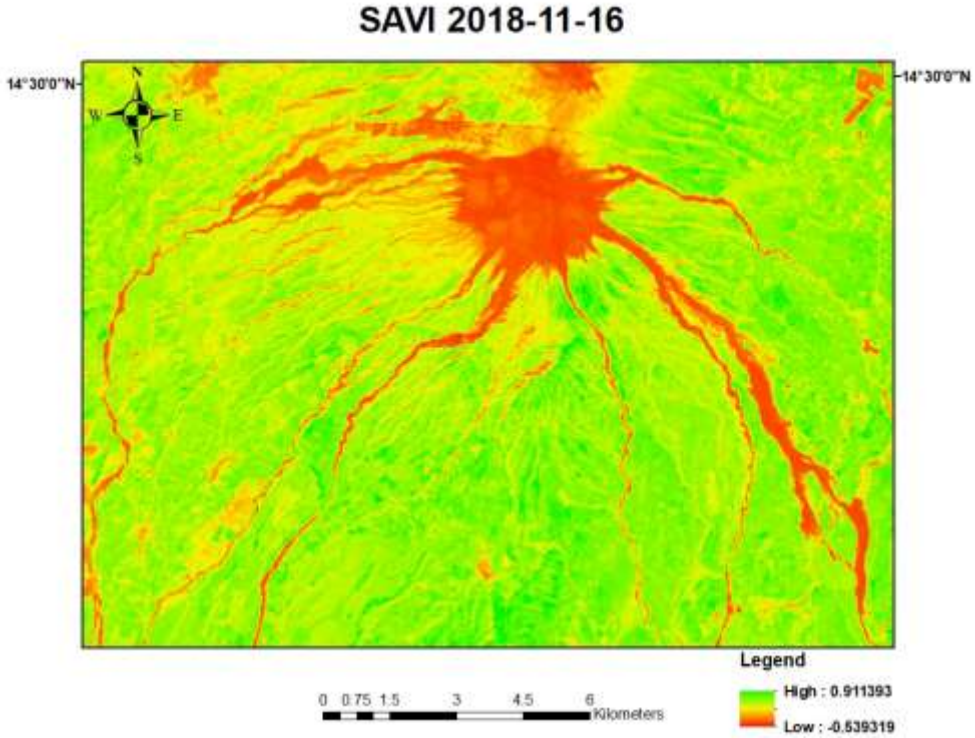

Figure 64 – Map of the Fuego volcano realized with an image of November of 2018, it has the SAVI calculated.

