APPLYING GIS AND RS IN ASSESSING THE CHANGE OF VEGETATION COVER IN TRAM CHIM NATIONAL PARK FROM 1988 TO 2017

Thanh Ngan Nguyen[1] and Thi Hien Hau Vo[2]

[1]Faculty of Environment, Ho Chi Minh City University of Natural Resources and Environment - 236B Le Van Sy Street, Ward 1, Tan Binh District, Ho Chi Minh City
Email: ntngan@hcmunre.edu.vn
[2]Faculty of Environment, Ho Chi Minh City University of Natural Resources and Environment - 236B Le Van Sy Street, Ward 1, Tan Binh District, Ho Chi Minh City
Email: hauvo.vt@gmail.com

ABSTRACT

Tram Chim National Park is an important nature reserve of the Mekong Delta. This national park is located within the administrative boundary of Dong Thap Province. This area has many rare and valuable species of plants and animals in Vietnam, especially sarus crane. In recent years, due to human impacts, the land cover types in Tram Chim National Park have changed very rapidly and complexly. The most heavily changed land cover is the vegetation cover. For this reason, this research is conducted to assess the change of vegetation cover in Tram Chim National Park from 1988 to 2017. Based on Landsat image data, the authors use GIS and RS tools to extract information about vegetation cover, then use the results obtained to analyze the fluctuation of this land cover. This research has initially shown the characteristics of vegetation cover change at Tram Chim National Park, provides the scientific basis for the development of appropriate solutions to improve the management and conservation effectiveness in this area.

Keywords: Vegetation cover; Tram Chim National Park; GIS; RS; Landsat image.

1. INTRODUCTION

Tram Chim National Park is a wetland, classified as a special-use forest of Vietnam. It is considered as an important and characteristic nature reserve of the Mekong Delta. Tram Chim National Park is located in Dong Thap Muoi Region, Tam Nong District, Dong Thap Province. This is an area of high biodiversity value, with many rare and valuable species of plants and animals (Nhan and Thong, 2011; Chung and Nghiep, 2014). Tram Chim National Park has many precious species of birds named in the Red Book, among them are the sarus crane (red-headed crane) (Archibald et al., 2003; Do and Bennett, 2009). Over the last few years, because of human activities, the land cover types in this area have changed very rapidly and complexly, especially vegetation cover. This has caused great difficulties for the conservation of biodiversity in Tram Chim National Park.

Due to this reason, this research is charged to assess the change of vegetation cover in Tram Chim National Park from 1988 to 2017 with Landsat image data (a type of medium resolution satellite image). The key point of this research is the use of GIS and RS technologies in forest management and monitoring. The GIS and RS software are used to extract information about vegetation cover from Landsat images, then the results obtained are used to analyze the fluctuation of this land cover in the study area. This method has been used widely in many parts of the world and gives valuable results for the forest managers (Coppin and Bauer, 1994; Shao et al., 1996; Hansen et al., 2008; Kuemmerle et al., 2009; Hansen et al., 2010; Broich et al., 2011; Baumann et al., 2012; Brandt et al., 2012; Lehmann et al., 2013; Margono et al., 2014; Potapov et al., 2015). The study area of this research is the entire of Tram Chim National Park that located within Tam Nong District.

2. METHODS AND DATA

2.1 Methods

In order to determine the change of vegetation cover in Tram Chim National Park, the authors approach using GIS and RS technologies. The whole research process of this research is divided into the following six major phases: (1) gathering associated data, (2) restoring and correcting Landsat images, (3) enhancing image quality and converting Landsat images, (4) classifying Landsat images and assessing the classification accuracy, (5) building distribution maps and calculating the area change of vegetation cover, (6) evaluating results and drawing conclusions. In the six phases mentioned above, two phases (4) and (5) are most important because they determine the accuracy of the results. The Figure 1 depicts the main features of the whole research process.

