USE OF HIGH RESOLUTION GOOGLE EARTH IMAGES FOR LAND USE/LAND COVER MAPPING IN THUY TRIEU COMMUNE, THUY NGUYEN DISTRICT, HAI PHONG CITY

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SUMMARY

The aim of this study was to establish land use map in 2016 using object-based classification technique in Google Earth image and analyze land use/land cover changes in the landscape of Thuy Trieu commune, Thuy Nguyen district, Hai Phong province in Vietnam over a period of 3 years (2013 - 2016). This paper introduced an object-based method to Google Earth image to map the land cover in Thuy Trieu commune in 2016, which approach applied multi-resolution segmentation algorithm of eCognition Developer and an object-based classification framework. In addition, landuse maps from 2013 created by Landsat 8 image were used to analyze the change in landuse types in 3 years period. The object-based method clearly discriminated the different land cover classes in Thuy Trieu in eight mainland use types with overall kappa value was 0.88. After overlaying landuse map of 2013 created by Landsat 8 image with the landuse map of 2016, all land cover changed during 2013 - 2016 were received. The results of this study will partly contribute to the development of tools in land management, which will save time, money and improve the accuracy of map data updates.

Keywords: eCognition, Google Earth satellite images, land cover change, land use.

I. INTRODUCTION

Land use is the human use of territory for economic, residential, recreational, conservational, and governmental purposes (Bureau of Land Management, U.S. Department of the Interior, 2005). The role of land use management is very important, because land resources are limited and finite with about 148,300,000 square km (Coble et al., 1987) and the global human population which expected to keep growing, and estimates have put the total population at 8.4 billion by mid-2030, and 9.6 billion by mid-2050 (Population Reference Bureau, 2014), is still increasing very fast. Land use detection and change analysis essential for better understanding of interactions and relationships between human activities and natural phenomena. This understanding is necessary for improved resource management and improved decision making (Lu et al., 2004).

GIS and remote sensing have the potential to support such models, by providing data and analytical tools for the study of urban environments. Urban land cover types and their areal distributions are fundamental data required for a wide range of studies in the physical and social science, as well as by municipalities for land planning purposes (Stefanov, W.L. and M.T. Applegarth, 2001). The advancement in science and technology, the use of satellite images combined with information technology especially Remote Sensing and GIS technology in the mapping work has reduced many difficulties in funding as well as the time of mapping (Ingvar Lindgren and Debashis Mukherjee, 1987).

Satellite images used in map creation usually have some drawbacks. The images are having only lower and medium spatial resolution (size of each pixel on the ground) in the range of 30 m to 80 m collected from sensors such as MSS, TM, ETM+, etc. Another limitation is that it may not be possible to obtain the latest satellite data or the image for the current year (K. Malarvizhia, S. Vasantha Kumarb, P. Porchelvan, 2016). Some other type that has high resolution often very costly and hard to apply large scale. The Google Earth tool has developed quickly and has been widely used in many sectors. The high spatial resolution images released from Google Earth, as a free and open data source, have provided great support for the traditional land use/cover mapping (Clark et al, 2010; Mering et al., 2010). They have been either treated as ancillary data to collect the training or testing samples for land use/cover classification and validation or used as a visualization tool for land use/cover maps (Kumariset al., 2011; Yu, L., Gong, P., 2011). However, very few studies have been undertaken to use Google Earth images as the direct data source for land use/cover mapping. If Google Earth images can achieve relatively satisfactory classification, it may provide some opportunities for detailed land use/cover mapping by costing little (Guo et al., 2010; Potere, 2008).

The aims of this study are to produce a land use/land cover map for Thuy Trieu, Thuy Nguyen, Hai Phong and compare with the land use map in the past in order to detect changes in land cover from (2013 - 2016).

II. RESEARCH METHODOLOGY

2.1. Study area

Thuy Trieu commune, Thuy Nguyen district is a coastal plain commune, located in the South East of the Red River Delta, 10 km North of the center of Hai Phong. Thuy Trieu commune has coordinates: 20.994164°N, 106.926845°E. With area is 1108 ha and terrain in there is unevenly uneven, around the river covering and dividing, salty soils, intermingled with sand dikes are low-lying lands and tidal creeks (system of ponds, dense lagoons) rivers. Thuy Trieu located in the tropical monsoon belt of Asia, the subtropical characteristics of the weather in Northern Vietnam, affected by the monsoon. In the recent year in Thuy Trieu have a lot of projects that make a lot of change in land cover types. That the reason makes Thuy Trieu become the location to conduct this study.

