APPLYING GIS AND RS IN ASSESSING THE CHANGE OF FOREST COVER IN THUA THIEN HUE PROVINCE: A CASE STUDY FROM 1989 TO 2015

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ABSTRACT

Forest cover plays an important role in developing socio-economy, protecting biodiversity, regulating water resources, reducing environmental pollution and limiting the impact of natural disasters for Thua Thien Hue Province. In recent years, because of the impact of human activities, the forest cover in this region tends to change rapidly and sophisticatedly. In order to manage the forest resources in Thua Thien Hue Province sustainably, the managers must monitor the change of forest cover in this region effectively. This paper presents initial results on the use of GIS and RS tools for analyzing the change of forest cover in Thua Thien Hue Province from 1989 to 2015. The main data source used in this research is the Landsat images of five years 1989, 2000, 2005, 2010 and 2015 at Thua Thien Hue Province. To address the research goal, the authors use RS tool to interpret Landsat images, then use GIS tool to build forest cover distribution maps and estimate forest cover area in this region over the years. This research has shown the area value and the changing trend of forest cover in Thua Thien Hue Province from 1989 to 2015.

Keywords: *Forest cover; Thua Thien Hue Province; Landsat image; GIS; RS.*

1. INTRODUCTION

Forest cover is a valuable natural resource of Thua Thien Hue Province. This cover plays a crucial role in developing socio-economy, protecting biodiversity, regulating water resources, reducing environmental pollution and limiting the impact of natural disasters for this region. Forest cover is mainly concentrated in the central and western parts of Thua Thien Hue Province. This region has a well-known nature reserve that is Bach Ma National Park (Lan et al., 2002). In recent years, due to human activities, the forest cover in Thua Thien Hue Province tends to fluctuate speedily and complicatedly. In order to manage the forest resources in Thua Thien Hue Province sustainably, the managers must have appropriate solutions for monitoring the change of forest cover in this region effectively. Using GIS and RS technologies is one of possible solutions to resolve this issue. This method has been used for a long time in many parts of the world in the field of forest management and monitoring (Coppin and Bauer, 1994; Shao et al., 1996; Woodcock et al., 2001; Yuan et al., 2005; Hansen et al., 2008; Potapov et al., 2008; Hansen et al., 2010; Brandt et al., 2012; Townshend et al., 2012; Kim et al., 2014).

This paper presents initial results on the use of Landsat image data - medium-resolution satellite image - for monitoring the change of forest cover in Thua Thien Hue Province from 1989 to 2015. The main data source used in this research is the Landsat images of five years 1989, 2000, 2005, 2010 and 2015 of the study area. To address the research goal, the authors use RS tool to interpret Landsat images, then use GIS tool to build forest cover distribution maps and estimate forest cover area in this region over the years. The study area in this research is the entire of Thua Thien Hue Province with one city, six counties and two towns.

2. METHODS AND DATA

2.1 Methods

The research process includes six main phases: (1) collecting related data, (2) correcting Landsat images, (3) enhancing image quality and transforming Landsat images, (4) classifying Landsat images and assessing the accuracy of classification process, (5) building forest cover distribution maps and estimating forest cover area, (6) evaluating results and drawing conclusions. The detailed research process diagram is shown in the Figure 1.

