REMOTE SENSING AND GIS APPLICATION ON FOREST COVER CHANGE DETECTION IN KIM TIEN COMMUNE, KIM BOI DISTRICT, HOA BINH PROVINCE FROM 1995 TO 2018

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SUMMARY

Remote sensing technology and GIS are considered as an effective and objective tool in monitoring and evaluating natural resources, especially in the detection of forest cover change. In this study, Landsat 5 TM satellite images in 1995, 2002, 2011 and Landsat 8 OLI/TIRS in 2018 were used to classify and detect the areas of forest change in Kim Tien commune, Kim Boi district, Hoa Binh province. NDVI (Normalized difference vegetation index) was employed to classify the forest cover from downloaded satellite imagery after pre-processing. The study has constructed a database and maps about forest cover for 4 different years 1995, 2002, 2011, 2018 with the accuracy greater than 75%, maps of forest cover change during 4 periods 1995 – 2002, 2002 – 2011, 2011 – 2018 and 1995 – 2018. The results showed that the total area of forest cover increased slightly, strongly fluctuated in the first period of 1995 – 2011, unevenly distributed and scattered throughout the entire commune. The forest cover decrease was concentrated mainly near residential areas, tended to expand gradually along the margin, especially according to the development of roads in the Southwest. Drivers of forest cover increased during the period 1995 – 2018 were the effective applications of forest plantation project, management, and protection.

Keywords: Change detection, forest cover, Hoa Binh province, Landsat, NDVI.

1. INTRODUCTION

Forests are important renewable natural resources and have a significant role in preserving an environment suitable for human life (Ngai, 2009). Forest reduces flood, drought, prevent erosion and landslide in both frequency and intensity. In Vietnam, the forest represents the characteristics of tropical rainforest (De Queiroz et al., 2013). Forest cover in 2016 is 41.19% (Loc, 2018). From 1979 to 1990 natural forest declined by 2.7 million hectares, accounted for 1.7%/year. In the period 1999 - 2005, the area of rich natural forest decreased and the medium forest decreased by 10.2% and 13.4% respectively (FIPI, 2009).

Nowadays, the development of the technology of earth observation satellite, remote sensing imagery and geographic information systems (GIS) have been applied in many fields of science and management (Al-Doski et al., 2013). Currently many states, and private forestry agencies, governments are implemented GIS and remote sensing for various applications (Pore, 2013), (Le et al., 2015). In addition, it is a very useful tool for analyzing change detection and mapping of the land cover of the forest. It also has an important contribution to make in documenting the change in land use/land cover on regional and global scales from the mid-1970s (Lambin et al., 2003; Hung and Hoang, 2009; Ha, 2016; Hoa et al., 2016).

The forest cover in Kim Tien commune, Kim Boi district, Hoa Binh province accounted for approximately 70% (Ha, 2016). However, this area has many fluctuations between forest land and productive land (Ngai, 2009). In addition, satellite scenes available in this area are often cloud-free. Based on GIS application and remote sensing, this study was carried out to construct maps and detail numbers of forest cover and change detection in Kim Tien commune as well as finding the key drivers of forest change detection and solutions for effective forest management.

2. RESEARCH METHODOLOGY

2.1. Study site

Kim Tien is a mountainous commune is located in South-West of Kim Boi district (Hoa

Binh province) with a natural area of 2,178.79 ha, it is 4 kilometers to the center of Kim Boi district (Figure 1).

