RESEARCH ON FOREST COVER CHANGE USING SENTINEL-2 IMAGES IN COMBINATION WITH SENTINEL-1 IMAGES ON GOOGLE EARTH ENGINE PLATFORM

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ABSTRACT: The research focuses on determining the area of forest lost due to a forest fires and deforestation in Ha Tinh province, Vietnam on Google Earth Engine platform in the period 2019 May to 2019 September. This platform makes image processing in general easy and fast, and a highlight is that it can be processed directly in the cloud without having to download it to the computer. Our research area is Nam Mountain, Huong son Ha Tinh province. With two times of Sentinel-2 images before and after the big fire in July 2019 and the series of images from January to December 2019 of Sentinel-1 images, we calculated the difference of Sentinel-2 images before and after the fire. Besides, the Random Forest classification method for Sentinel-1 images classification was used to determine the land cover of this area. Then, the agricultural land has been separated from the forest cover and it is used as Mask to cover the agricultural land. The difference between the two times of the Sentinel-2 image is thresholded as 0.2 and using the Mask of agriculture land will be the result of forest cover change in the Nam mountain area. The results were compared with image on Google Earth and forest fire statistics documents during the study period and found that many points of forest cover change were similar. The study demonstrated the feasibility of using Sentinel-2 and Sentinel-1 images to detect the forest changes over a study area quickly and in the closest possible way to real-time.

1. INTRODUCTION

Forests are precious resources that we always need to preserve. In order to do well in managing forest resources for sustainable development, monitoring and assessing forest changes is an important task. Recently, along with the development of remote sensing technology, information technology with the explosion of programming languages has helped scientists to have new ideas when researching in the field of natural resources and environment. In particular, with the launch of Google Earth Engine (GEE) with JavaScript or Python programming language, which is a cloud computing platform for storing and developing geographic datasets, it is easier to create maps with time series analysis using the available satellite on the cloud, its processing and coding capabilities is good. Since first proposed in 2010, GEE abilities have been utilized for many applications (Mutanga and Kumar, 2019), including vegetation mapping and monitoring, land cover/ land use change mapping (Midekisa et al., 2017), flood mapping (DeVries et al., 2020; Sunar et al., 2019). Besides, with a large number of freely available satellite images and direct image processing tools has been a potential application in studies related to the land cover changes and vegetation changes. Spatial and temporal analysis has been performed on this platform in a flexible and very efficient manner. Availability of global optical as well as radar image data in the GEE data catalog and web-based tools used in many studies, including (Sidhu et al., 2018) that used the Landsat 5 series of images , MODIS and GEE to determine land cover change in Singapore or (Rayne et al., 2020) applied Setinel-2 images to identify changes in the archaeological site of North Africa. Since then, there have been many different studies related to the application of GEE to evaluate changes in the earth's surface, (Tamiminia, et al., 2020) that has reviewed more than 300 articles from various journal sources over the past 10 years about the application of GEE in image processing and overall the results are very positive. Thus, in this study, we experimented with Sentinel-2 satellite image processing in two periods before and after the forest fire event in Ha Tinh area, Vietnam and combined with Sentinel- 1 entire 1 year. This area is a very hot and dry area and is susceptible to be forest loss due to fire. With the available GEE and image tools, the processing to determine this change of forest cover is done quite quickly and well.

2. STUDY AREA

The research area is around Nam Mountain in Huong Son and Vu Quang districts, Ha Tinh province. The experimental area has mainly mountainous terrain mixed with plains. Ha Tinh province has sloping terrain from West to East (average slope of 1.2%, sometimes 1.8%) and is strongly divided by small rivers and streams of the Truong Son range, with many transitional terrain forms, interleaved with each other. Forests in the study area are mainly natural forests, usually tropical forests. In high mountains, we can meet subtropical coniferous forests. Most of the planted forest is pine, currently, there is over 18,000 ha, of which over 7,000 ha can be exploited.