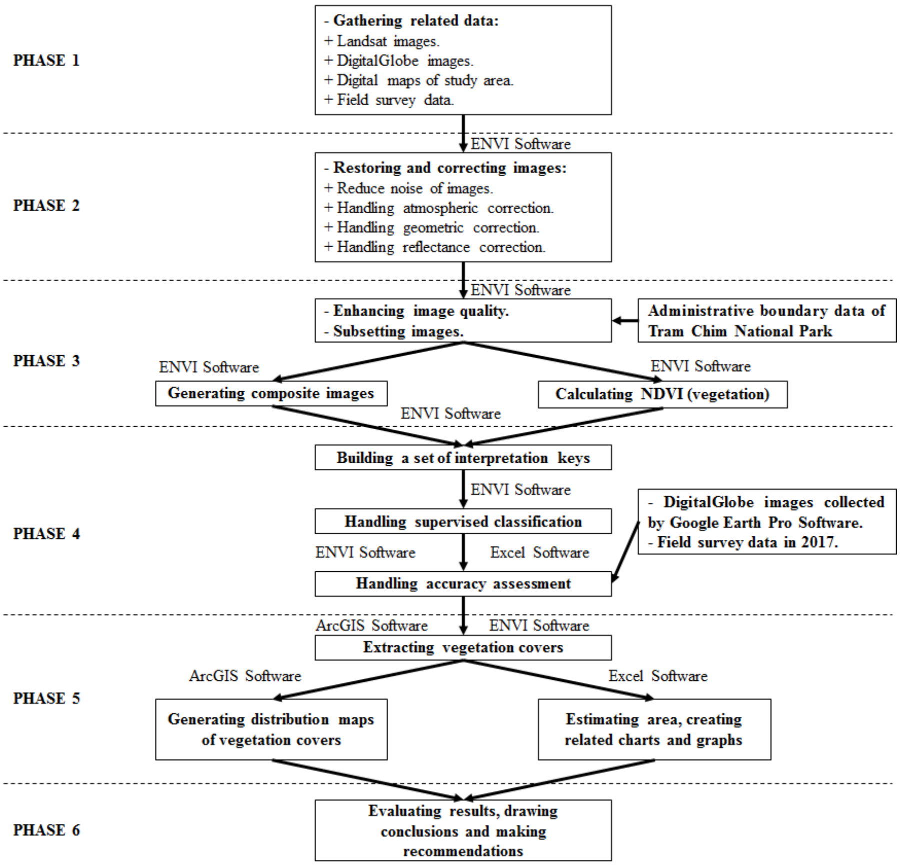


Figure 1. The main features of the research process diagram.

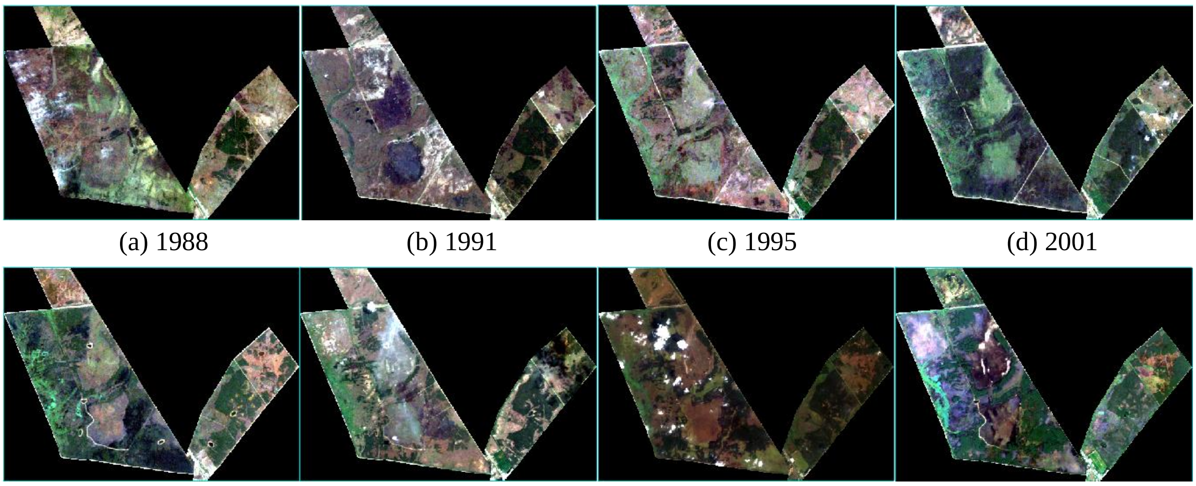
2.2 Data

To carry out research contents, the authors use the following three main types of data: (1) RS data, (2) GIS data, (3) field survey data. The RS data used is the Landsat images of eight years 1988, 1991, 1995, 2001, 2004, 2010, 2015 and 2017 in the study area (Scene ID is path 125 and row 053). The GIS data is the base map in MapINFO TAB format of Tram Chim National Park in 2011 that consists of six main classes: forests, grasslands, ponds, boundaries, roads and guard stations. The field survey data is collected in 2017 with Garmin GPSMAP 64st handheld GPS receiver and Canon 700D camera. This is an important basis for assessing the accuracy of classification results from Landsat images. In addition, the authors also use the DigitalGlobe images that collected by Google Earth Pro software to assist in evaluating the accuracy of classification results.