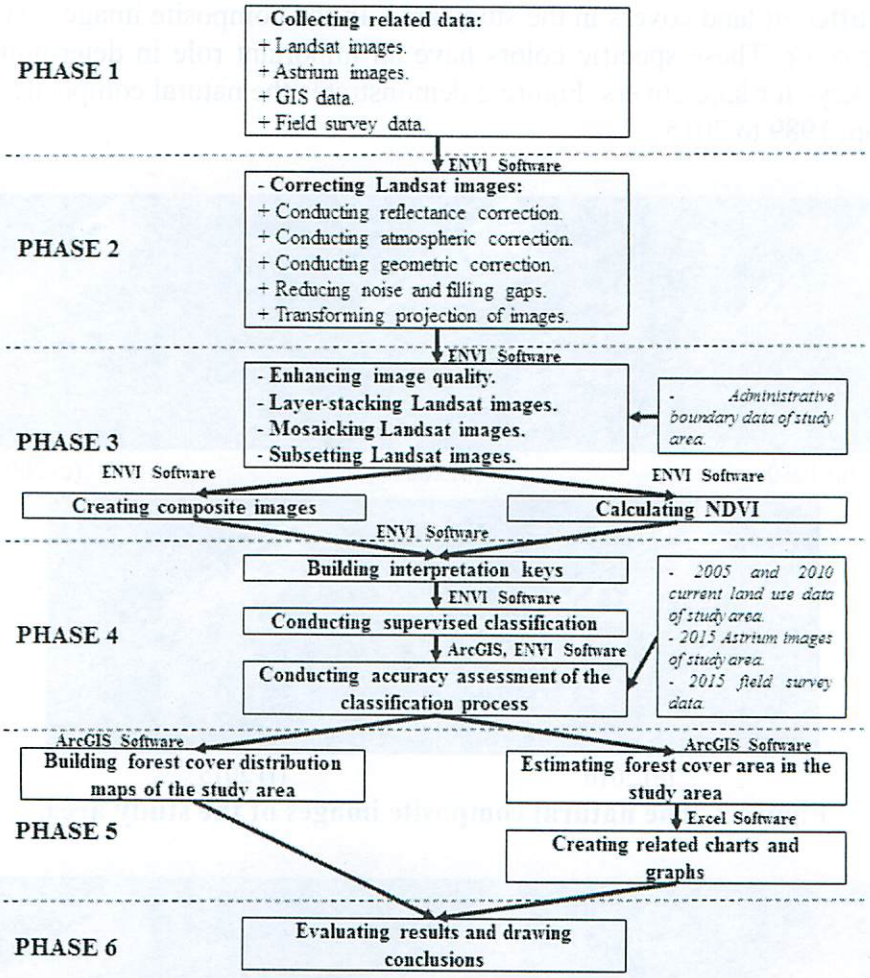


Figure 1. Detailed research process diagram

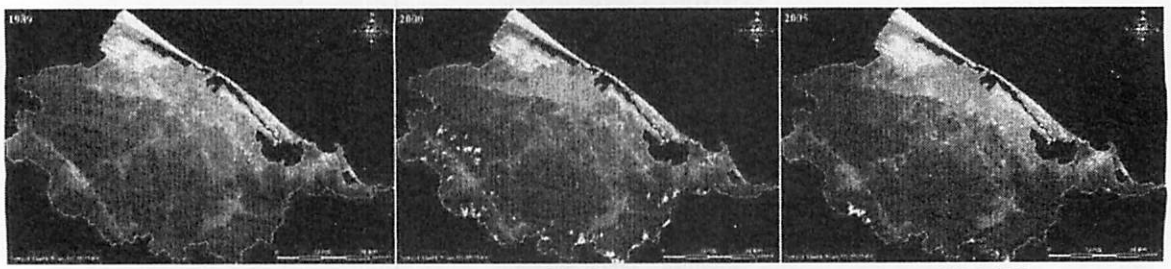
2.2 Data

To handle this research, the authors use three types of data: (1) remote sensing data, (2) GIS data, (3) field survey data. The remote sensing data used in this research is the Landsat images of five years 1989, 2000, 2005, 2010 and 2015 of the study area (*Scene ID* is path 125 and row 049). The second type of data used in this research is the GIS data of the study area. The GIS data includes the administrative boundary data and the current land use data in 2005 and 2010 of the study area. The third type of data used in this research is the field survey data of the study area. The field survey data is collected in 2015 with Garmin GPSMAP 60CSx handheld GPS receiver and Canon 700D camera. Besides that, the authors also use the Astrium images (a type of high-resolution satellite image) in 2015 of the study area to assess the accuracy of the classification process.