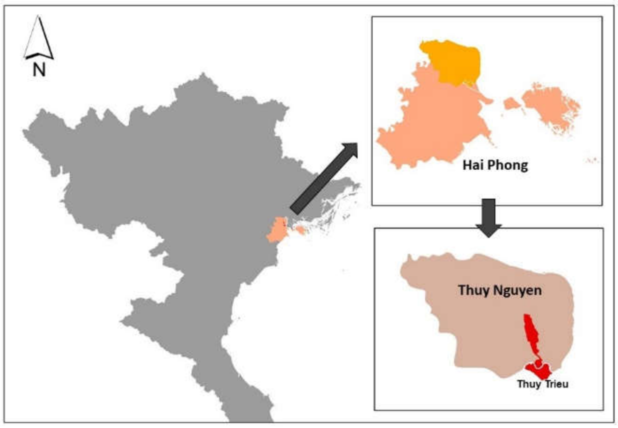

Figure 1. Location of Thuy Trieu, Thuy Nguyen, Hai Phong

2.2. Data Sources

There are two types of satellite images were used in this study: Landsat 8 and Google Earth. The Landsat imagery was downloaded from the USGS Global Visualization Viewer website. Satellite data for the years of 2013 were collected. The image has low cloud cover (< 10%).

Photo Landsat 8:

LC08_L1TP_126046_20131008_20170429_01_T1 taken on 10th August 2013 is the suitable one and had been chosen for classified land-use.

The second type of satellite image is Google Earth colected in 8/26/2016 which has a very high resolution (< 1 m). But this type of image only have four band color: Red (0.625 µm - 0.695 µm), Green (0.530 µm - 0.590 µm), Blue (0.455 µm - 0.525 µm) and alpha.

2.3. Data Processing

Figure 2 is showing the flowchart of data processing that used to conduct this study. Overall this study can divide into 3 main steps. Firstly, download Google Earth images and classifying land use objects. Secondly, classification all object and check the accuracy of the map. Thirdly, detecting the change in land use by comparing with the land-use map in 2013.

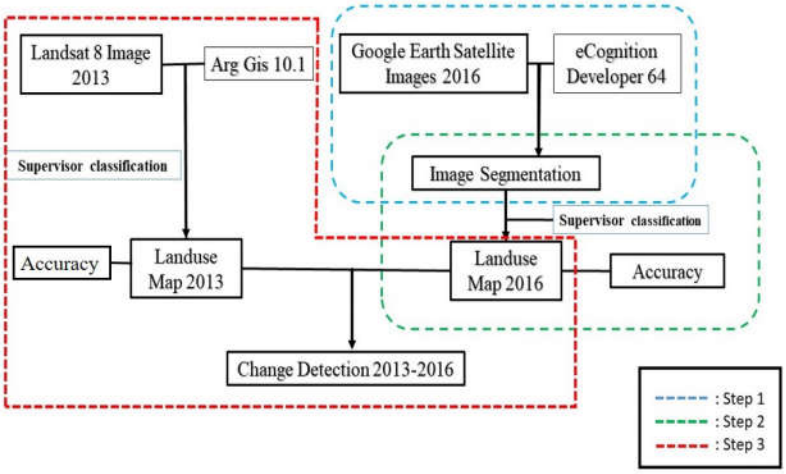

Figure 2. The flowchart of data processing

Step 1: Download Google Earth images and classifying land use objects

Since, Google Earth imagery can only download in regular images (not raster images), software Universal Maps Downloader 9.26 has been used. The coordinate systems of interest area is identified by two points in North-East and South-West. After selecting the desired resolution, the software will automatically download all the piece images in that area. Universal Maps Downloader 9.26 also provides a tool to combine the pieces images into a complete image.