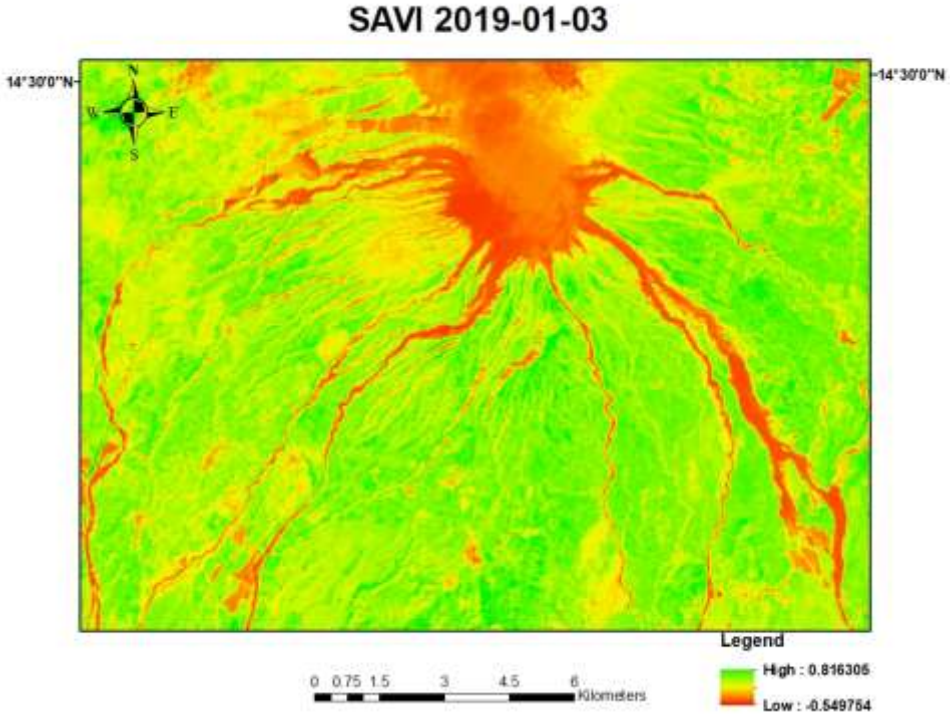

Figure 75 – Map of the Fuego volcano realized with an image of January of 2019, it has the SAVI calculated.

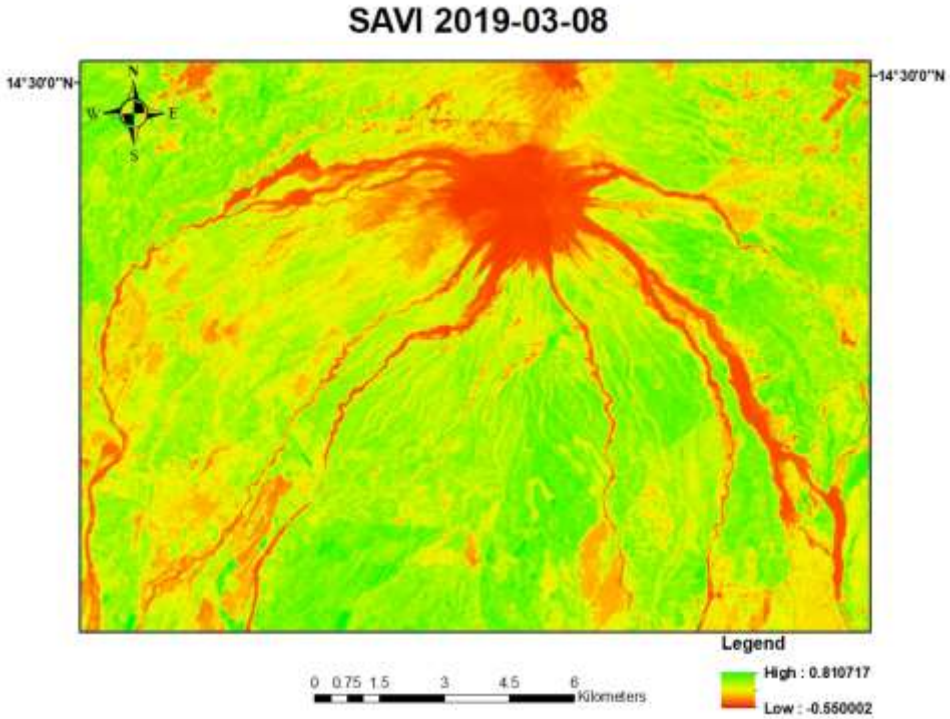

Figure 86 – Map of the Fuego volcano realized with an image of January of 2018, it has the SAVI calculated.

