DETERMINATION OF LAND COVER CHANGE BY MULTI-TEMPORAL RADAR IMAGERY

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ABSTRACT: Vietnam is an Asian country with a hot and humid tropical climate, monitoring the land cover with optical satellite images is usually used. However, because of the cloud cover, the optical satellite image is not good. To overcome these effects, Radar image is a useful option, which the radar pulses can penetrate through the clouds, regardless of day or night. In this paper we mention the use of multi temporal C band satellite images to monitor land cover changes of an area in the Mekong Delta, Vietnam. The image used is Sentinel-1, a free image provided by the European aerospace agency (ESA). The set of 3 images is March 2015, March 2016 and February 2017. Double polarized images (VV, VH) were subsetting for VH polarization to determine the land cover changes. With 3 time of images which were composited, then using Random Forest (RF) classification method to detect the change of some land cover types. Evaluate the accuracy for determining by RF classification achieved over 80%.

1. INTRODUCTION

Information on land use and land cover changes are essential for the planning, management and reasonable use of natural resources and environmental protection. In many cases, the task of studying land cover changes takes place on a large scale and requires quick results. Therefore, remote sensing data is an effective tool to assist this task. Previously, researches used remote sensing satellite images to determine the land use/land cover changes were mainly concentrated in optical satellite images. However, in areas with tropical climates like Vietnam, clouds cover all year and to monitor the changes in the surface by optical images is quite difficult. The optimal solution for studying variability in land cover is Radar satellite image. There have been many different radar satellite systems with different resolutions and different prices. But in this paper, we mainly focus on Sentinel-1 satellite imagery which is a free image provided by ESA.

In the world, there have been many studies on the application of Radar satellite image in land cover classification, such as: (Longepe et al., 2011, Niu and Ban 2013, Balzter et al, 2015). The characteristics of these studies are to use multi-temporal and dual-polarized radar images to increase the accuracy of land cover change monitoring. For studies related to surface cover fluctuations such as urban growth monitoring, forest monitoring and disaster management, images used to determine the changes are often ground-range images and are multi-polarization (Zhong et al., 2015). On the theory of change detection, there is a very important step that is image classification or statistical analysis methods. The studies of (Jordi INGLADA, Gregoire M ´ ERCIER, 2007) are typical for the method of analyzing statistics on multi-temporal SAR image series. Statistics are measured using the Kullback-Leibler divergence. In another study by Zied Bouyahia, 2008, the author used an unsupervised classification method of Hidden Markov Chain (HMC) to solve the angle difference when using single look complex images.

Maoguo Gong et al 2012 combined mean ratio and log ratio images and used wavelet networks method to determine the surface cover change in the time series. Meng Liu et al in 2012 used distance measurement and segmentation of images with the minimum error method (K&I) 2 (Kittler and Illingworth, 1986) for determining the change of objects on the multi-temporal and multi-polarization radar images. Maoguo Gong et al 2015 used the Deep neural network method to identify changed and unchanged areas on multi-temporal SAR satellite images.

In general, the methods mentioned above have advantages and disadvantages when determining changes by using multi-temporal SAR images. In this study we focus on a machine learning method that is Random forest for the purpose of classifying changed and unchanged objects on images. Because our study area is Binh Duong province of Vietnam, is an area with many types of perennial plants and production forests, so the changes are mainly the change of vegetation, so RF method is quite appropriate. Also combined with statistical analysis on images between periods to detect the changes before applying the Random forest method.

2. STUDY AREA AND DATA

2.1. Study area

The study area is part of Dau Tieng district, Binh Duong province, located in the northwest of Binh Duong province. The north borders Hon Quan district; northeast border Chon Thanh district, the same province of Binh Phuoc. The East borders Bau Bang district; southeast of Ben Cat town. To the west is Dau Tieng Lake in Duong Minh Chau district; southwest of Trang Bang district, Tay Ninh province. The South borders Cu Chi District, Ho Chi Minh City. In the study area, agricultural land is mainly planted with rubber trees and other perennial fruit trees such as durian, mango, jackfruit, ..., rubber area of Dau Tieng up to 53200 ha, accounting for 43.4% of rubber area in Binh Duong province.