After having satellite images, all object represents in this will be defined. Object-based image analysis requires the creation of objects or separated regions in an image. One established way to do so is image segmentation. The segmentation algorithm applied in this study is the so-called, multi-resolution segmentation, which is available in the eCognition software. The multi-resolution segmentation algorithm is a bottom-up region merging technique starting with a single image object of one pixel and repeatedly merges them in several loops in pairs to larger units. This algorithm is also an optimization procedure that minimizes the average heterogeneity for a given number of objects and maximizes their homogeneity based on defined parameters. Three key parameters, namely scale, shape, and compactness, need to be set in multi-resolution segmentation. Additionally, different scale parameters, based on visual analysis of segmentation results, were attempted. Once the segmentation process was done, the classification was implemented using a resource-based sample collection and a standard nearest neighbor algorithm. Based on these procedures, land cover maps for the year 2016 were generated.

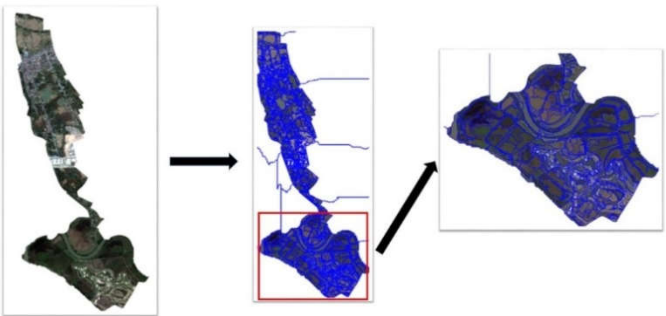

Figure 3. Google Earth image of Thuy Trieu commune and its object based classification

Step 2: Classification and Accuracy

Classification

The Nearest Neighbor classifier in eCognition was used to perform an object-based classification. This classifier uses a defined feature space, e.g., using original bands or customized bands, and a set of samples that represent different classes in order to assign class values to segmented objects. The procedure consists of teaching the system by giving certain image objects as samples and classifying image objects in the image object domain based on their nearest sample neighbors. Initially, there are eight land cover classes were considered for this purpose including Bare lands, Golfs course, Industrial, Mangrove Forest and Forest, Residential, Rice fields, Water Body, Wetlands - Aquaculture.

Figure 4. Field photo of land use type

Accuracy

An important component of accuracy assessment, Cohen's kappa coefficient is calculated from the error matrix. Kappa tells us how well the classification process performed as compared to just randomly assigning values, i.e. did we do better than random.

In this article, we use ArcGIS to create templates. By using Create random points (in Arc toolbox). 96 random points were created within the boundary of Thuy Trieu commune.

And used Kappa coefficient that was computed using the equation:

$$K = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}$$ *(Congalton, 1991)*

Where: N: Total number of sites in the matrix;

r: Number of rows in the matrix;

x_{ii}: Number in row i and column i;

$x + i$: Total for row i;

x_{i+}: Total for column.

Step 3: Change Detection

Supervised classification categorizes an image's pixels into land cover/vegetation classes based on user-provided training data. These training data identify the vegetation or land cover at known locations in an image

(Priyanka Khandelwal, 2013). It has several advantages over simpler methods like unsupervised classification. First, because the classes are user-defined, they are ensured to conform to the classification hierarchy of the investigation. Second, the use of training data improves the ability to differentiate between classes with similar color profiles. Finally, the method tends to be more reliable and produce more accurate results (Priyanka Khandelwal, 2013). Supervisor classification method on ArcGIS is used to classified landcover in the Landsat 8 image.

Use the same method that we use to define the accuracy of land-use map in 2016. With 42 random points create in ArcGIS, all these points will be compared with the map in 2013 from Google Earth Pro. Apply the Kappa formula to define the accuracy of this map.

Change detection for GIS is a process that measures how the attributes of a particular area have changed between two or more time periods. Change detection often involves comparing aerial photographs or satellite imagery of the area taken at different times (Priyanka Khandelwal, 2013). In this study, the area of each land cover class was calculated and the forest cover changes were analyzed. Overlaying existed forest map and classified map in 2016 to derive the changes in a period of 3 years (2013 - 2016). In order to see the overall change in the region, studied site was then chosen to characterize the land cover changes in one short-term period (2013 - 2016). Detection of land cover changes was achieved by overlaying (in ArcGIS 10.1) and post-classification comparison of the land cover maps of the different time periods. The changes were accompanied by the respective cross-tabulation matrix showing the change pathways, in order to determine the quantity of the conversions. Change dynamics are presented in maps using a grouping of changes for more clarity in the results.