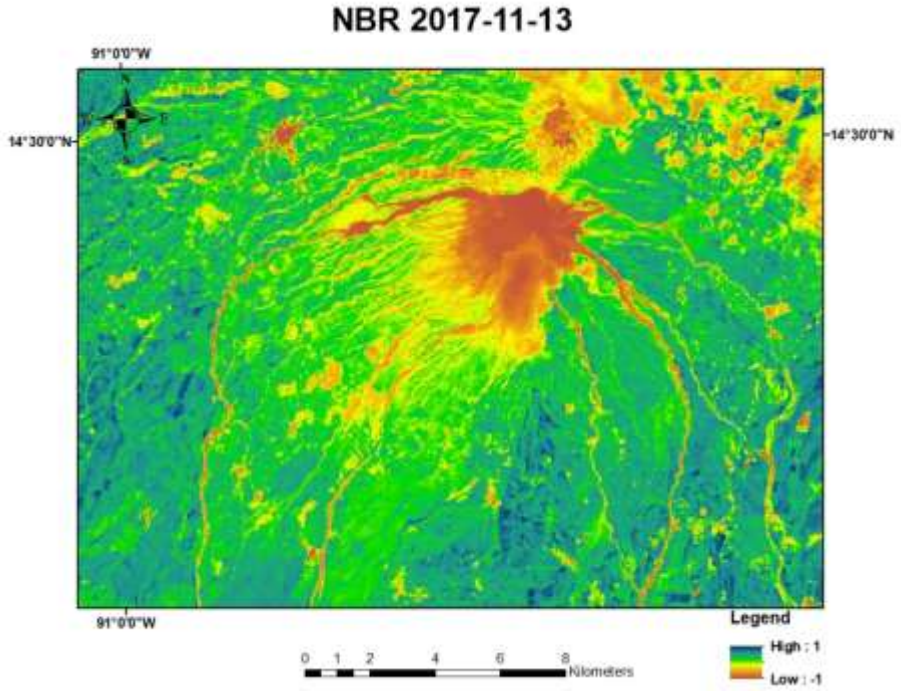

Figure 97 – Map of the Fuego volcano realized with an image of November of 2017, it has the NBR calculated.

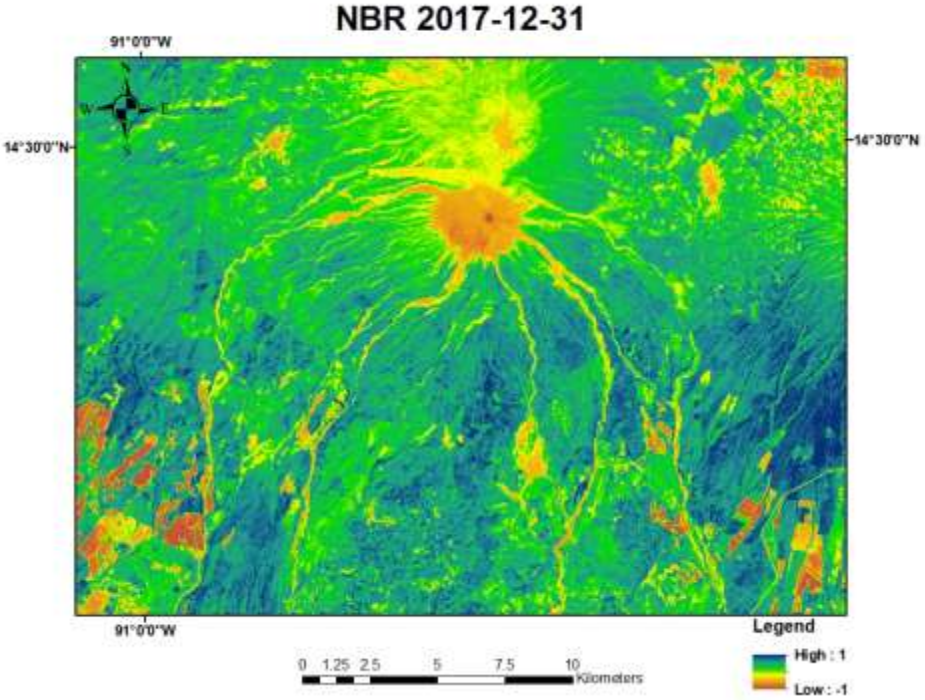

Figure 108 – Map of the Fuego volcano realized with an image of December of 2017, it has the NBR calculated.