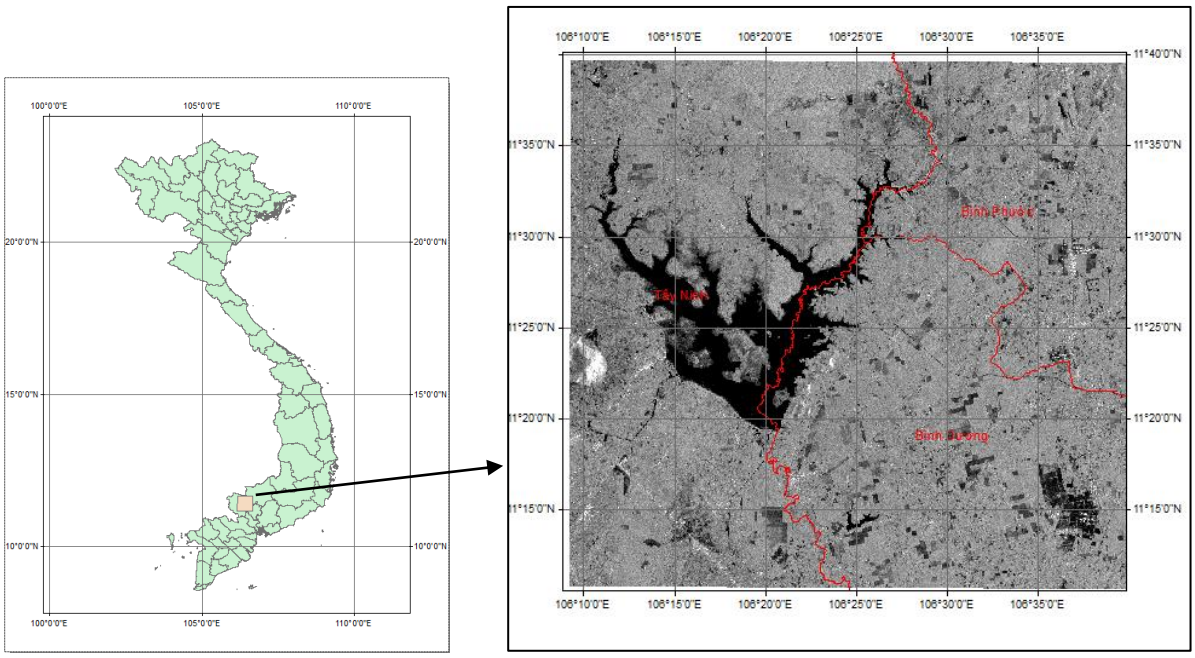

Figure 1: Location of study area and Sentinel 1 data of Dautieng, Binhduong

2.2. Data used

The research material is Sentinel-1 satellite image band C with a period of 12 days. This

is a good data to assess the seasonal variation of land cover objects. Sentinel-1 data used is Level-1 ground range detected images (GRD), 10m resolution, dual polarization (VV and VH). Sentinel-1 data were carried out with pre-processing steps on SNAP toolbox software includes calibration to compute sigma nought values; terrain correction; convert to dB value; Filter noise on multi-temporal images.

The Sentinel -1A image set is shown in Table 1, including a 3-time of images separated by 1 year from March 2015 to February 2017. The Sentinel-1A data were pre-processed using the open source software SNAP Toolbox of European Space Agency. Pre-processing of SAR image consisted of geocoding, radiometric calibration, incidence angle normalization.