III. RESULTS AND DISCUSSIONS

3.1. Classification

3.1.1. Land use map in 2016

There are all 8 types of land use that are mentioned in this map: Mangrove and Forest, Residential, Rice Field, Wetlands and Aquaculture, Bare Land. Industrial, Water Body, Golf Course. The area and percentage for each type of land use are represented in the table 1.

Table 1. Land use types of Thuy Trieu in 2016

No.	Type of Land use	Area (ha)	Area (%)
1	Mangrove and Forest	81.4	7.34
2	Residential	144.6	13.05
3	Rice Field	173.8	15.68
4	Wetland and Aquaculture	441.4	39.84
5	Bare Land	41.5	3.74
6	Industrial	36	3.25
7	Water Body	76.9	6.94
8	Golf Course	112.4	10.14
	Total	1107.9	100

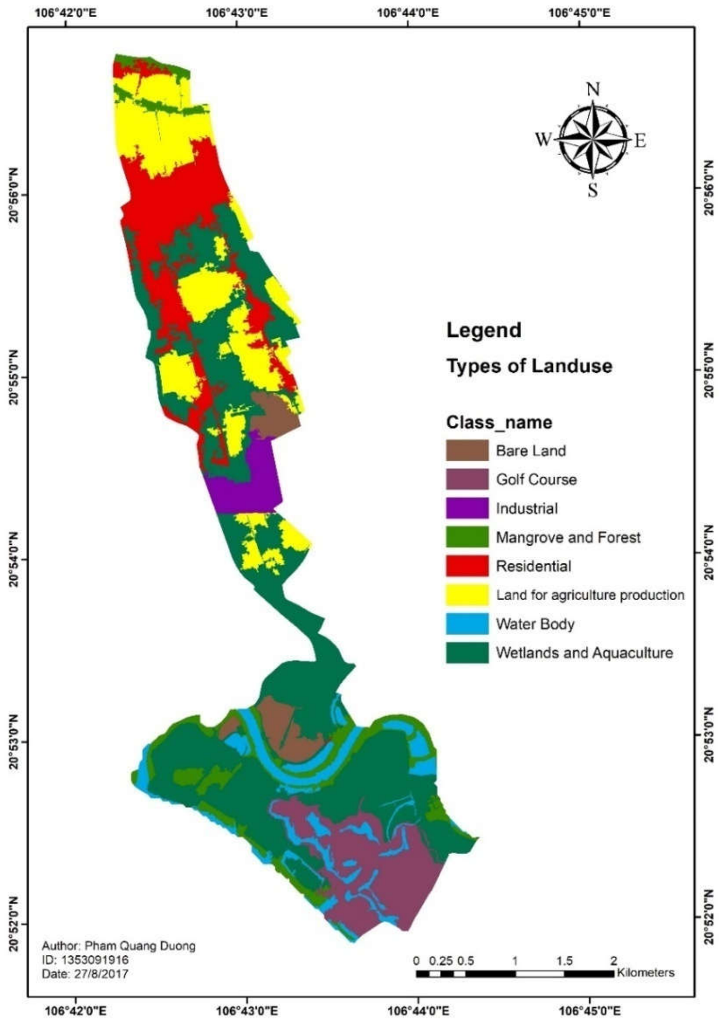

Figure 5. Land use map of Thuy Trieu 2016

There are also other types of land use in Thuy Trieu commune. But because of the small size of the sections, it was merged into some group with themost similar characteristic. Wetlands and Aquaculture area have the largest area of 441.4 ha (39.8% of the total area of the commune). Because Thuy Trieu commune is located near Bach Dang rivers, most of the communes are mudflats, lakes, and lagoons... By the time many people renovated and converted this part into aquaculture. That is also the reason why wetlands and aquaculture were combined in one part. Due to a large amount of silt and fertile soil, the area of rice cultivation also accounts for a large part of the total area of the commune, 173.8 hectares (15.68% of the commune area). Besides the residential area, there is also a large area with 112 hectares of which is a 36-hole golf course in Vu Yen island. "According to the Ministry of Planning and Investment, the 36-hole golf course planning area on Vu Yen island covers an area of nearly 1.6 million square meters in Dong Hai 1 ward, Hai An district, and Thuy Trieu commune, Thuy Nguyen district. The golf course project is located in the entertainment area, housing and ecological park Vu Yen island of Dinh Vu - Cat Hai Economic Zone, Hai Phong" (Retrieved from Government Portal Socialist Republic of Viet Nam, 2015).