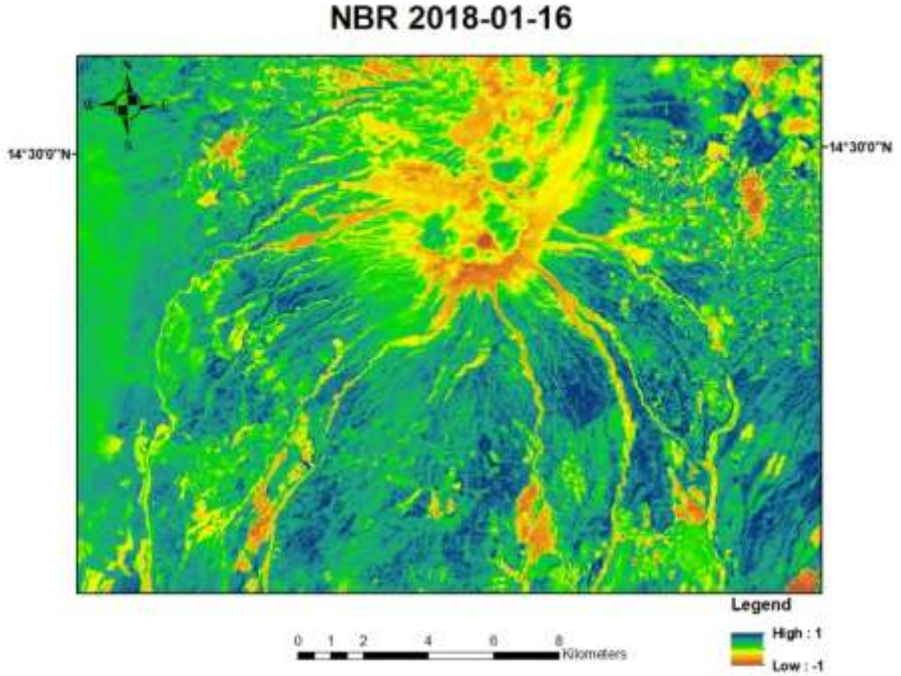

Figure 119 – Map of the Fuego volcano realized with an image of January of 2018, it has the SAVI calculated.

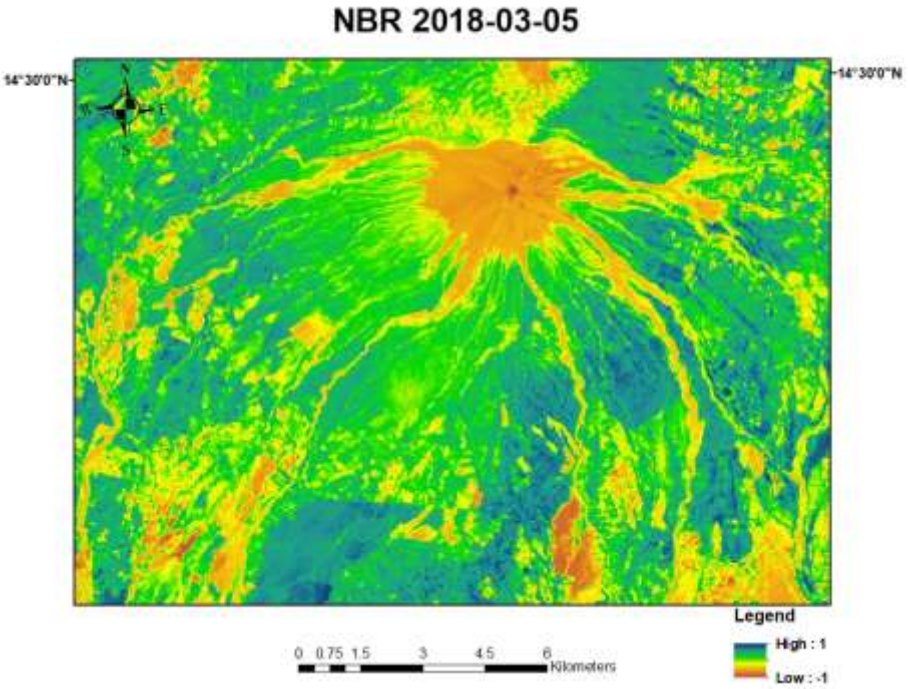

Figure 20 – Map of the Fuego volcano realized with an image of March of 2018, it has the NBR calculated.