Table 1: Sentinel -1A image set

Order number	Image acquisition date	Phân cực	Orbit
1	March 2015	VV,VH	Ascending
2	March 2016	VV,VH	Ascending
3	February 2017	VV,VH	Ascending

3. METHODOLOGY

3.1. Characterization of land covers on multi-temporal SAR images

Analysis of multi-temporal SAR images of Dau Tieng area (from March 2015 to March 2016), the land cover can be divided into two main groups: (i) the changed land cover and (ii) The unchanged land cover (refer to Figure 2). The most land cover changes mainly include perennial crop land that is rubber tree or other fruit trees. Unchanged land covers are usually residential areas or rice field areas. Figure 2 shows the RGB color composite image of Sentinel-1 of three observation periods, March 2015, March 2016 and February 2017. Different colors in the composite image are three times corresponding to the change of different types of land coves. The white or black color in the RGB image is displayed correspondingly unchanged objects because of the stability of the surface scattering in time series images (Figure 2). On the other hand, the different colors in the RGB image show the objects changed because of the different backscattering values of each pixel over time.

We found that where vegetation is covered, the reflection value on the image will be higher than the non-vegetation locations. Pixel values of vegetated objects are usually greater than -12db while if areas with clear cut are smaller scattering values. To see the difference, the profiles have been drawn through those areas, we can see the difference between three years. Look at the figure, there are different colors showing the change between the 3 periods, which is blue, green, yellow, magenta. If the color is blue, it means that in 2017, there were new plant objects, but if it was green, it means that in 2016 there were new objects appeared but after that in 2017 disappeared . If the place has the magenta, then according to the principle of the color combination, there were plants in 2015 and 2017 but not in 2016. Where the yellow areas were equivalent to the vegetation cover areas in 2015 and 2016, but not in 2017.