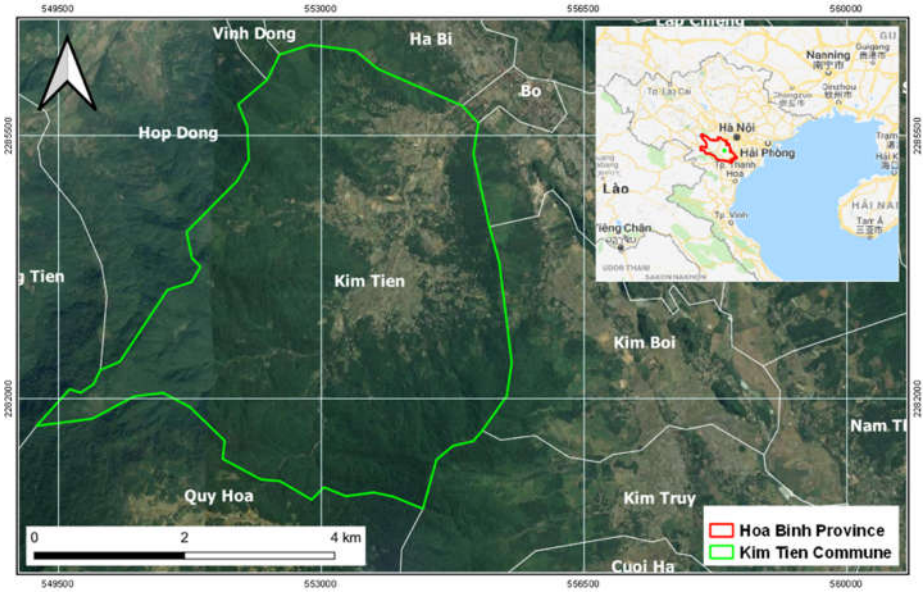

Figure 1. Location of Kim Tien commune, Kimboi district, Hoa Binh province

2.2. Materials

The chosen period was from 1995 to 2018, there were four different scenes: 1995, 2002, 2011 and 2018. Landsat 5 and Landsat 8 satellite images have been processed at level L1 (include radiometric, geometric, and precision correction, and uses a DEM to correct parallax errors due to local topographic relief) with a resolution of 30 m. The default projected coordinate systems was WGS84 UTM zone 48N. All the satellite data were downloaded freely on http://glovis.usgs.gov.

Table 1. Landsat images used in the study

Image codes	Acquisition date
LC81270462018158LGN00	2018/06/07
LT51270462011187BKT00	2011/07/06
LT51270462002290BJC00	2002/10/17
LT51270461995175BKT00	1995/06/24

2.3. Methods

2.3.1. Interviewing

To enhance the accuracy of the classification method and forest cover change detection: local people were interviewed, including staffs and authorities of the Kim Tien commune. For identifying the drivers of land cover change: the study focused on local people during the research period, middle-aged people and elderly with traditional experiences.

2.3.2. Data processing

Image processing: ArcGIS 10.5 was employed to construct maps of the forest over the periods. The method of interpretation and classification of images Landsat included three main stages, preprocessing, classification and change detection, representing in the following workflows (Figure 2).

2.3.3. Classification using NDVI

Normalized Difference Vegetation Index (NDVI) developed for estimating vegetation cover from the reflective bands of satellite data (Taufik et al., 2016). The multispectral remote sensing data technique was used to find the spectral signature of different objects such as vegetation, concrete structure, road, urban areas, rocky areas and remaining areas, the formula of NDVI is expressed as follow (Singh et al., 2016):

$$NDVI = (NIR - RED)/(NIR + RED)$$

Where: NIR is the reflection value of the near-infrared band, RED is a reflection value of the red band. Low NDVI value represents where vegetation cover is low, in contrast, it is high if the vegetation cover is high and range from -1 to 1.