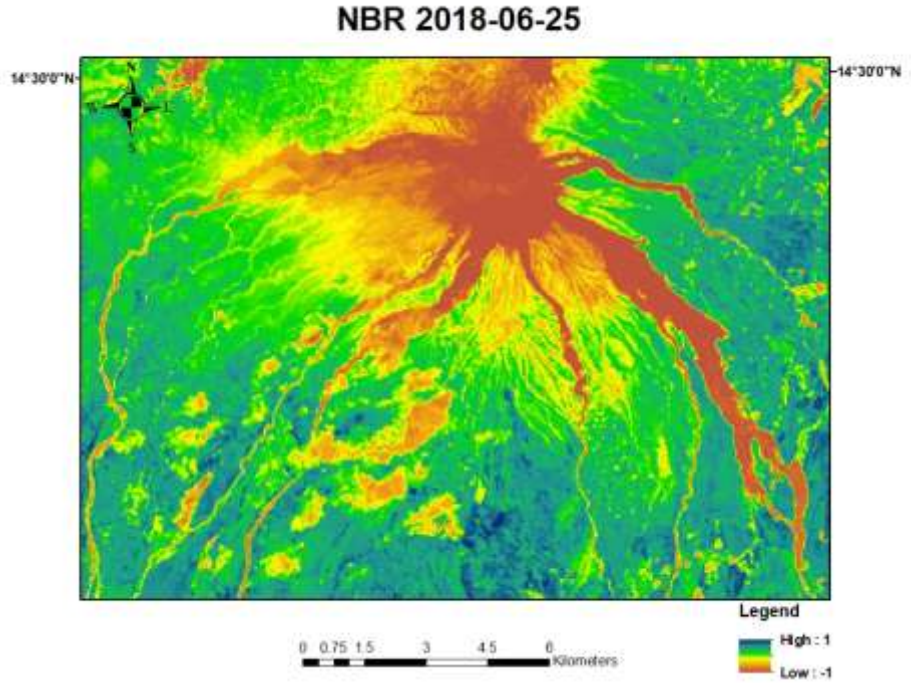

Figure 21 – Map of the Fuego volcano realized with an image of June of 2018, it has the NBR calculated.

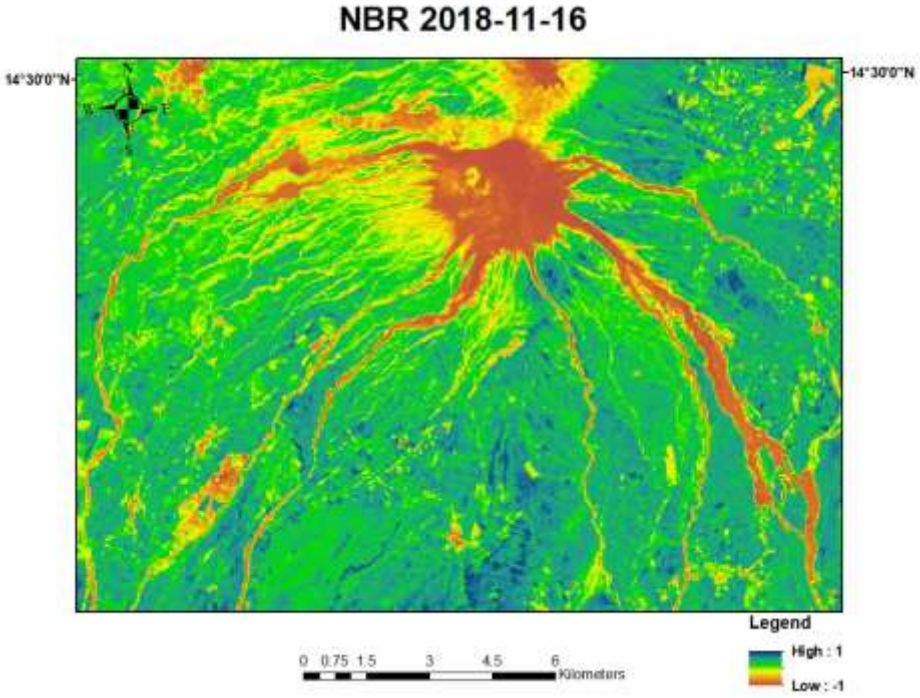

Figure 22 – Map of the Fuego volcano realized with an image of November of 2018, it has the NBR calculated.