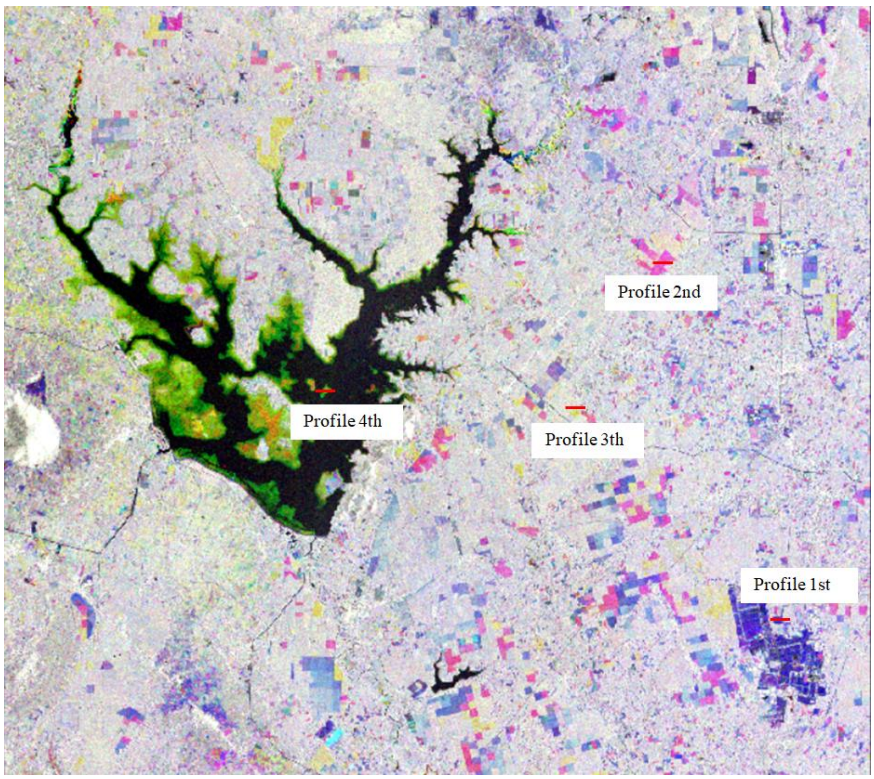

Figure 2: RGB color composite image of Sentinel-1A with profile positions

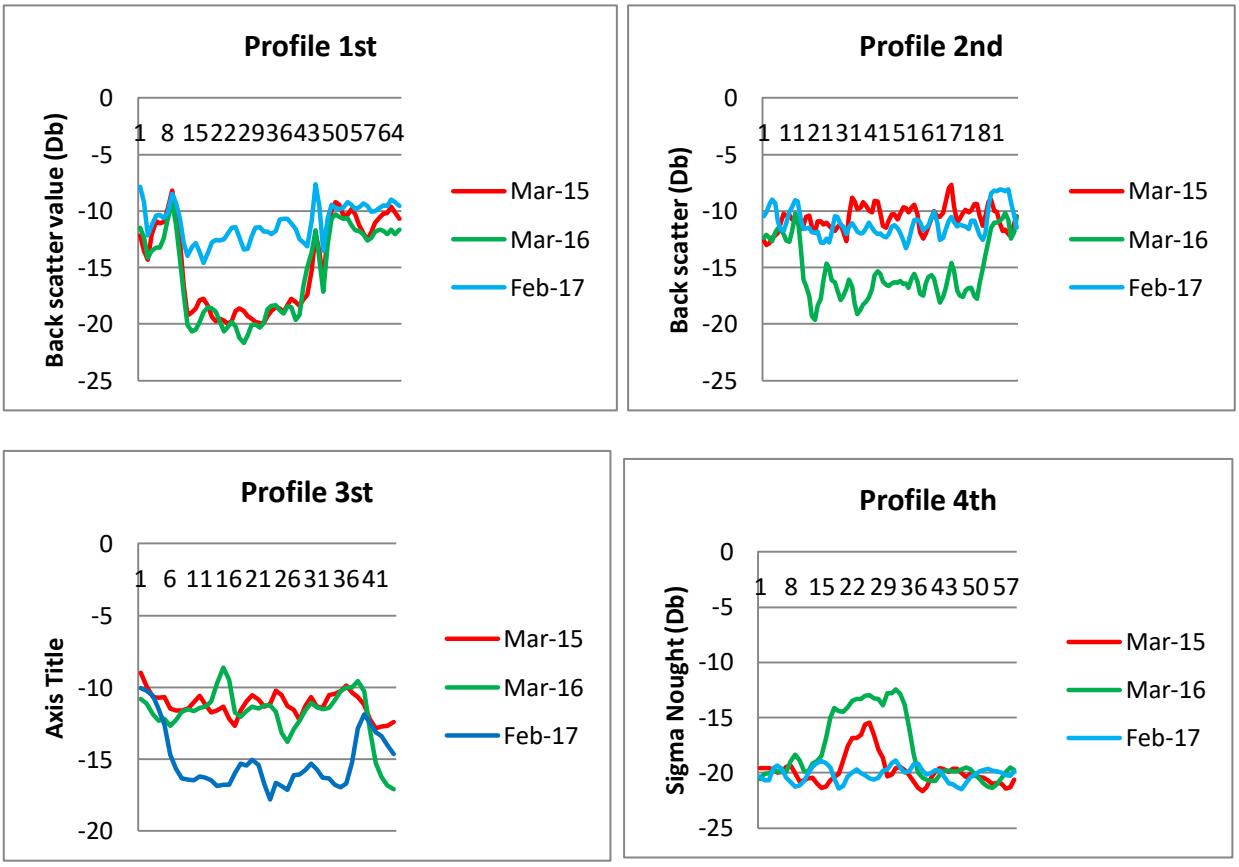

Figure 3: Profiles of 4 types of land cover change that correspond with the locations are shown in Figure 2

3. 2 Research methods

Through analysis of changes of land cover on Sentinel-1 multi temporal images, we selected a method for monitoring the change of the Dau Tieng, Binh Duong area by Random Forest (RF) algorithm (Refer to Figure 4). Random Forest classification method (RF) based on 3 VH images in three periods which were color composited with the Red color assigned to 2015, Green color assigned to 2016 and blue color assigned to 2017 (Figure 2)

Overview of Random Forest method:

Random Forest is an algorithm consisting of many individual decision trees that act as unions. Each individual tree in Random Forest makes a prediction about the class and the class with the most votes becomes the prediction of that model (see figure 3). Random Forest model is very effective for image classification because it mobilizes hundreds of smaller models inside with different rules to make the final decision. Each sub-model can be different and weak, but according to the" wisdom of the crowd" principle, the classification result will be more accurate than using any single model.