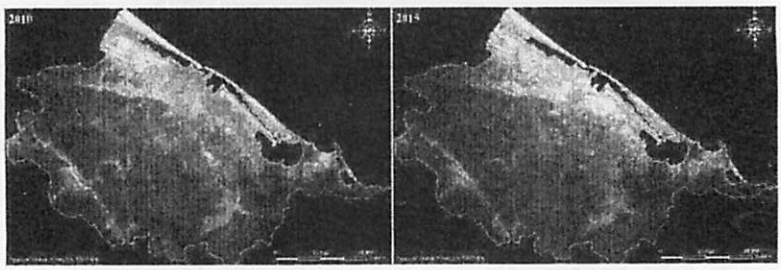
3. RESULTS AND DISCUSSION

3.1 Results of creating composite images and calculating NDVI

The Landsat images used in this research are collected from the GloVis website of USGS, US Federal Government (https://glovis.usgs.gov). After collecting Landsat images, the authors handle to correct, enhance image quality, mosaic and subset these images based on the administrative boundary data of Thua Thien Hue Province. The subsetted images are used to create the composite images of the study area. These composite images help the interpreter discriminate different land covers in the study area. In the composite images, each land cover has a specific color. These specific colors have an important role in determining the set of interpretation keys for land covers. Figure 2 demonstrates the natural composite images of the study area from 1989 to 2015.

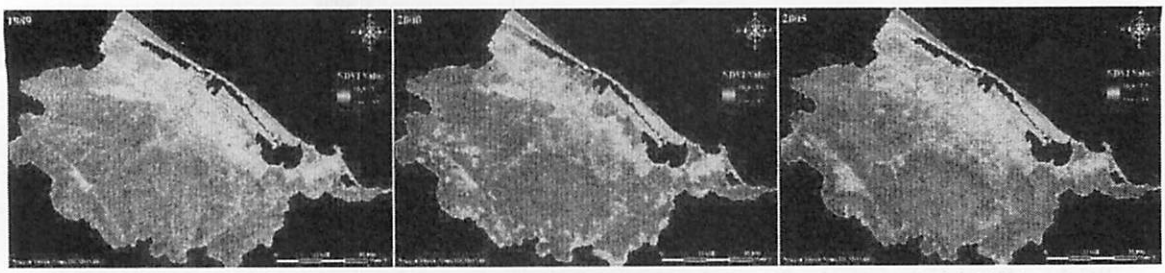


(a) 1989 (b) 2000 (c) 2005

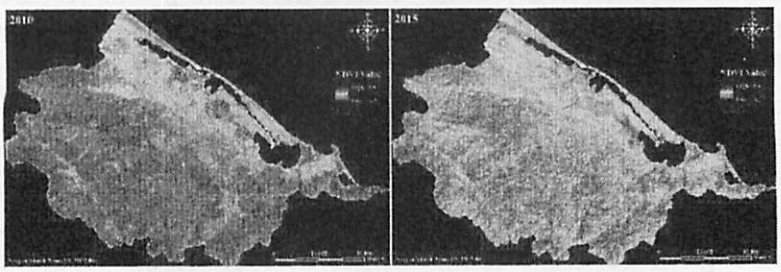


(e) 2010 (f) 2015

Figure 2. The natural composite images of the study area.



(a) 1989 (b) 2000 (c) 2005



(e) 2010 (f) 2015

Figure 3. The NDVI images of the study area

Besides creating composite images, the subsetted images are also used to estimate NDVI. The NDVI helps the interpreter determine vegetation pixels from Landsat images (Rouse et al., 1974). The NDVI values can range from -1 to 1 (Rouse et al., 1974). The areas without vegetation (bare soil, rock, sand) usually have low NDVI values, the areas with sparse vegetation (shrubs, grasslands, crops) usually have moderate NDVI values and the areas with dense vegetation (forest) usually have high NDVI values (Rouse et al., 1974). The NDVI images of the study area are shown in the Figure 3.