The study area has extremely harsh weather from May to August and is also a place where a lot of agricultural people gather, so the phenomenon of burning forests to get farming land is still quite common. The time of the study is the period from January 2019 to December 2019 to be able to see the most clearly and visually the changes of plants in the study area. The study area is shown in Fig. 1 .

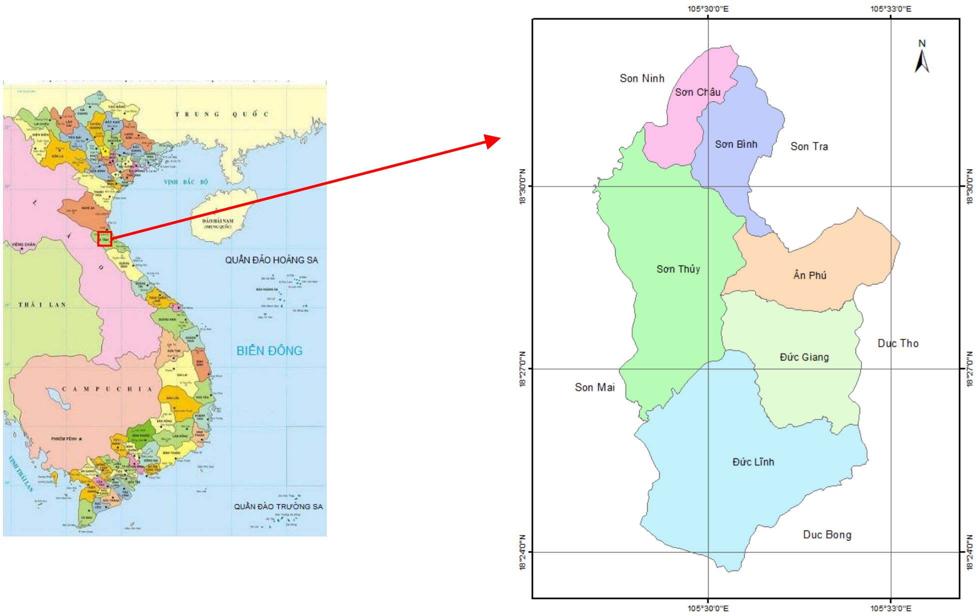

Fig. 1: Study area is in Nam mountain, Ha Tinh province

3. MATERIAS AND METHOD

3.1 Dataset

To detect changes in forest cover, we chose Sentinel-2. The supplied L2A product has been corrected for surface reflectance using the Dense Dark Vegetation (DDV) algorithm and the Atmospheric Pre-corrected Differential Absorption (APDA) algorithm (ESA Sentinel-2 User Handbook). In addition, we selected a series of Sentinel-1 images within a year to further determine the seasonal change of vegetation cover. Sentinel-1 images are processed at level 1 (level-1) with ground range detected (GRD) being the most appropriate. This type has a spatial resolution of 10m and has a repeat period of 12 days. The image acquiring period is from January 2019 to December 2019.Table 1 shows the image selected for processing

Table 1: Images used in the research

Sensor	Date Range	Spatial Resolution (m)
Sentinel-2 (previous)	March 2021-May 2021	10, 20
Sentinel-2 (after)	September 2021-December 2021	10, 20
Sentinel-1 GRD (VV)	Jannuary 2021-December 2021	10

3.2 Method

Google Earth Engine (GEE) was used to do image processing in this study. GEE works through a JavaScript Application Online Interface (API) called the Code Editor. On this interface, users can write and run scripts to share and repeat geospatial data processing and analysis processes. Code Editor helps users to perform all the functions available in Earth Engine. The input data can be exploited directly on the data WEB pages without downloading to the computer, which is an advantage of GEE, allowing us to quickly analyze data without depending on the data and memory capacity of the computer. Here is the interface of GEE.