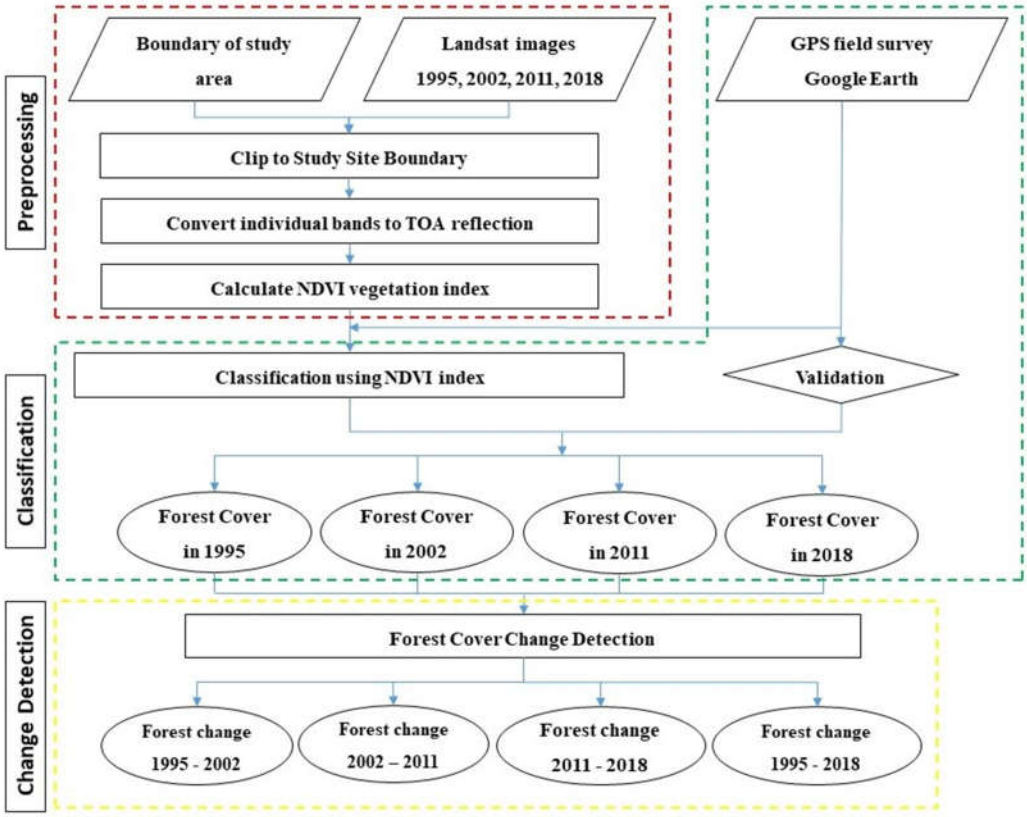

Figure 2. Workflows of the Study

2.3.4. Field survey

A field survey was conducted to collect ground control points with the help of Global Positioning System (GPS) device. The surveyed points included information about forest and other land use types as well as the position (latitude and longitude) in order to conduct the classification and accuracy assessment. 210 points were collected in the field, distributed evenly across the entire boundary of the commune.

2.3.5. Accuracy assessment

Kappa coefficient was used to evaluate the accuracy of classification result, based on the land cover types from classified maps and real field, Google Earth.

2.3.6. Change detection

Forest cover change detection was achieved by overlay each pair of classified layers in a specific period. The information of the overlay map is a coincidence of unchanged objects and the difference of objects in a region. From the detection, the findings will provide information about the change of forest cover over periods in terms of spatial and time.

3. RESULTS AND DISCUSSION

3.1. Forest cover in Kim Tien in the period 1995 – 2018

3.1.1. NDVI thresholds

The study classified NDVI as follows: from 0.62 to 0.79: forest includes natural forest, plantation forest; from 0.46 to 0.62: shrub and grassland, from 0.36 to 0.45: residential area, road, infrastructure, and bare land; from 0.1 to 0.36: agricultural land. The value of NDVI for agriculture was lower than for the residential, road and infrastructure because the acquisition time was not in the crop season and almost was bare land, the local people houses have been unevenly distributed around the foot of the mountain.

3.1.2. Forest cover maps

The forest cover maps were conducted by using NDVI thresholds for each period: 1995, 2002, 2011 and 2018. The study focused on forest change detection, so forest and non-forest were the two main objects for interpreting.