3. RESULTS AND DISCUSSION

3.1 Creating natural composite images and estimating NDVI

The first step of the creating composite image process is to collect Landsat images in the study area from the EarthExplorer website of U.S. Federal Government (https://earthexplorer.usgs.gov). These Landsat images are removed stripe noises, calibrated relevant parameters, enhanced quality and subsetted based on administrative boundaries of Tram Chim National Park. The subsetted Landsat images are used to create natural composite images. In natural composite images, each land cover has a different characteristic color similar to the color perception of the human eye. These characteristic colors help interpreters distinguish between different types of land cover on the images, thereby building a set of interpretation keys for the image classification process. The natural composite images of the study area are shown in the Figure 2.



(a) 1988 (b) 1991 (c) 1995 (d) 2001

(e) 2004 (f) 2010 (g) 2015 (h) 2017

Figure 2. The natural composite images of Tram Chim National Park.

In addition, the subsetted Landsat images are also used to calculate the NDVI. The NDVI stands for Normalized Difference Vegetation Index, an RS index proposed by J. W. Rouse Jr., R. H. Haas, J. A. Schell and D. W. Deering in 1974. This index is used to identify vegetation pixels from Landsat images (Rouse et al., 1974). The NDVI is calculated based on the reflectance of near infrared wavelengths and red wavelengths with vegetation (Rouse et al., 1974). The theoretical values of NDVI are from -1 to 1 with the vegetation pixels have positive values (Rouse et al., 1974). Figure 3 demonstrates the NDVI calculation results of the study area.

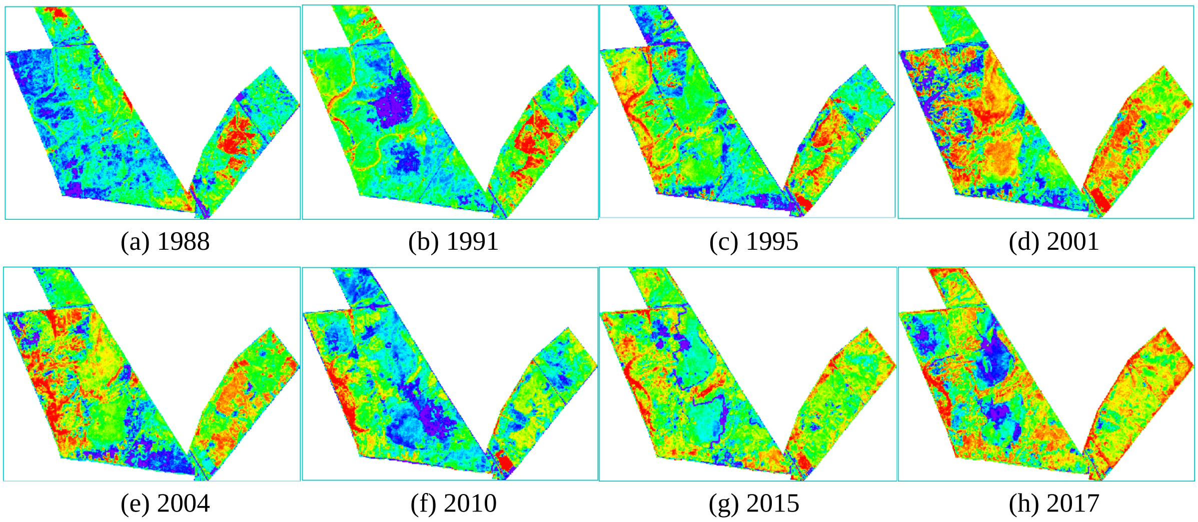


Figure 3. The NDVI images of Tram Chim National Park.