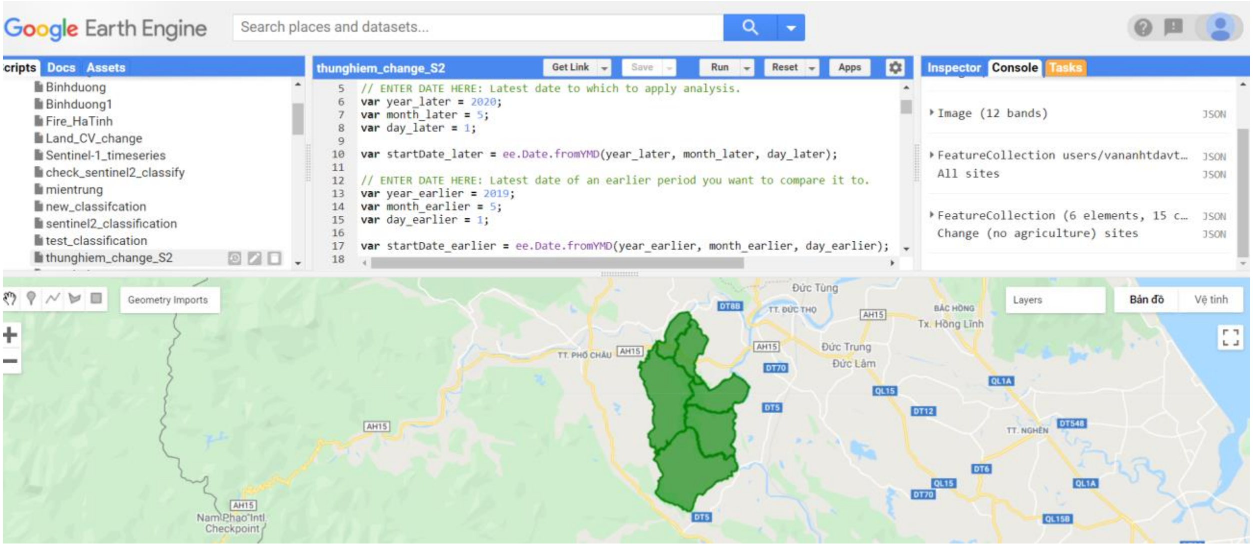

Fig.2: GEE's interface to write code for executing the commands

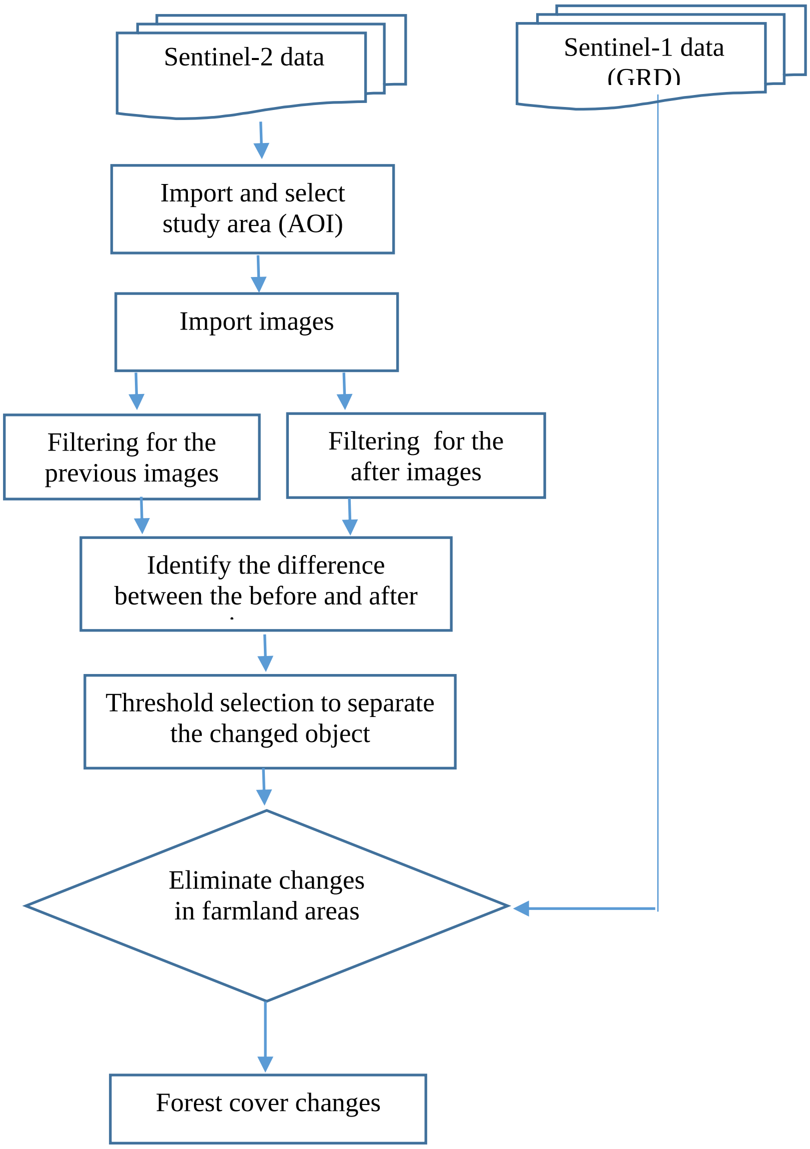

Fig. 3: Image processing flowchart for determining forest cover changes on GEE

As stated above, the data set of Sentinel-2 and Sentinel-1 are automatically obtained from the European COPERNICUS WEB site. The image processing procedure to extract forest cover change is shown in Fig. 3. With those, we have written code to perform the importing and image processing steps on GEE.

3.2.1 Import and select the study area (AOI)

This is a limited area for image processing. The study area can be drawn directly on the screen or selected from an existing file. In the case of our research focusing on the small region in