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BADE, a tool for Burnt Areas Detection & Evolution.

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Abstract

BADE is a support tool for forest researchers and technicians programmed in Google Earth Engine (GEE) platform that serves to detect forest areas that have been burned after a wildland fire, as well as fire severity. It allows the evaluation of vegetation recovery with the visualisation of time series grouped by fire severity and for different spectral indices from which the user can choose. Its use is very simple because of the graphical interface that the user can adjust for a target area of study by selecting the date of the fire, the index to evaluate in the graph and drawing the study area where the dNBR is going to be mapped. Both the map and the graph can be easily downloaded by the user.

1. Introduction

Fire has been a fundamental element in the dynamics of ecosystems in Mediterranean landscapes (Keeley et al. 2012) and for many forest ecosystems, it is the main one (González et al. 2006). These processes were used as a management tool in many rural areas, but the depopulation of these areas in southern Europe during the 20th century has made fires a major environmental problem, as they have become more frequent and more extensive (Pereira et al. 2006). According to data from the European Forest Fire Information System (EFFIS) (<http://effis.jrc.ec.europa.eu/>), between 2010 and 2019 there were about 19,000 ignitions in Portugal with a burned area of about 140,000 ha. The scenario in Spain during the same period is not much more encouraging, with 12,000 fires burning approximately 123,000 ha in Spain.

After a forest fire, it is necessary to carry out emergency works for the protection of soil and vegetation in the short term and long-term forest management to encourage the recovery of unfavourable areas and the reduction of vegetation in those areas where the fire has been good for recovery (Francos et al., 2016). Planning these types of actions is difficult because covering the entire burned area is costly and time-consuming. Therefore, use is made of remote sensing techniques that assess vegetation recovery by means of spectral indices (White et al. 1996). This is often difficult to apply for untrained technicians in remote sensing applications, who have to carry out a first evaluation followed by forest planning. This is where decision support tools come in to help managers make the right decisions. The objective of this work is to show the creation of the BADE tool, which is an easy-to-use support system for the detection of burned forest areas and that evaluates the recovery of vegetation and is based on remote sensing techniques accessible to everyone.

2. Material and Method

This tool is built on the GEE platform, which allows users to work and download the available large catalog of satellite imagery and other planetary-scale geospatial data. In addition, it allows the use of Google's servers to process and analyse all this information.

GEE allows the use of multiple remote sensing processes with simple steps, which can be replicated and used in other works avoiding repeating long processes. In this way, it makes the work more efficient and avoids human error when repeating the same steps for similar studies.

Such is the power of this platform, that it allows users to create their own applications once they have programmed some processes, and share them with other users who are not so fluent in programming. In this way, advanced users can generate a graphical interface that processes multiple tasks to produce a final result that is the desired result for the creator of the app. For all these reasons, GEE was the solution for the creation of the BADE tool.

2.1. BADE Architecture

BADE is a decision support tool for forest managers who need to detect burnt areas after a wildfire has occurred, along with the severity of the fire and the recovery of the vegetation up to 10 years later. It uses the Landsat mission to work from 1984 to the present day, together with a set of operational processes that can be easily adjusted by the user with its interface to set the survey configuration inputs, such as date of the fire, spectral index to be obtained and region of interest. A map and time series are automatically obtainable and reconfigurable as downloadable results (Fig 1).

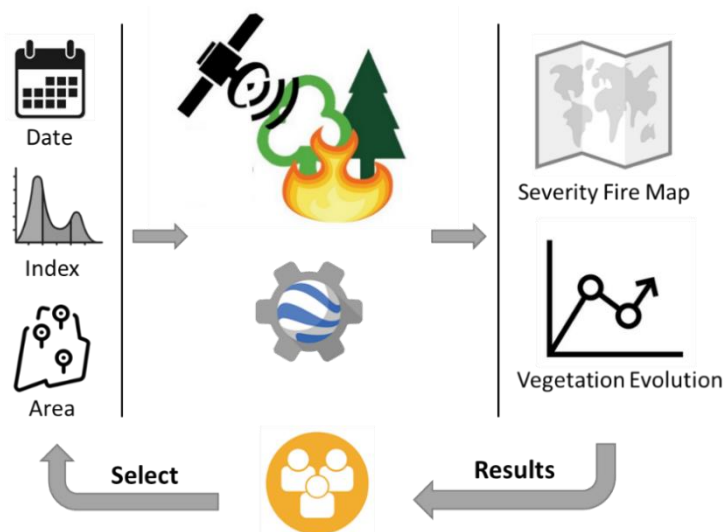


Figure 1: Scheme of the decision support tool, BADE.