3.1.2. Accuracy

The formula for kappa is:

$$\frac{\text{Observed} - \text{expected}}{1 \quad \text{Expected}}$$

Observed is overall accuracy, in this case, is 88/96 or 89.6%. Expected is calculated from the rows and column totals.

The product matrix is the sum of the diagonals: 1152.

The Cumulative Sum is: 9216.

We have: 1152/9216 = 12.5%.

$$K = \frac{89.6 - 12.5}{1 - 12.5} = 88\%$$

A Kappa coefficient of 0.88 (95% confidence interval from 0.836 to 0.924) was achieved. The strength of agreement is considered to be good. It means that the relationship between map and field situation is very strong.

3.2. Change detection

3.2.1. Land use Map in 2013

Land cover map of Thuy Trieu commune in 2013 by using Landsat 8 satellite images. The accuracy of this map after applying Kappa formula like the step above is 75%. It means that the accuracy of this map is quite good and the relationship between the map and reality really strong.

The spatial distribution of changes over a different time interval. In the three years from 2013 to 2016, the type of land use in Thuy Trieu commune has changed in all areas. But the change is not much excepted in the central and south. These two areas have a great shift in the type of land-use.

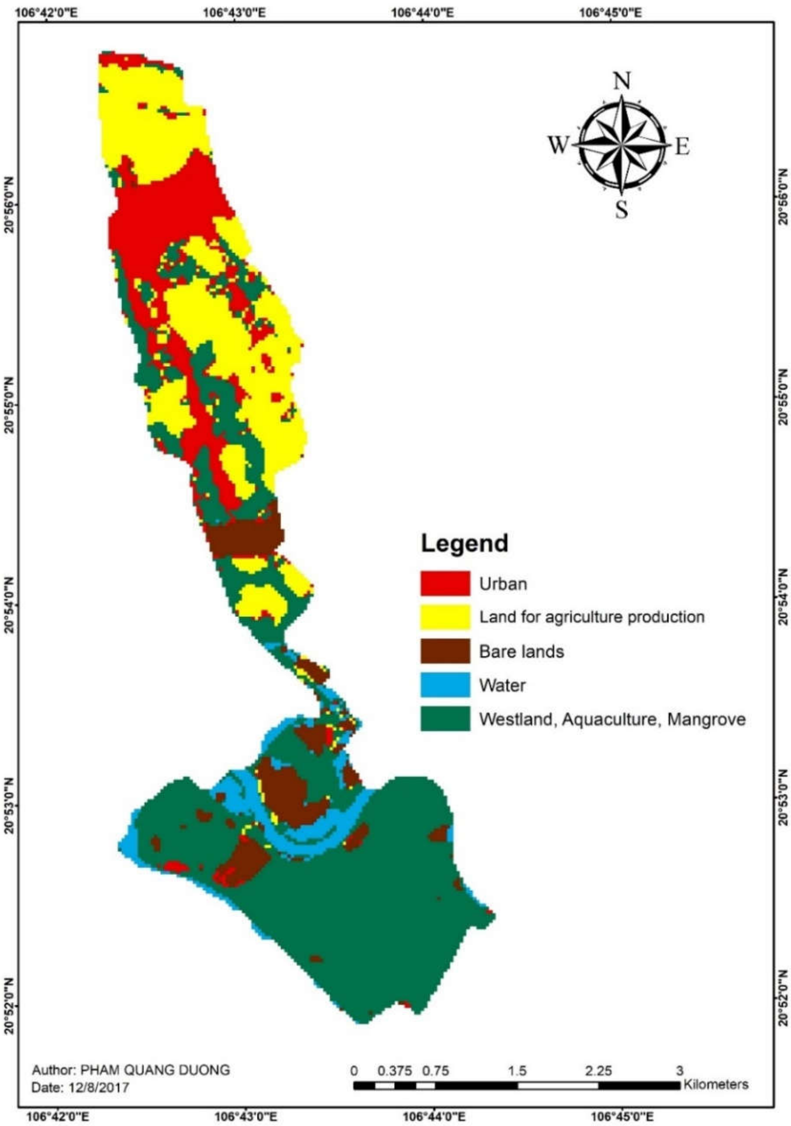

Figure 6. Land use map of Thuy Trieu 2013 and its change in 2013 - 2016

3.2.2. Detail change

Detail changes in the area of each type of land use. In five types of land use, there are two types is increasing, construction area is 176 hectares (an increase of 105% compared to 2013) because of V-Ship Industrial Park and project of Vu Yen golf course establishment. Besides that area of water body has increased but not significantly with 17 ha (up 28%). The other types of land-use are reduced: wetlands, bare land, rice's field with the area of 60 ha, 46 ha, 87 ha. The area of bare land fell the most with nearly 50% of the area. In the period from 2013 to 2016, a part of the land has been planted upstream. In addition, the same land was converted for other purposes.