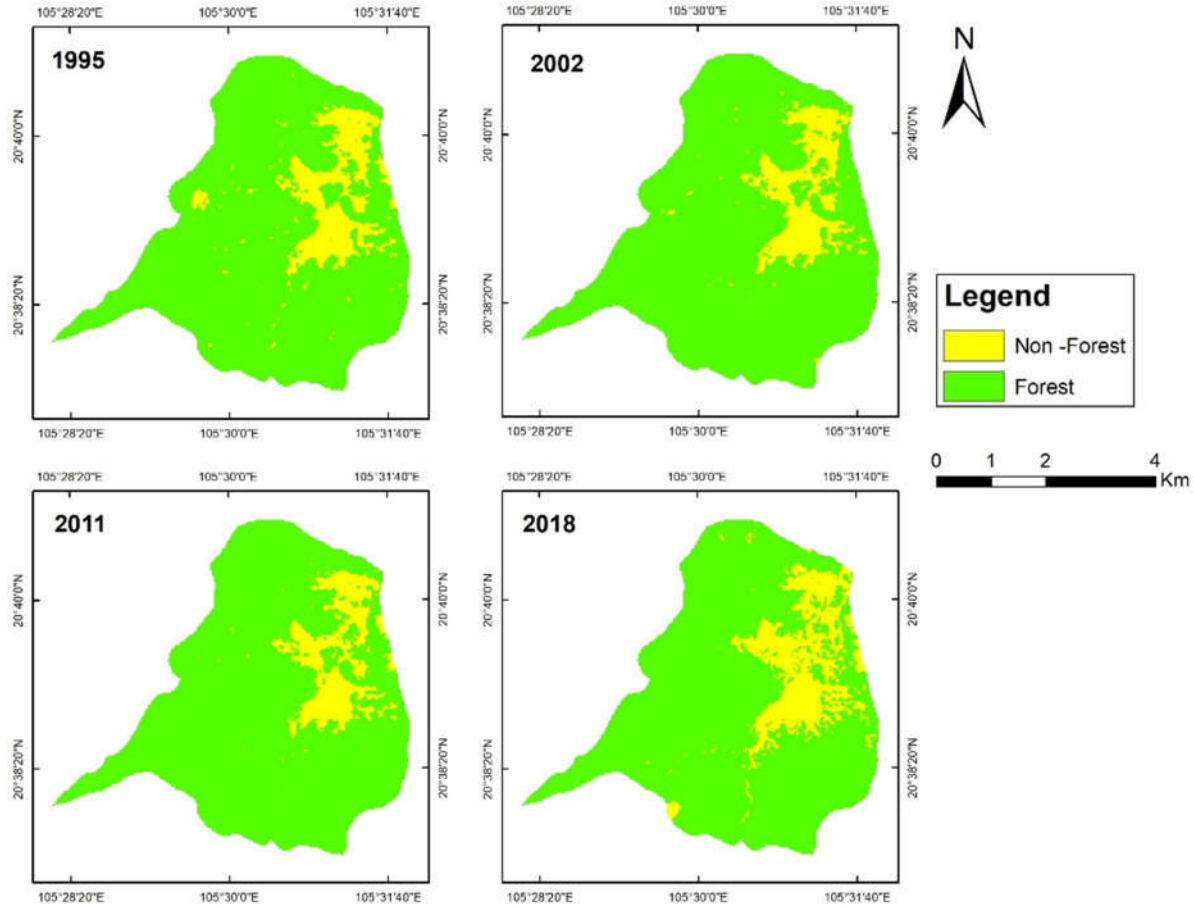

Figure 3. Status of forest distribution in Kim Tien commune in the period 1995 – 2018

Figure 4 shows an area of forest in the study site changed over the research period, there was a change between forest and non-forest area (residential, agriculture, water, bare land).