3.2 Classifying images and assessing the classification accuracy

Based on the natural composite images and the NDVI images, the authors conduct to identify the interpretation keys for the image classification process. This is considered as the most important step of the image classification process because it greatly affects the accuracy of classification results. After completing the interpretation key identification step, the authors classify the Landsat images by supervised classification method with Maximum Likelihood algorithm. The image classification process divides Landsat images into seven main types of objects: (1) thick forest, (2) sparse forest, (3) scrub grassland, (4) bare soil, (5) built-up land, (6) wetland, (7) waterbody.

After classifying Landsat images, the authors handle to assess the accuracy of classification results. The first step of the accuracy assessment process is to build the Base Error Matrices based on the results obtained and the verification data. From the Base Error Matrices, the authors calculate two parameters Kappa Coefficient and Overall Accuracy, which are two parameters that represent the accuracy of image classification process. The accuracy assessment process is performed on the classification results for three years 2010, 2015 and 2017, as there are sufficient verification data to compute the parameters. The Kappa Coefficient and Overall Accuracy of the classification results in 2010, 2015 and 2017 are shown respectively in Table 1. The values in Table 1 show that the results of all three selected years are in line with the USGS standard.

Table 1. The results of the accuracy assessment of the classification process.

Classification result	Verification data	Number of samples	Overall Accuracy	Kappa Coefficient
2010	DigitalGlobe images	1,000	88%	0.85
2015	DigitalGlobe images	1,000	93%	0.91
2017	DigitalGlobe images and field survey data	1,000	86%	0.82

The classification results are also used to determine the composition of the land cover types over the eight year of survey. The graph that described the structure of land cover types in the study area from 1988 to 2017 is shown in Figure 4. The chart shows that three types of land covers included thick forest, wetland and waterbody have the most variation, while the other types of land covers have changed but not significantly.

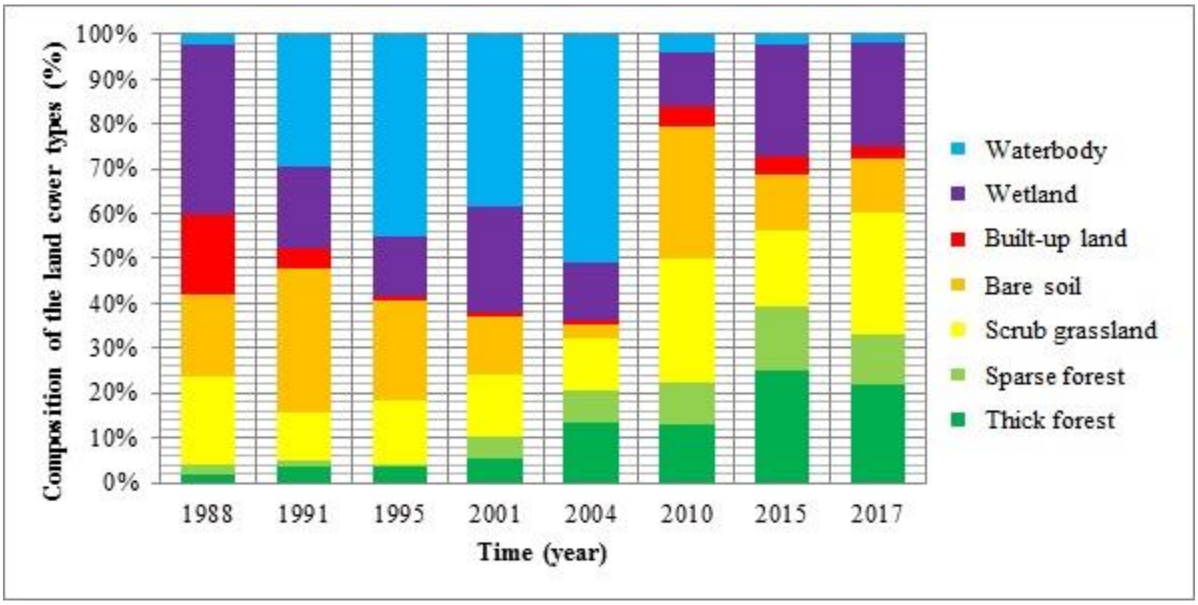
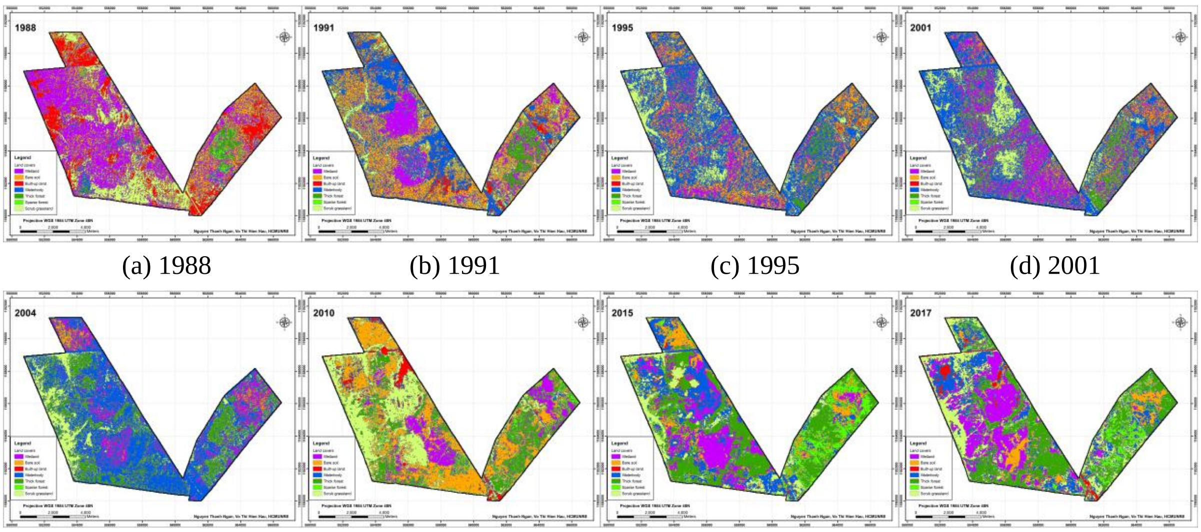