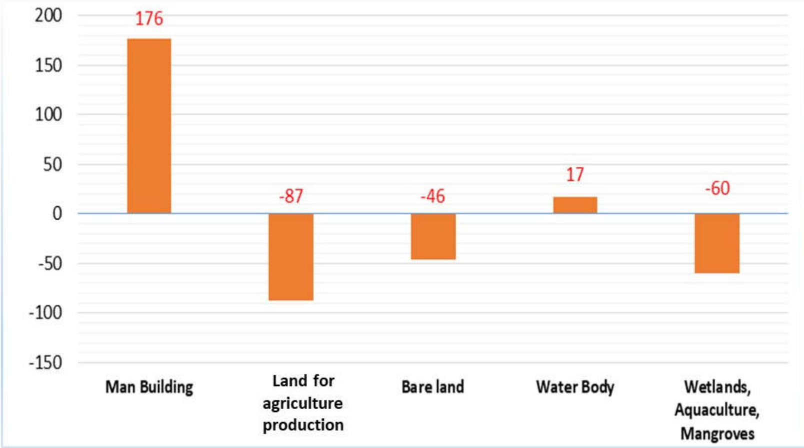

Figure 7. Change for each type of land use in hectare

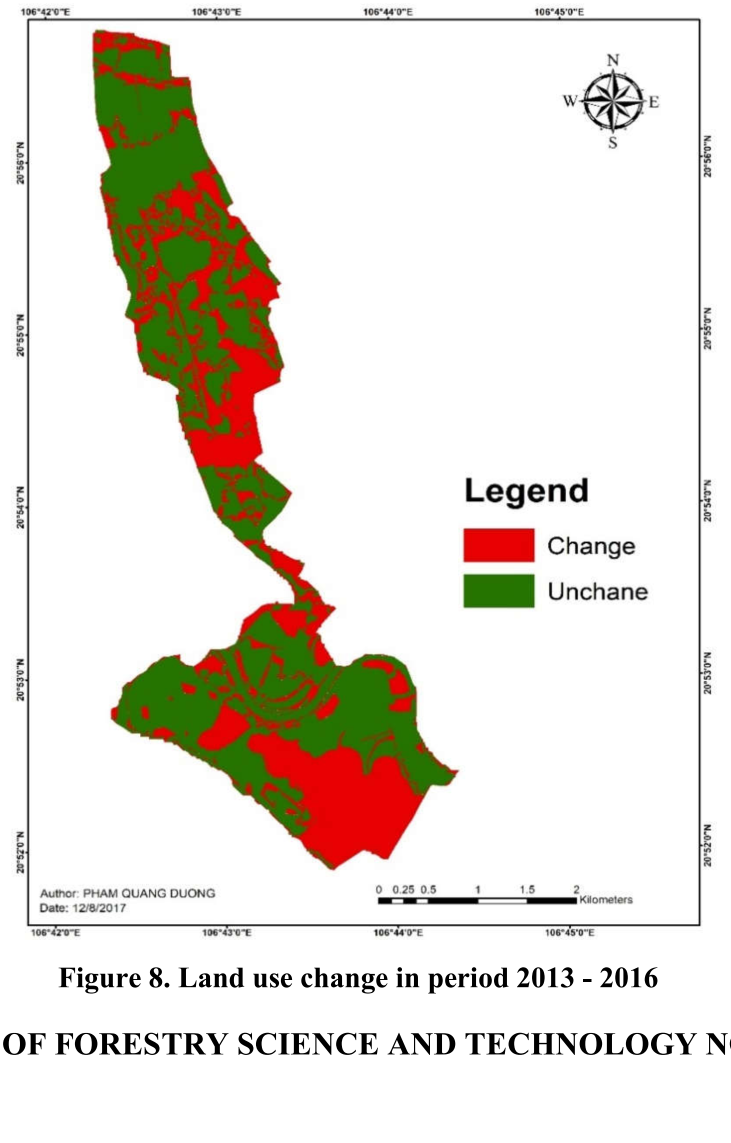

Figure 8. Land use change in period 2013 - 2016

3.3. Limitations of the methodology

First of all, limitations of software used in thestudy (Google maps downloader) can only download the latest Google Earth images. Therefore, in determining the change of land use, we have to use Landsat 8 images to compare. More over, the limitation of Google earth is that it may not be possible to obtain the original multispectral band data and hence image classification using unsupervised or supervised techniques cannot be carried out.