the area which has fire happen in July 2019, thus this area was created in shape file from ArcGIS software. This file was imported into GEE and used as a variable named "sites".

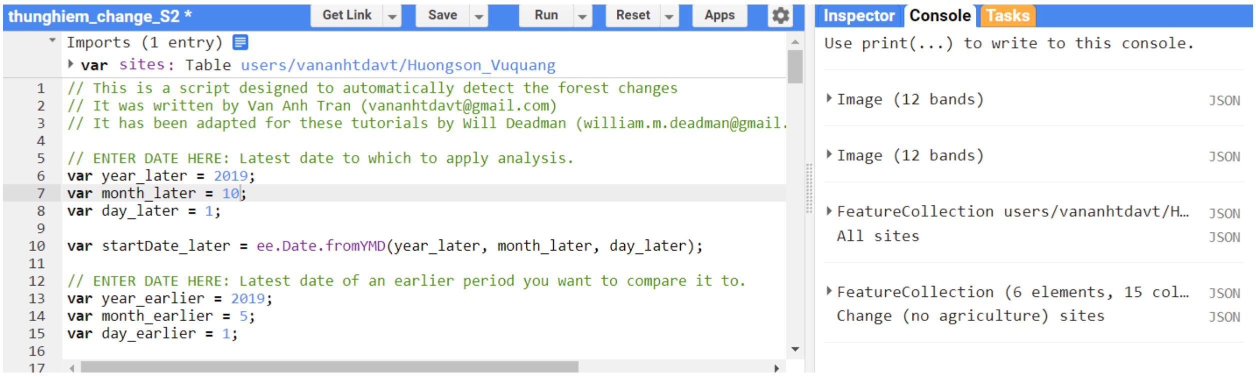

Fig. 4: Import, select the study area and set time to select images

3.2.2 Filtering the images

The Sentinel-2 images are split into two sets of images according to the date before and after the event. Each collection is then filtered within to the area of interest that the user defined and to select the images with limited cloud percentage to less than 10%, based on the imagery metadata. Pixels that pass the requirements will be retained in the collection. A cloud mask is applied using a quality assessment band provided by (ESA, 2020) .