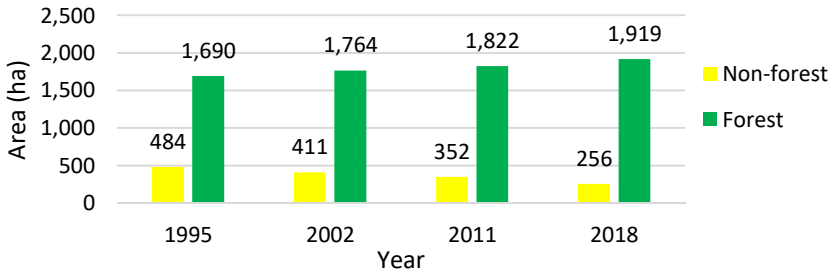

Figure 4. Non – forest and forest cover area changed over time

Forest cover in the study site was quite high and has increased from 1995 to 2018, highest in 2018, 1,918.62 ha (88.23%) and lowest in 1995, 1,690.29 (77.77%). The non-forest area has declined from 1995 to 2018, 484.38 ha (22.27%) to 256.05 ha (11.77%) respectively.

3.2. Accuracy assessment

Using the results of NDVI classification, Google Earth and the field collected points, the study determined the accuracy for each certain year. The overall accuracy of the classified forest cover map is 75.65% in 1995, 80% in 2002, 81.74% in 2011 and 84.35% in 2018.

3.3. Forest cover change from 1995 to 2018

3.3.1. Forest area

The forest change area value was extracted from the change detection map (Figure 6) and represented in table 2 with four different objects: non-forest, forest decreases, forest increase and forest unchanged.

Table 2. Forest area change detection from 1995 to 2018

Objects	Period							
	1995 - 2002		2002 - 2011		2011 - 2018		1995 - 2018	
	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)
Non - forest	314.55	14.46	285.39	13.12	222.75	10.24	229.77	10.57
Forest decreases	96.30	4.43	66.87	3.07	33.30	1.53	26.28	1.21
Forest increases	169.83	7.81	125.46	5.77	129.51	5.96	254.61	11.71
Forest unchanged	1593.99	73.30	1696.95	78.03	1789.11	82.27	1664.01	76.52

Table 2 indicated the general trend of the forest cover in the Yen Bai commune illustration for the change detection of each period. It is evident that from 1995 to 2013 the forest increased significantly by 10% at the end of this period.

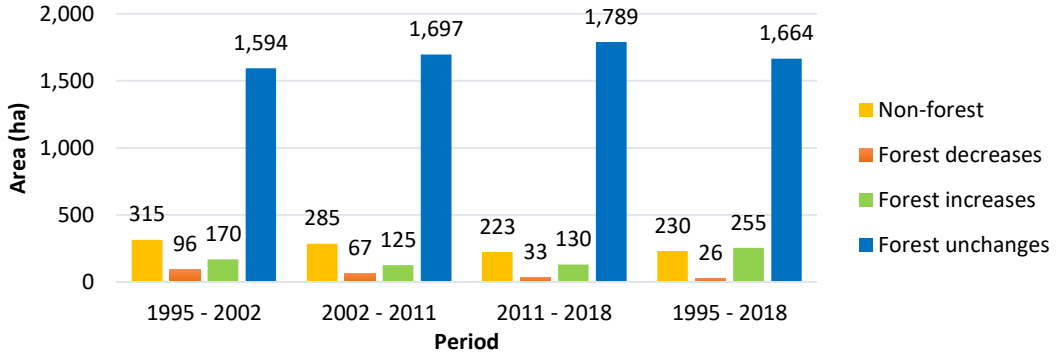

Figure 5. Forest area change in each period from 1995 to 2018

Figure 5 gives the big picture of what happened in each surveyed period in terms of forest cover changes over time. The two objects forest cover decreases and increases (indicated by orange and green respectively) shows that the negative trend was forest decrease almost all the time surveyed.