3.2 Results of classifying images and assessing the accuracy of classification process

The natural composite images and the NDVI images are used to build interpretation keys. Building interpretation keys is an important process in classifying Landsat images because it affects the accuracy of the classification process. After building interpretation keys, the authors conduct supervised classification on the subsetted images. The supervised classification algorithm used in this research is Maximum Likelihood algorithm. This process separates the study area into six classes: (1) forest, (2) sparse vegetation, (3) bare soil and urban land, (4) waterbody, (5) sand and cloud, (6) cloud shadow.

After classifying Landsat images, the authors handle to assess the accuracy of the classification process which is expressed through Kappa Coefficient and Overall Accuracy. Because of the lack of verification data, the authors can only assess the accuracy for the classification results in three years 2005, 2010 and 2015. The Table 1 shows the Kappa Coefficient and Overall Accuracy of the classification results in 2005, 2010 and 2015. The values in Table 1 show that only the result in 2015 is in line with the USGS standard.

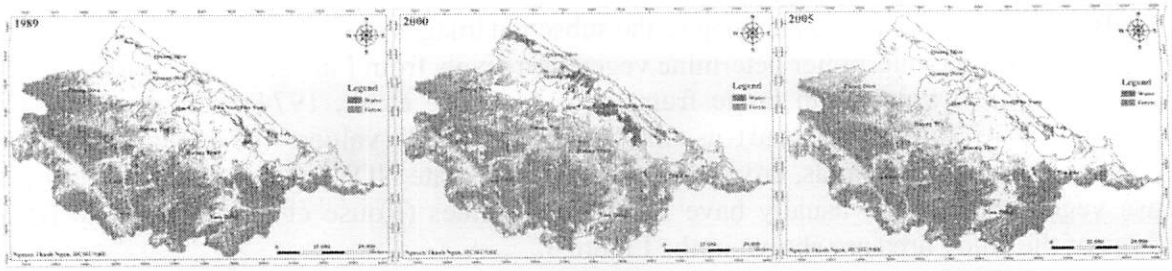
Table 1. The results of the accuracy assessment of the classification process

Classification result	Verification data	Overall Accuracy	Kappa Coefficient
2005	Current land use map	78.6215%	0.7298
2010	Current land use map	84.0539%	0.7809
2015	Astrium images and field survey data	86.5153%	0.8365

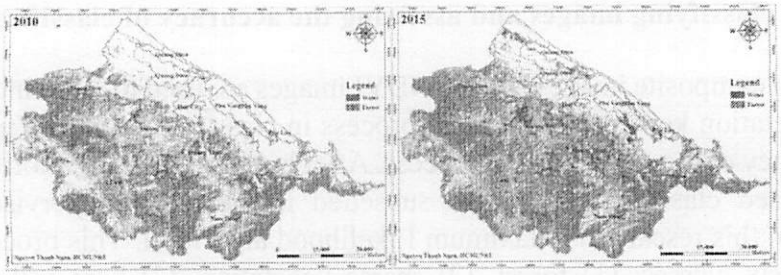
3.3 Results of building distribution maps and estimating forest cover area

After performing supervised classification, the authors conduct to extract forest cover data from classification results. The forest cover data is combined with other GIS data to build forest cover distribution maps of the study area. These maps are shown in the Figure 4.

Besides building forest cover distribution maps, the authors also use forest cover data to estimate forest cover area and percentage change of forest cover in the study area. The results of this process are shown in the Table 2. After estimating forest cover area, the authors use these results to create the graph of the forest cover area in the study area from 1989 to 2015. This graph is shown in the Figure 5.