The composite images are made by calculation of the median values of each pixel (in all bands) in the sets. This step uses the function of GEE as 'reducer' to perform the compositing from the images in the set for generating a single output image. The cause of using this method for analyzing because using the median value reduces the effects of cloud (high values) and shadow (low values), and the resulting outputs are seamless mosaics appropriate for visualization purposes.

3.2.3 Identify the difference between the before and after image

The algorithm used to detect changes in images between two times is a per-pixel arithmetic operation that computes the amount of reflectance difference between color composite images, over all bands at each pixel i.

This method was chosen because it is simple, does not use sample areas, and is quick to use and easy to understand for many users without much knowledge of image processing, allowing them to modify the code to suit their needs. This is a well-used method in studies involving land cover changes using medium resolution data [24]. The Google Earth Engine script aggregates the difference between each spectrum band of the composite image and creates a new 'image difference' layer (Rayne et al, 2021), with values varying between 0 and 1.

$$D = \sqrt{\sum (I1_i - I2_i)^2} \qquad (1)$$

where $I1$i: Pixel value at before image band i

$I2$i: Pixel value at after image band i

3. 2.4 Create threshold for change detection

By surveying different images of before and after the forest fire event in 2019 in Ha Tinh through calculation by Eq.1, we found that the threshold for classifying the changes is 0.2. However, because the characteristics of optical satellite images have similarities in the spectrum of forest cover with some agricultural crops, after determining the change from Sentinel-2 images, the results are still mixed. Therefore, the combination of the Sentinel-1 image time series was used to separate the agricultural land cover and the forest land cover by using the Random Forest classification for the series of images from January to December 2019, Details of the method can refer to the documentation (Tran V.A et al 2019). VH polarization was selected because it is suitable for the structure of vegetation (Nicolau et al, 2021). Then take the agricultural land as a mask to remove the changes caused by agricultural land.

The RF was proposed by Breiman (Breiman, 2001). This is a supervised classifier based on decision trees and improved bagging and bootstrapping techniques. Bootstrapping is a very famous statistic method, was introduced by Efron in 1979 (Efron, 1979).

The Random Forest (RF) is an algorithm comprising of many single decision trees. Each tree is created from randomly selected training pixels (bootstrap). The two parameters that need to be defined in this classification algorithm are the number of trees to grow (ntree) and the number of variables to split at each node (mtry). The ntrees selected depend on the shortest processing time to achieve the lowest error, ntree runs from 1 to 500 trees as default and mtry ranges from the minimum number of independent variables (equal to 1) to the maximum number of independent variables that used in the classifier.

After the Random Forest model is created, each result of the bootstraps in the set will vote for the most popular class and give a classification result. The model is formed based on the most voted classifier of each decision tree diagram (Breiman, 2001)

4. RESULTS AND DISCUSSION

With the processing of Sentile-2 data for determining forest cover changes and combined with the use of Mask for agricultural areas from series images of Sentinel-1, the resulting map is the lost forest area, Fig. 4 shows the forest cover change map with without crop land on GEE and ArcGIS. For validating the result of the study, we collected data from newspaper sources and Google Earth to determine the extent of change in the study area between June and July 2019. Statistics shows that in Nam Mountain, Huong Son and Vu Quang districts, there was a big fire on July 8 and 9 and also 13 cases of forest clear cut for farming happen in 2019.