Secondly, Comparing a very high-resolution image (0.5 m x 0.5 m) to a medium resolution image (30 m x 30 m) will have many shortcomings and difficult to reconcile, and the accuracy of the results will not high. Landsat 8 is medium resolution only with pixel size ranging between 30 m. It may not be possible to visually see the individual buildings, roads, etc. With this spatial resolution, the land use maps can be prepared only through automated image classification methods such as supervised or unsupervised classification techniques, which can not get 100% accurate results.

In the classification process there are two easily confused objects that are water surface that the aquaculture pond. However, the area of the ponds is quite small, so in the classification step by eCognition software, the water surface of the ponds has been grouped together with the surrounding orchard into a separate object. This object can be easily distinguished from the big water surface.

V. CONCLUSION

From the results obtained after studying the land use types and changes in land use change by applying remote sensing technology and GIS in Thuy Trieu commune, Thuy Nguyen district, Hai Phong city in the period of 2013 - 2016, the thesis draws some conclusions: High-resolution Google Earth satellite imagery. Suitable for applying to map setting. This method is a substitute for traditional methods that take a lot of time and effort. Also using Google Earth imagery is more efficient than using other types of images such as Landsat 7.8, Radar...

In Thuy Trieu commune, 2016, eight common land use types has been classified with high accuracy (88%). The main types of land use are Wetland and Aquaculture with nearly half of commune area. Beside that is an area for indusial and residential. From there, local authorities have the cadastral reference data with the most recent landmark, replacing the maps built many years ago.

In the step of determining the variation in land use type. We have obtained some information. Over the three year period from 2013 to 2016, there have been significant changes in land use patterns. Evidence that the completion of the construction of the V-Ship industrial park, golf course project... changed part of the area (110 ha) of the commune. This is also a good reference for local authorities in land use management.

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SỬ DỤNG ẢNH VỆ TINH CÓ ĐỘ PHÂN GIẢI CAO GOOGLE EARTH ĐỂ THÀNH LẬP BẢN ĐỒ SỬ DỤNG ĐẤT VÀ ĐÁNH GIÁ BIẾN ĐỘNG LỚP PHỦ Ở XÃ THỦY TRIỀU, HUYỆN THỦY NGUYÊN, THÀNH PHỐ HẢI PHÒNG

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TÓM TẮT

Bài báo trình bày kết quả thành lập bản đồ sử dụng đất năm 2016 từ ảnh vệ tinh Google Earth và phân tích sự thay đổi lớp phủ tại xã Thuỷ Triều, huyện Thuỷ Nguyên, Hải Phòng giai đoạn 2013 - 2016. Sử dụng phương pháp phân loại hướng đối tượng trên phầm mềm eCognition để phân loại ảnh Google Earth năm 2016 và ảnh Landsat 8 năm 2013, chồng ghép bản đồ hai giai đoạn để phân tích sự thay đổi loại hình sử dụng đất trong 3 năm. Phương pháp phân loại hướng đối tượng đã tách biệt được 8 loại hình sử dụng đất khác nhau ở Thủy Triều, độ chính xác của bản đồ giải đoán có giá trị chỉ số Kappa là 0,88. Tiến hành chồng ghép với bản đồ sử dụng đất năm 2013, bài báo đã phân tích được biến động các loại hình sử dụng đất trong giai đoạn 2013 - 2016. Kết quả của nghiên cứu này sẽ đóng góp một phần vào việc ứng dụng công nghệ GIS và viễn thám trong quản lý đất, giúp tiết kiệm thời gian, tiền bạc và nâng cao độ chính xác của việc cập nhật dữ liệu bản đồ.

Từ khóa: Ảnh vệ tinh Google Earth, biến động lớp phủ, eCognition, sử dụng đất.

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