As its name implies, Random Forest (RF) is based on:

1. Random = Randomness;
2. Forest = multiple decision trees (decision trees).

The unit of RF is a decision tree algorithm with some hundred trees. Each decision tree is randomly generated from random sampling and only using a small part of random features from all variables in the data. In the final state, the RF model often works very precisely, but in return, it is impossible to understand the mechanism of action within the model because the structure is too complicated. RF is therefore one of the black box models.

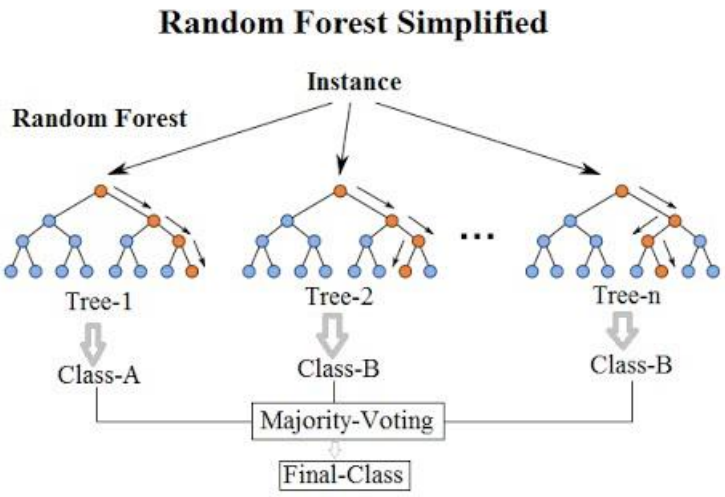

Figure4: Diagram of RF formation

Random Forest steps

1. Randomly select "k" features from the "m" features in the set.

Note that k << m

2. From the "k" features, calculate the "d" node that is best for classification Node.
3. Divide the child nodes according to the best node found
4. Repeat steps 1-3 until you reach k node
5. Repeat steps 1-4 to create the "n" tree+

Based on the RF method, we offer the image processing procedures for 3 Sentinel-1 images in Figure 5.