Figure 4. The structure of land cover types in the study area from 1988 to 2017.

3.3 Building distribution maps and assessing the change of vegetation cover

The vegetation cover data extracted from the classification results is combined with the administrative boundary data of Tram Chim National Park to generate distribution maps of vegetation cover in the study area. These distribution maps are the basis for the estimation and assessment of the change in vegetation cover in the study area during the eight years of survey. These distribution maps are shown in Figure 5.



(a) 1988 (b) 1991 (c) 1995 (d) 2001

(e) 2004 (f) 2010 (g) 2015 (h) 2017

Figure 5. The distribution maps of vegetation cover in Tram Chim National Park from 1988 to 2017.

In addition, the vegetation cover data obtained is also used to create graphs showing the area change during the survey period. These graphs show the main features of the area change over time of vegetation cover in the study area. Figure 6 illustrates graphs showing the area changes of three vegetation cover types thick forest, sparse forest and scrub grassland from 1988 to 2017.

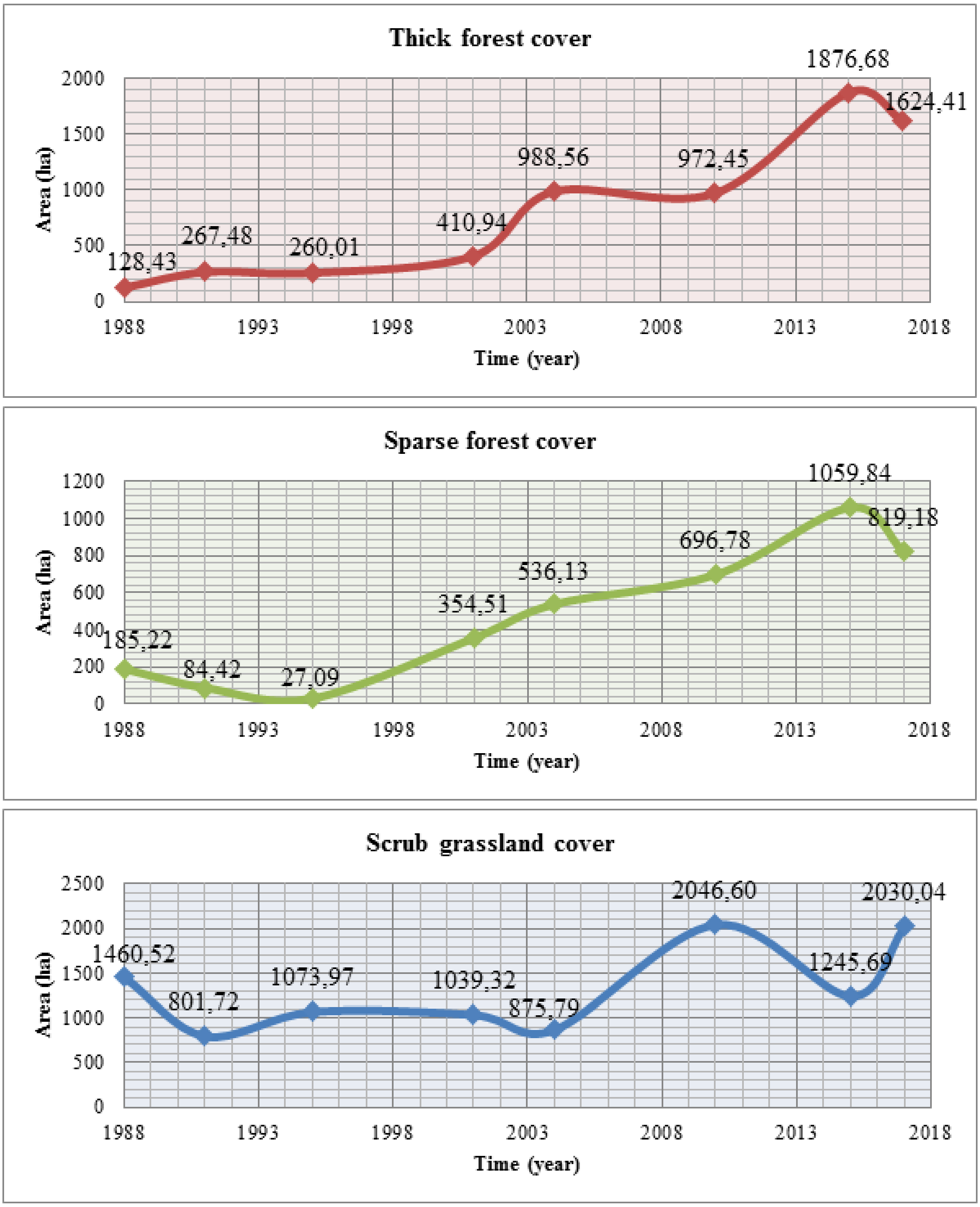


Figure 6. The area changes of thick forest cover, sparse forest cover and scrub grassland cover from 1988 to 2017.

The maps in Figure 5 and the graphs in Figure 6 point out the main characteristics of three major types of vegetation cover in the study area during the survey time. The area of thick forest cover ranges from 128.43 ha to 1,876.68 ha, maximum in 2015 and minimum in 1988. The area change process of thick forest cover can be divided into six main phases, including three phases of increase 1988-1991, 1995-2004 and 2010-2015, three phases of decline 1991-1995, 2004-2010 and 2015-2017. The area of sparse forest cover ranges from 27.09 ha to 1,059.84 ha, maximum in 2015 and minimum in 1995. The area change process of sparse forest cover