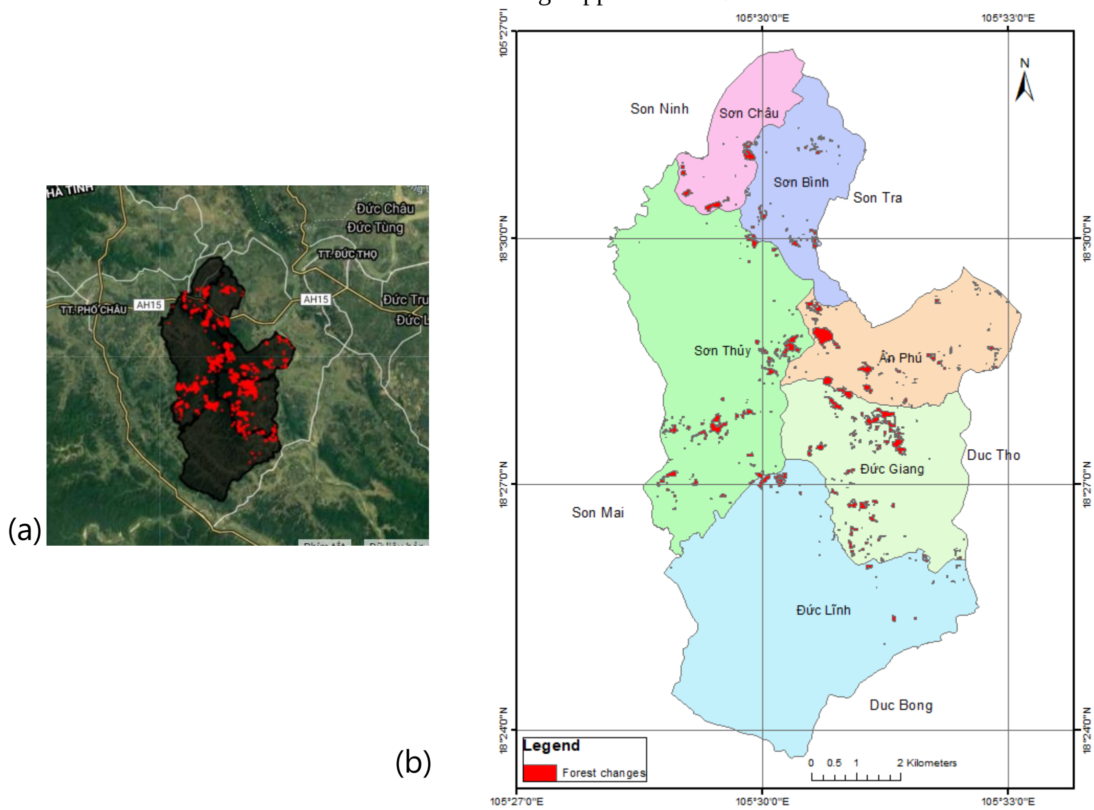

Fig.5: Map of forest change in Nam mountain, Ha Tinh province

Fig. 6 The scene of the forest fire in the Nam mountain area of Ha Tinh province on July 8, 2019 (Tuoitreonline, 2019)