BADE performs a large set of geospatial processes in an iterative and replicable way in GEE so that the user obtains its results over and over again each time the process is executed. The steps that this tool continuously performs are as follows:

First, a function is applied to each Landsat mission (5-7-8) that calculates with the spectral bands various indices (Nbr, Ndvi, Msi, Ndi, Rci, Gci, Evi2) for each of the images in each collection, followed by another function that removes to each image the pixels that have clouds or leftovers according to a quality control band that the Landsat images have (pixel_qa). After this, the 3 collections can be combined as a single collection containing the calculated indices and are cloud-free scenes.

Second, is to divide this collection by the date of the fire (that the user enters in the tool) as a pre-fire collection and a post-fire collection; these collections will be used to calculate both the fire severity map and the time series. Therefore, to obtain the severity map to each of these collections, it is filtered by the time span that the user enters to reduce each collection by a similar range. In addition, these collections are filtered one last time by the region of interest that the user draws on the map with the design tools as the region of interest. On these filtered collections, a reduction is generated that converts it into an average pre-fire image and a post-fire image. These images will have the average value of the bands containing the spectral indices. To obtain the burned area, the nbr index is used, which by means of the difference between the scene before and after the fire (dNBR) can calculate the area of vegetation that has changed between the two periods due to the disturbance. The process of generating the dNBR ends with the filtering of the pixels that are considered as loss of vegetation being the value greater than 0.1 and those that are less are masked because they are surfaces that have not been burned.

Third, the image is reclassified into 3 fire severity classes, low, medium and high. Low being those areas where the dNBR value is between 0.1 and 0.25, medium value between 0.25 and 0.5 and high value greater than 0.5, which the user can export as a result in GEOTIFF format. These three classes (low, medium, high severity) are

vectorized to subsequently evaluate their temporal evolution in the recovery of vegetation by the indices. Prior to obtaining these graphs for each severity, these three classes are dissolved to obtain a single vector (fire perimeter) and also those polygons that have small surfaces are filtered to really leave the burned area and eliminate pixels that introduce noise.

Fourth, the three results obtained are mapped in image format, the continuous and masked dNBR, the fire severity classes and the fire perimeter.

Fifth, the time series for each fire severity is calculated for a maximum period of 10 years after the fire, provided that there is information in the Landsat collection. The graph that is generated is the mean value of the pixels within the fire severity polygons and for the dates that there is scene. In addition, the index that the user selects from all the calculated ones is displayed.

Finally, the user can download the results of the image or the graph.

2.2. Workflow

This tool requires very few user steps to display the results. The first step that every user must perform is to delimit the date of the fire that will be analysed. To do this, the user must select the year, month and day of the fire, together with the time span or range before and after the fire that will be used to calculate the dNBR (this step is variable to generate a complete image of the burned area without clouds and therefore with all the pixels) (Fig 2.1). The second thing the user has to do is to select the index to be plotted to see the time series of each severity (Fig 2.2). The third thing to do is to draw the region of interest to filter the Landsat collection to that study area (Fig 2.3). After performing these steps, the results are generated and the 3 layers (continuous dNBR, damage severity classes and fire perimeter) appear in the map viewer (Fig 2.4) which can be downloaded by clicking on the download button (Fig 2.5) and the time series is shown in the blank space (Fig 2.6) which can also be downloaded later.



Figure 2: Parts of the graphical interface of the BADE tool. 1. fire dates; 2. selected index for the time series; 3. draw region of interest where the fire occurred; 4. layers visible on the map; 5. download image of fire severity classes; 6. time series graph of the selected index.