can be divided into three main phases, including one phase of increase 1995-2015, two phases of decline 1988-1995 and 2015-2017. The area of scrub grassland cover ranges from 801.72 ha to 2,046.60 ha, maximum in 2010 and minimum in 1991. The area change process of scrub grassland cover can be divided into six main phases, including three phases of increase 1991-1995, 2004-2010 and 2015-2017, three phases of decline 1988-1991, 1995-2004 and 2010-2015. The area change tolerance for thick forest cover is the largest of the three vegetation cover types surveyed. The analysis results are relatively consistent with the theory of forest evolution. The main causes of the area decline of thick forest cover and sparse forest cover are forest fire and illegal exploitation of the people.

4. CONCLUSIONS

The obtained results show that this research has solved the target of using Landsat image data to identify the main features of vegetation cover change at Tram Chim National Park from 1988 to 2017. The research has identified the direction, speed and rule of change of major vegetation cover types in Tram Chim National Park from 1988 to 2017. The research has also pointed out the main reasons that caused the change of vegetation cover in this area. The obtained results from this research demonstrate that thick forest cover and sparse forest cover tend to decrease, while scrub grassland cover tends to increase since 2015. This is considered a bad sign for the development of the forest ecosystem in this area. The satellite imagery and map data collected from this research are a valuable source of data to support managers in developing strategies to improve the performance of management and conservation of biodiversity for Tram Chim National Park. The results of this research are also a useful reference for similar studies in the forestry and environmental sciences.

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