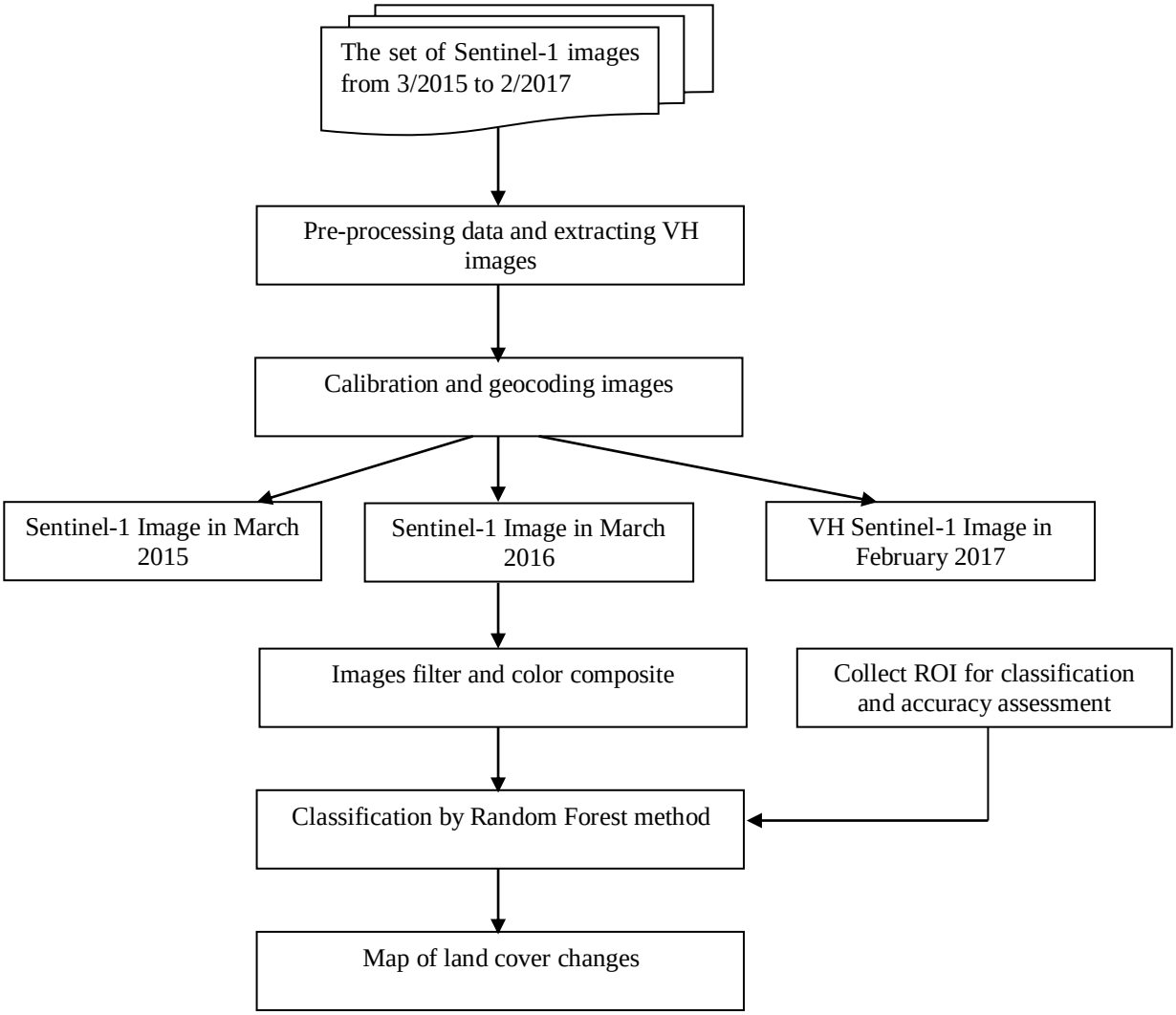

Figure 5: Sentinel-1 image processing flow chart for land cover change detection

4. RESULTS AND DISCUSSION

Results of the land cover change monitoring experiment for Dau Tieng area, Binh Duong province from the Sentinel-1 VH data shown in Figure 6. We used the land use map of Dau Tieng district in combination with Google Earth image to assess the accuracy of the experiment result. There have been 60 check points corresponding to the location on the land use status map and Google Earth was taken. The location of these points is shown in Figure 7.