3.3.2. Change detection maps

Figure 6 illustrates how forest changed in term of spatial distribution. The most fluctuated areas were concentrated in the northeast and the center of the commune. Areas with forests increased scattered and uneven while areas with forest declined were concentrated near another land, mainly residential and infrastructures.

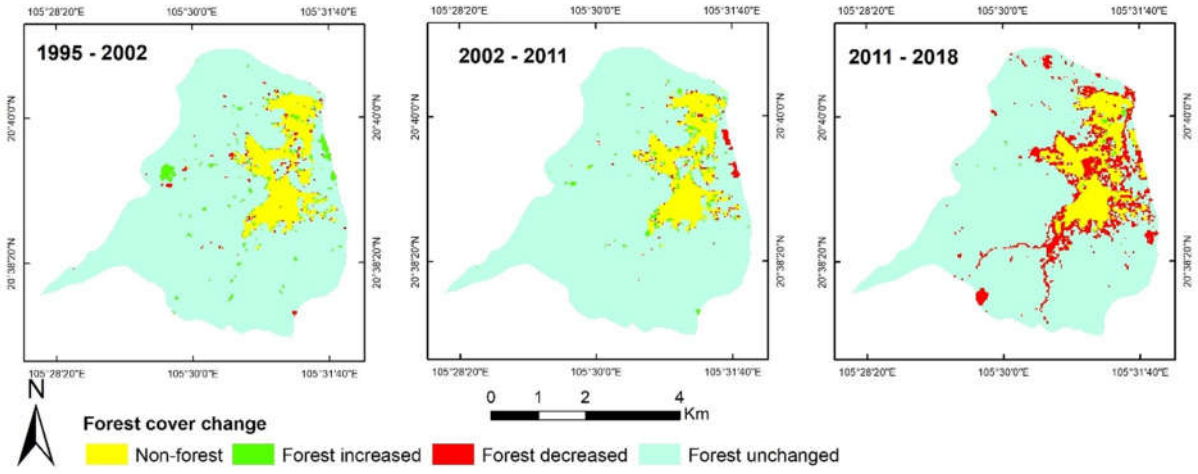

Figure 6. Forest changed detection in three periods

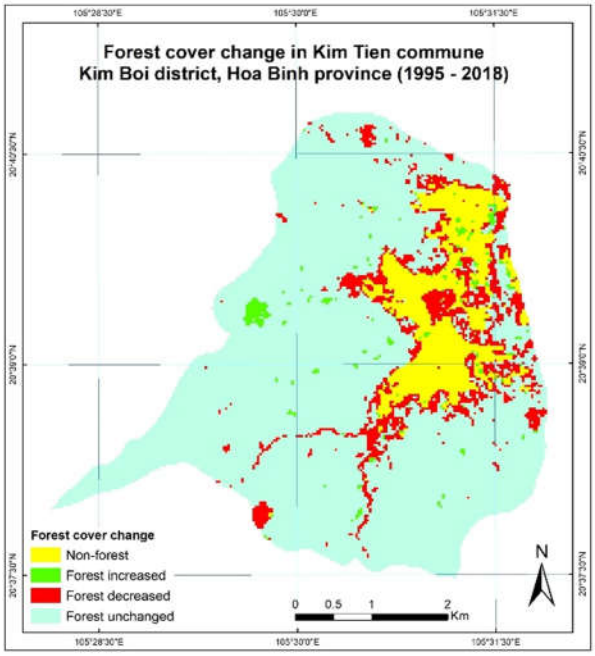

Figure 7. Forest cover change in the period of 1995 – 2018

After the 23-year survey period, the map was established to show a significant change in forest cover. Similar to the mentioned periods, the most changed forest area was still concentrated around non-forest land, mainly residential areas. After 2011, there was a clear reduction in the forest to the southwest due to the development of the road, along with the development of the roadside residential area.