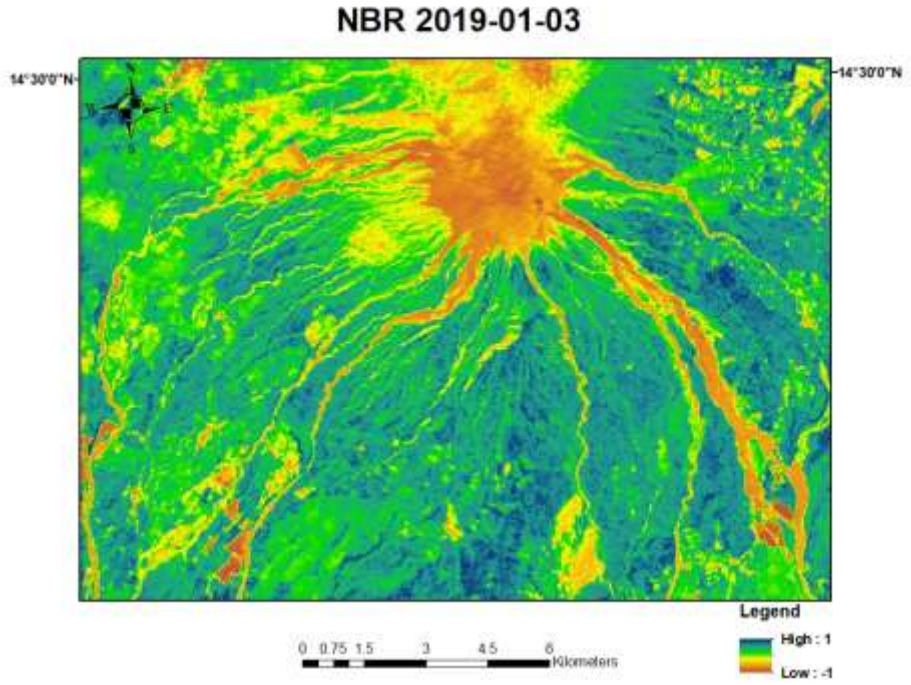

Figure 23 – Map of the Fuego volcano realized with an image of January of 2019, it has the NBR calculated.

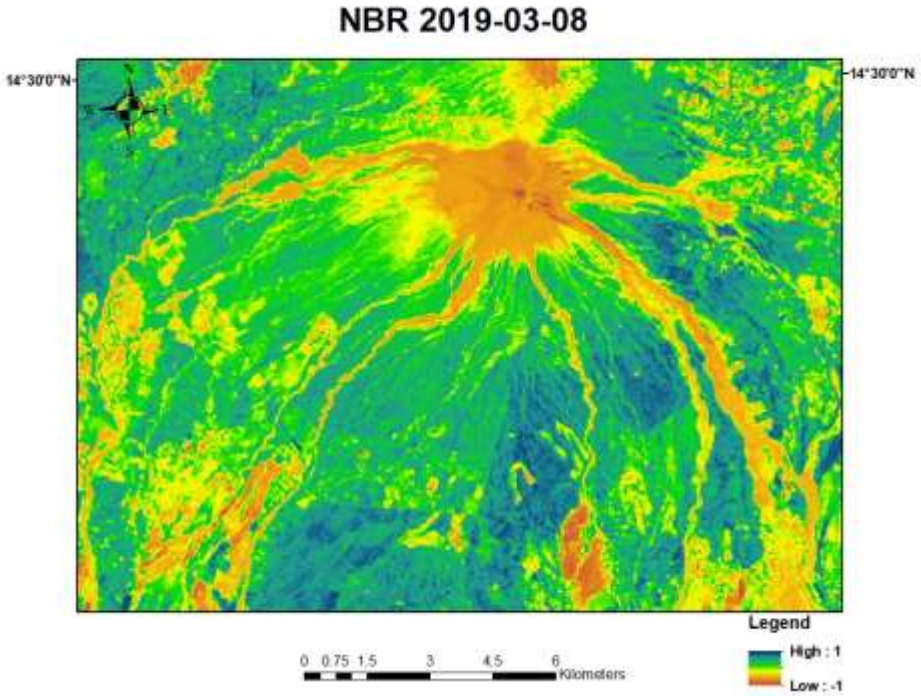

Figure 24 – Map of the Fuego volcano realized with an image of March of 2019, it has the NBR calculated.

RECOMMENDATIONS

Use Landsat 8 images to calculate Land Surface Temperature (LST), this can be done using algorithms. This can be integrated to the groups of maps created to define even further the area were the vegetation was burned or affected by gasses. Layers of data can be added like vegetation classification, rivers, etc. Field notes can be added to confirm the changes.

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