3. Results

The link to use the tool is as follows: <https://javierrieju.users.earthengine.app/view/re-forest-fire> that to show the results that this tool offers to users, an example of use has been made for a fire that occurred during the summer of 2017 in the municipality of Altura, belonging to the region of Valencia, eastern Spain. Here, we used the date 2017/07/01 and region of interest in rectangle mode on the location of Altura.

It can be seen in Figure 3 how the map has a three-colour image according to the severity of the fire (low, medium, high), along with two other layers which are the perimeter and the continuous dNBR image that can be viewed by selecting them in the layer tab. In addition, the time graph of the selected index is generated, where the average value of each severity class is shown for the years after the fire (Fig. 3).

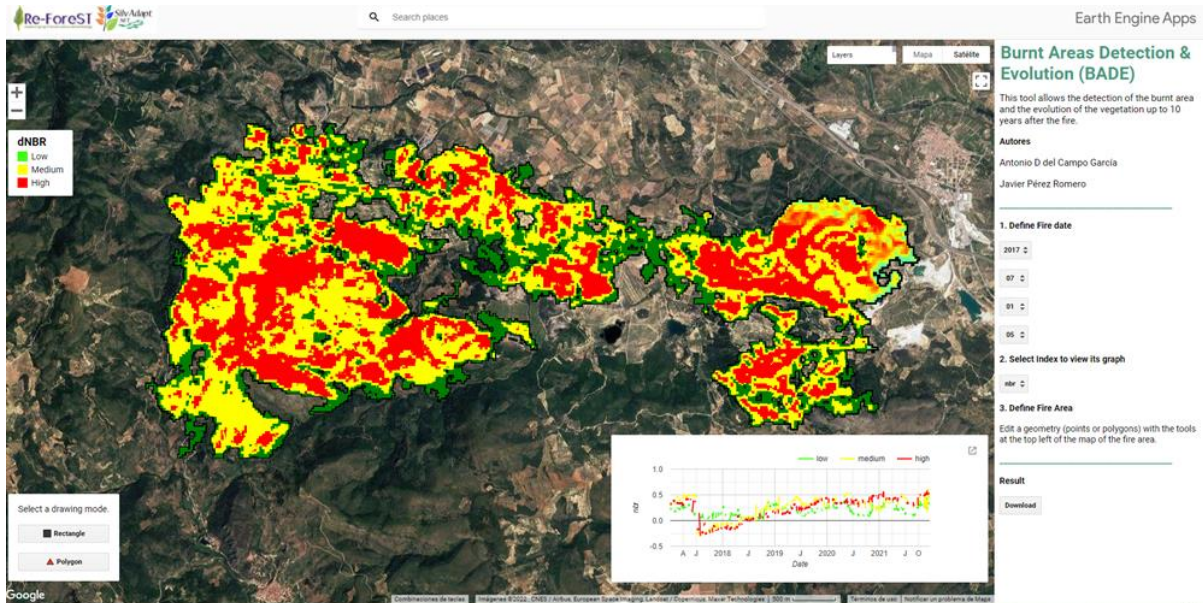


Figure 3: Example execute in BADE tool

These results can be downloaded for use outside the tool. In the first case, the image can be downloaded by clicking on the download button and a new window will open in the explorer for you to choose the directory to save the file in compressed format. The image with the name class_dNBR and the date and time interval set by the user can then be decompressed and is in GEOTIFF format available for use in a GIS (Fig. 4.1).

Finally, you can also download the graph in different formats once you expand it in a new tab. This graph is iterative and the user can consult the values by moving the mouse over the graph. The formats that can be downloaded are CSV, SVG and PNG files (Fig. 4.2).