(a) 1989 (b) 2000 (c) 2005



(e) 2010 (f) 2015

Figure 4. The forest cover distribution maps of the study area

Table 2. The area value and percent change of forest cover in the study area from 1989 to 2015

Year	Forest cover area (ha)	Percent to total area (%)	Percent Change (%)	Annual Percent Change (%)
1989	236,074	49.1865		
2000	250,052	52.0908	5.9210	0.5383
2005	215,460	44.8846	-13.8339	-2.7668
2010	216,283	45.0560	0.3820	0.0764
2015	274,978	57.2833	27.1381	5.4276

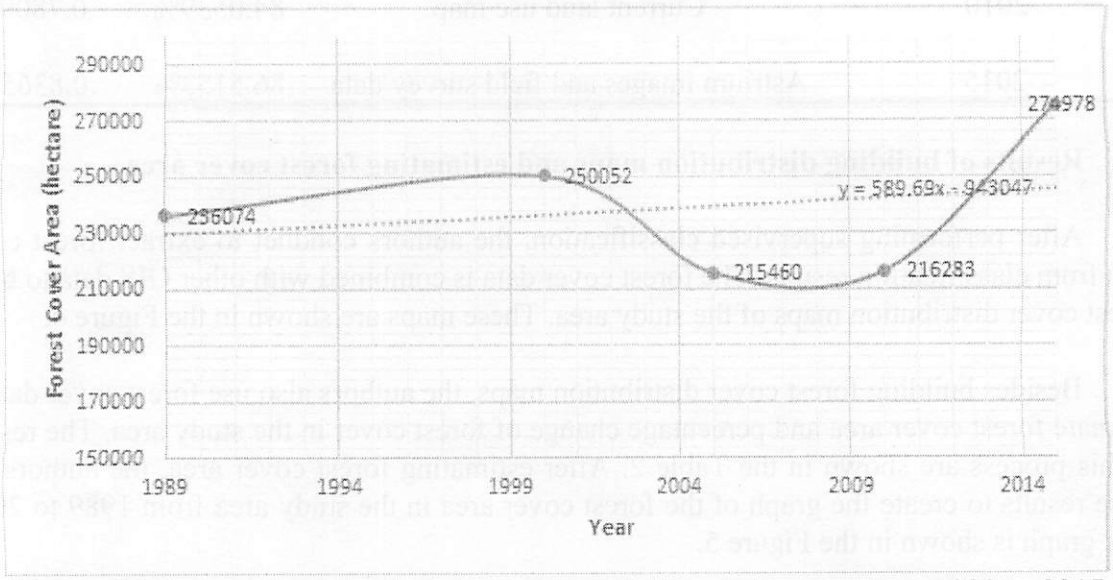


Figure 5. The graph of the forest cover area in the study area from 1989 to 2015

Based on the results in the Table 2 and the graph in the Figure 5, the authors identify the changing trend of the forest cover area in the study area from 1989 to 2015. From 1989 to 2000, the forest cover area in the study area tends to increase at a rate of 0.5383% per year. From 2000 to 2005, the forest cover area in the study area tends to decrease at a rate of 2.7668% per

year. From 2005 to 2010, the forest cover area in the study area tends to increase at a rate of 0.0764% per year. From 2010 to 2015, the forest cover area in the study area tends to increase at a rate of 5.4276% per year. Besides, based on the maps in the Figure 4, the authors also determine the spatial distribution of forest cover in the study area. The forest cover is mainly distributed in four counties and two towns: A Luoi County, Nam Dong County, Phong Dien County, Phu Loc County, Huong Thuy Town and Huong Tra Town.

4. CONCLUSIONS

From the results obtained, the authors find that this research has fully solved the research goal which is mentioned in the introduction. This research has identified the area value, percentage, changing trend, and change rate of forest cover in the study area from 1989 to 2015. Besides, this research has also determined the characteristics of the spatial distribution of forest cover in the study area from 1989 to 2015. These will be valuable data for the managers of Thua Thien Hue Province in managing forest resources sustainably. In addition, through this research, the authors have built a process to create forest cover distribution map and estimate forest cover area from Landsat image. This will be a useful reference for the studies in natural resource management field.

5. REFERENCES

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