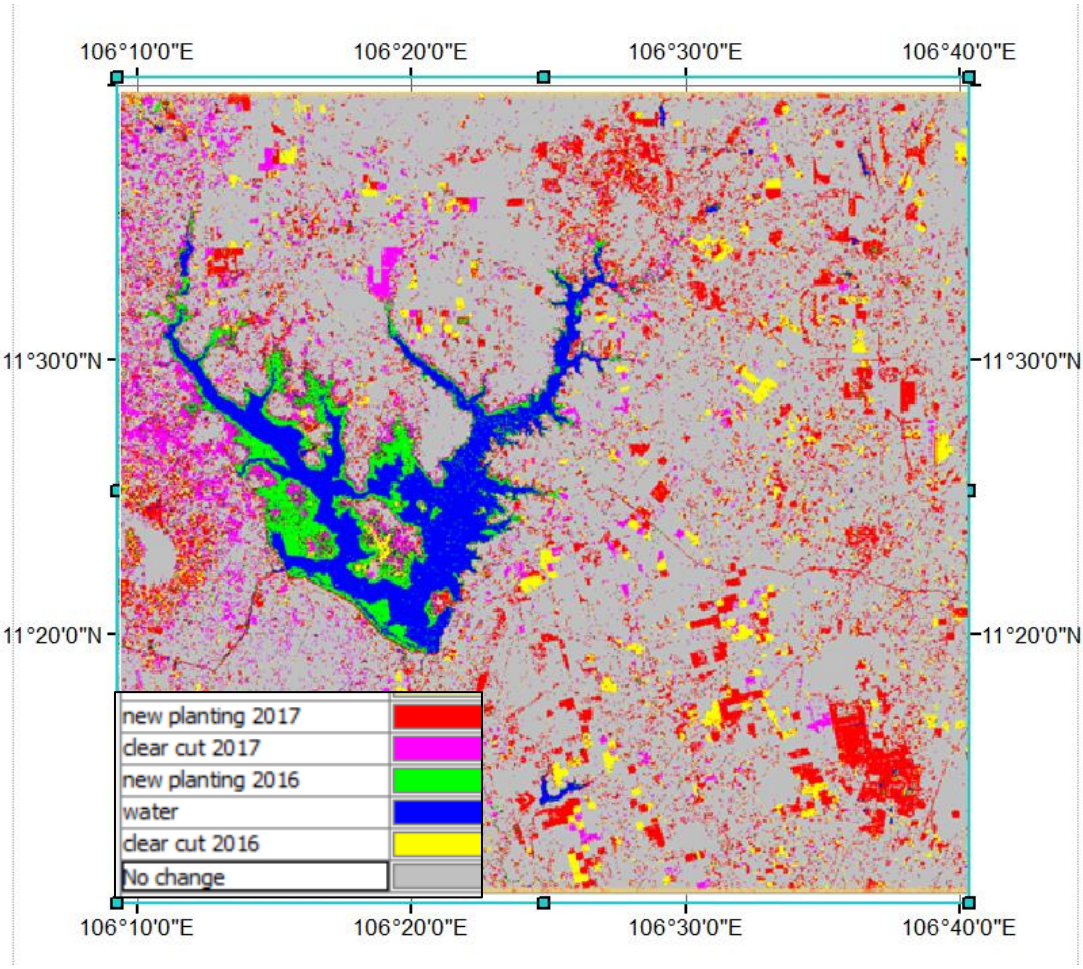

Figure 6: Land cover change monitoring by Random Forest

When using check points to evaluate the accuracy of the classified land cover change, Table 2 is obtained. Looking at the results, we can recognize that the areas of land that change are primarily rubber trees. In 2017, there were quite a few new rubber growing areas, shown in red in the results. Besides, there were also some places that have removed rubber trees where magenta color. Areas without trees in 2016 are often short-term crops such as crops and rice because the land was abandoned in 2016, while in 2015 and 2017, plants appeared in these locations. The areas shown by the green are trees that are also short-term planting areas, as of 2015 there were no vegetation cover but until 2016 they were newly planted and by 2017 these locations were not exists in these positions. In general, changes in Dau Tieng and Binh Duong areas are related to agricultural land use. The area of stable or little change were residential land.

Referring to the classification accuracy table (Table 2) for the land cover change layers, it is easy to realize that water and New planting 2017 have the highest accuracy of 100%. This is understandable because the water surface of Dau Tieng lake area is quite large and has a stable level of scattering. In addition, the object of New planting 2017 also has a large area on the image where the new planted layer is rubber trees, so their scattering is quite high. The other data layers have the maximum accuracy is also because they are short-term crops such as rice or crops, the scattering is also weaker.