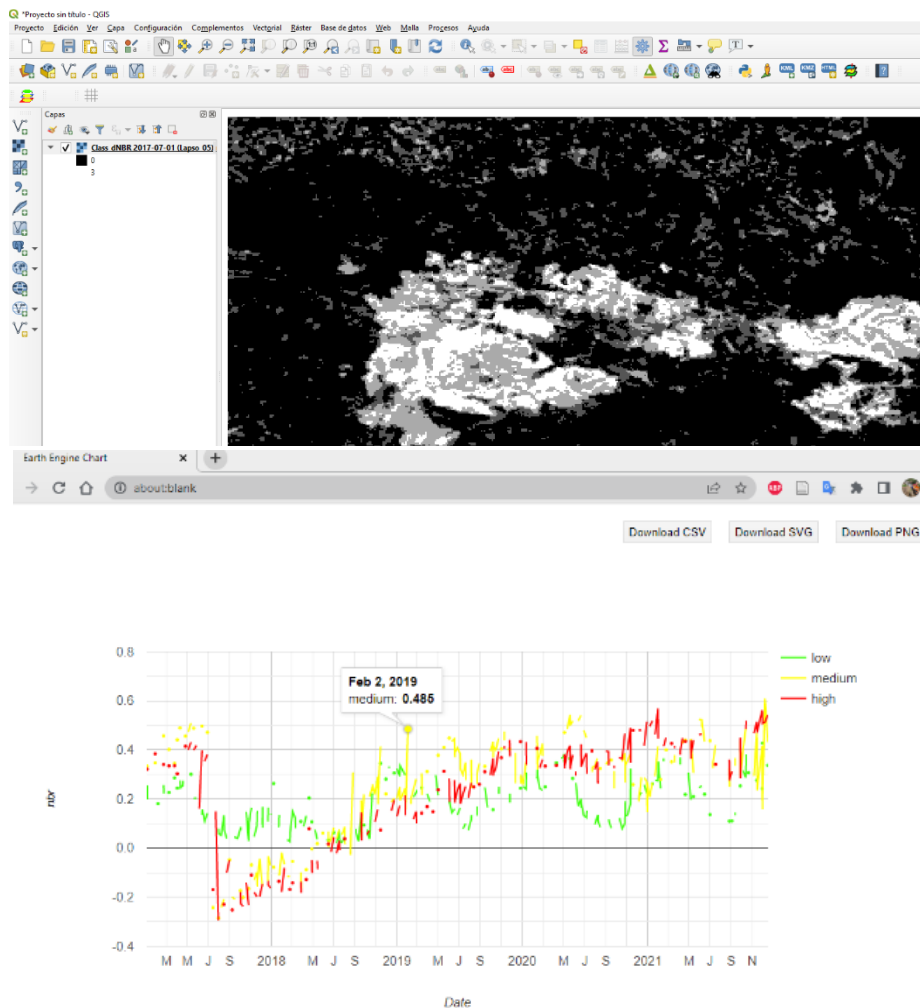


Figure 4: Results provided by BADE tool; 4.1. Map GEOTIFF; 4.2. Iterative Plot.

4. Discussion and Conclusion

The BADE tool allows users to use it easily even if they have no remote sensing experience. Moreover, it is very fast to use and does not require any software or programming knowledge to run it. It simply requires a web browser in which, thanks to its graphical interface, it is easy and intuitive to follow the necessary steps to obtain the results. This makes the tool of great potential for users who are less familiar with computer programs and who work with analysing, assessing or understanding forest fires from three different perspectives. Starting from the technical level, these users can use this support tool to make decisions on forest actions or planning. Then, at the research level, they can use this tool as a method to analyse multiple fires with identical methodologies in order to make meta-analyses or comparisons. At the educational level, this tool allows students to see the potential of remote sensing and new technologies to address the recovery of burned areas.

It is true that BADE needs to continue to incorporate more information for the user to select from all the outputs it generates. These new calculations to be presented and which will be incorporated in future versions will be focused on evaluating with greater precision this evolution, discriminating or differentiating areas with similar characteristics with the help of zonings that consider the physiography of the study area, seeing the trend that the vegetation presents or evaluating how long it takes for burnt areas to reach the pre-fire greenness value. All these improvements will allow managers to evaluate and recognise the study terrain in order to better target the works of action.

Therefore, among the limitations of the current tool are the information on post-fire recovery of vegetation: users know roughly what the average recovery of the entire burned area is like, but there is nothing spatial to help distinguish whether or not, where or when recovery is occurring.

It definitely seems that the tool has the basis to establish itself as a useful tool that should be further developed and complemented so that forest managers who are in contact with fieldwork and that the computer part is a little further away can use it in their daily work. It allows them to know and obtain information on post-fire vegetation quickly and easily without requiring great effort or expertise in remote sensing or programming.

5. Reference

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