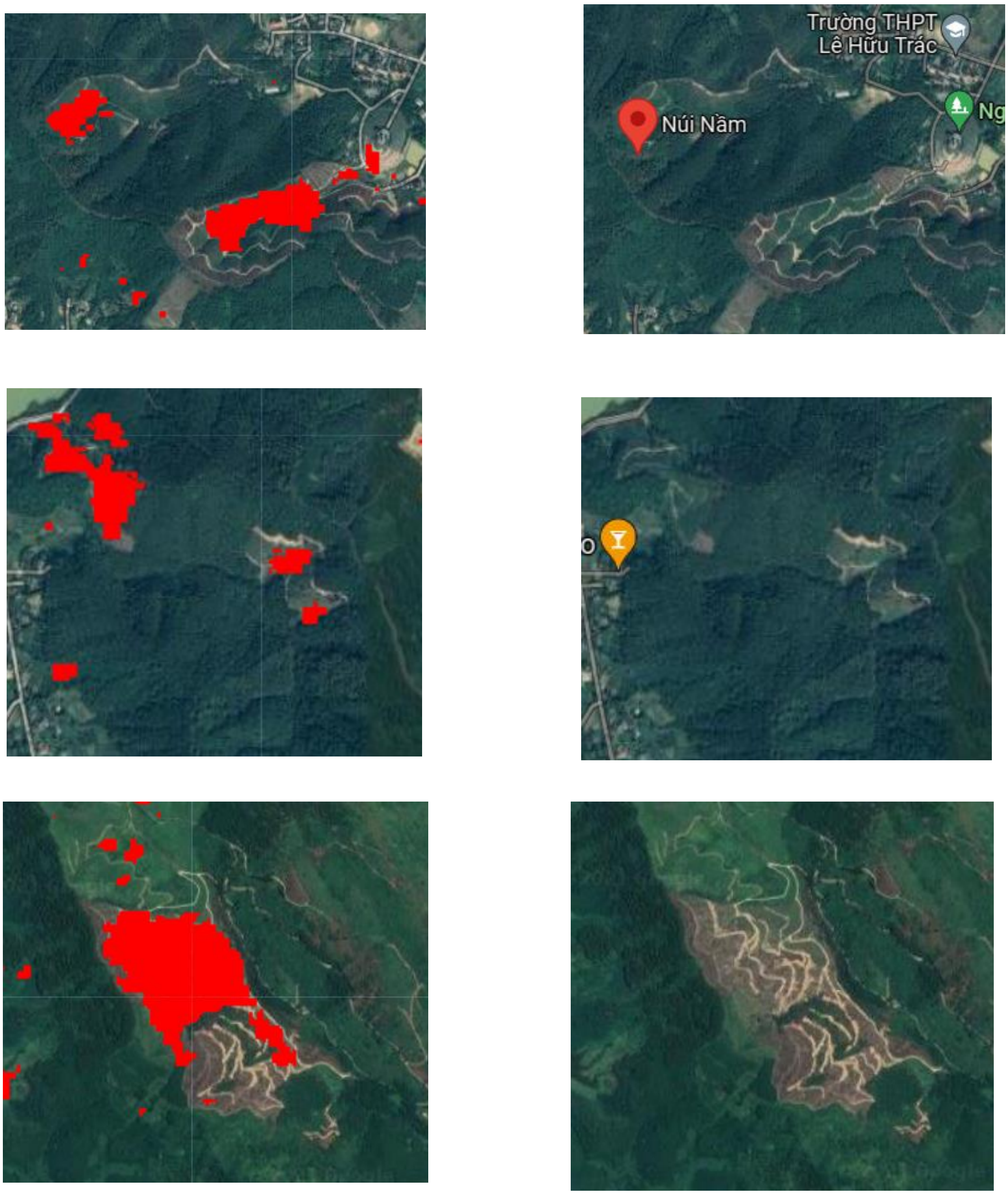

Fig.7 The locations of several check points around the Nam Mountain area

After using Google Earth Pro to check locations with forest cover changes, we found that there are some similarities between the results from images processing and Google check. Figure 6 depicts the locations of several check points around the Nam Mountain area. According to the description of the fire from July 7 to 9, 2019, the fire sites are close to residential areas and most of them are pine, acacia and protection forests.

5. CONCLUSION

With Sentinel-2 images before and after the big fire in Nam mountain area, Ha Tinh province from July 7th to July 9th, 2019 and Sentinel-1 satellite images from January to December 2019, the map of forest changes in 2019 was built for this area. The results were compared with Google image and there were many similarities in terms of fire locations.

The combination of Sentinel2 and Sentinel-1 image data is very useful for determining the change of forest cover area because these types of images are acquired with a fairly thick frequency, which is 6 days for Sentinel-1 images and 5 days for Sentinel-1 images. For Sentinel2 images, real-time forest loss monitoring is very feasible. In addition, the monitoring of deforestation with GEE platform has shown a great advantage of the method, which is the convenience of selecting image data without having to download it to a computer, which saves time for data processing and does not take up computer space to store large amounts of data. In particular, the GEE platform is a cloud-based computing environment that can support various operations related to image processing, mapping, and model generation.

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