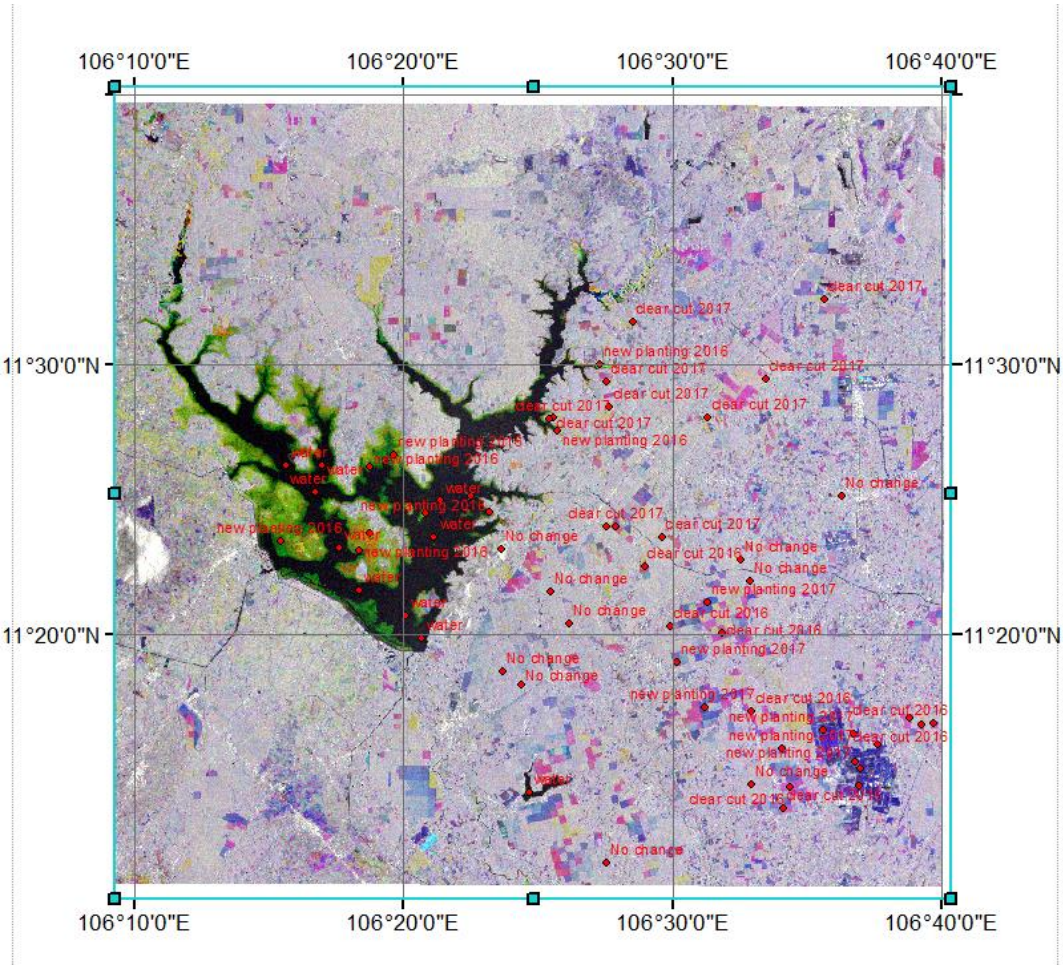

Figure 7: Locations of check points

Table 2: Accuracy of land cover change classification

No	Layer	Accuracy (%)
1	New planting 2017	100
2	Clear cut 2017	90
3	New planting 2016	90
4	Water	100
5	Clear cut 2016	80
6	No change	90

4. CONCLUSIONS

Through the analysis and testing results of the Random Forest classification method, the change and no change of land cover in Dau Tieng, Binh Duong, Vietnam have been identified from Sentinel-1 polarized VH image data in 3 times which were March 2015, March 2016 and February 2017. The test results of the method show the accuracy of determining land cover such as water, New planting 2017 reaches the highest accuracy of 100%, while other data layers achieve accuracy above 80%. This proves that the Random Forest method is suitable for determining land cover changes in areas with many type of vegetation.

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