3.4. Driving forces of forest change

3.4.1. Forest decreases

Poor households occupied approximately 40% of the total population of Kim Tien, awareness of local people was low. Because of no land for production, and have no investment, they destroyed the forest for their own use. Some households illegally exploited the forest to encroach on the land for agricultural production. People always do anything to get away from hunger, poverty and they hunt animals, cut trees, exploit forest product illegally to sell for money to serve the need of their surviving.

3.4.2. Forest increases

From 1999 to 2017 there were two forest plantation projects carried out in the commune: 661 and W7 project. The 661 project was implemented since 1999 with the purposes were planting, increasing forest cover, and protecting forest also increasing awareness of local people about protecting the forest. The W7 project was carried out in 2010, it lasted in 7 years and finished in 2017 funded by Germany. In this project, the commune was supported on plant varieties and plant techniques.

4. CONCLUSION

The research has successfully developed a database and maps of forest status in 1995, 2002, 2011 and 2018 with appropriate accuracy by using NDVI index, maps of forest change detection in each period. According to the results of the analysis, the proportion of forest cover increased gradually from 1995 to 2018. In this period, the figures increased from 1690.29 ha to 1918.62 ha and the area without forest decreased from 484.38 ha to 256.05 ha. The number showed that forest land management and forest plantation projects in the research area has been conducted effectively with some afforestation and resforestation projects. The proposed solutions to solve these forest losses are improving local people's livelihood, raising their awareness, enhancing management and protection, applying the cutting-edge technology in forest management.

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ỨNG DỤNG VIỄN THÁM VÀ HỆ THỐNG THÔNG TIN ĐỊA LÝ ĐỂ PHÁT HIỆN BIẾN ĐỘNG RỪNG TẠI XÃ KIM TIẾN, HUYỆN KIM BÔI, TỈNH HOÀ BÌNH GIAI ĐOẠN 1995 - 2018

Trần Quang Bảo, Nguyễn Thị Huệ, Lê Sỹ Hòa

Trường Đại học Lâm nghiệp

TÓM TẮT

Công nghệ viễn thám và hệ thống thông tin địa lý (GIS) được coi là một công cụ hiệu quả và khách quan trong việc giám sát và đánh giá tài nguyên môi trường, đặc biệt là trong việc xác định biến động diện tích rừng. Trong nghiên cứu này, ảnh vệ tinh Landsat 5 TM năm 1995, 2002, 2011 và Landsat 8 OLI/TIRS năm 2018 của xã Kim Tiến, huyện Kim Bôi đã được sử dụng để phân loại và xác định các khu vực có sự thay đổi của diện tích rừng. Nghiên cứu sử dụng chỉ số khác biệt thực vật chuẩn hoá NDVI để thực hiện phân loại ảnh. Các bản đồ phân loại đất rừng và đất khác năm 1995, 2002, 2011, 2018 đã được thành lập với độ chính xác trên 75%, qua đó nghiên cứu cũng tạo được các bản đồ biến động lớp phủ rừng trong 4 giai đoạn khác nhau: 1995 - 2002, 2002 - 2011, 2011 - 2018 và 1995 - 2018. Kết quả cho thấy tổng diện tích che phủ rừng tăng dần qua các năm, biến động nhiều nhất trong giai đoạn đầu, từ 1995 đến 2011 và phân bố không đồng đều, rải rác trên toàn bộ xã. Khu vực giảm rừng tập trung chủ yếu ở gần khu dân cư, có xu hướng mở rộng theo sự phát triển của đường xá ở phía Tây Nam của xã. Diện tích che phủ rừng tăng trong khoảng thời gian 1995 - 2018 có sự đóng góp của các dự án trồng, quản lý và bảo vệ rừng trong hai năm là 1997 và 2017.

Từ khoá: Che phủ rừng, Chỉ số thực vật NDVI, Landsat, phát hiện biến động, tỉnh Hòa Bình.

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