

ASSESSMENT OF LAND USE CHANGE IN KON - HA THANH RIVERS CATCHMENT USING LANDSAT IMAGES

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Abstract - Analysis of land use maps will provide important information upon which most management and intervention policies rely. Land use changes may have major impacts on the use of resources such as conditions for land and water use. However, land use map is often scarce for large area due to expensive statistics measurement work. In this study, the land use of Kon – Ha Thanh rivers catchment is mapped from 1990 to 2017 using remote sensing and geographic information system (GIS). It is found that the land use map generated in this study is in good agreement with the actual map provided by Binh Dinh Province Department of Planning and Investment (2017). Land use maps and the trend of conversion between soil types are analyzed and presented in detail during 1990-2017. The study outcomes can provide essential information for planning and sustainable development activities in the context of rapid industrialization and urbanization epoch.

Key words - GIS; Land use; Kon – Ha Thanh; Landsat Images.

1. Introduction

Land use is changing due to human development activities and also due to natural conditions. Assessing changes in land use is essential to developing effective management strategies, especially in the current era of rapid industrialization and urbanization. The information and statistical data on land use changes is very important for planning, management land. In this study, the land use of Kon – Ha Thanh rivers catchment was mapped from 1990 to 2017 using remote sensing and geographic information system (GIS).

Nowadays, with the development of science and technology, the satellite images and remote sensing GIS technology has supported many people in studying the dynamic variables of land use cover. Remote sensing data is multi-time, multi-spectral, large-scale coverage allows access and conduct researches quickly, effectively as well as saving time. Especially in the study of land use maps, this technology has many advantages based on the ability to update information and analyze changes quickly. The application of high resolution remote sensing images in resource management has been a new direction for natural resource planning in general as well as forest resources in particular [1] - [5].

The human activities including urbanization, resources exploitation and development of hydropower reservoirs have been considered to have large impacts in land use change in Kon – Ha thanh rivers catchment. This river catchment is in South Central Vietnam and covers major parts of Binh Dinh province. There is a small part of river basin belong to Gia Lai province. (Figure 1). Kon and Ha Thanh are main rivers in this basin, which have basin area of 2582 km² and 549 km², respectively. The total river length of Kon and Ha Thanh about 178 km and 58km, respectively. This area is featured by a variety of morpho structures like the relatively narrow mountainous area on the upstream. The altitude ranges from 0 to 1400 above sea level.

This basin is characterized by a variety of morph structures such as relatively narrow mountainous at upstream and small plains in the river mouth. Land use features are complex due to the increasing of settlements as well as the water body area. This is a consequence of the massive development of hydropower during the past 20 years. The natural vegetation was represented by natural forests. The water surface is mainly hydropower and irrigation reservoirs, and river system. The hillsides are occupied by planted forests, while in the lowlands and plains, agricultural crops are mostly expanded (cereals, vegetables, rice). There have been several studies on this river basin, but most of them have focused on the flow regime under the influence of climate change [6] or operating a hydroelectric reservoir [7].

In this catchment area, changes in land use area are considered to have impacts on natural resources and ecological process such as flows, soil erosion, land use conditions. Especially, the situation of forest exploitation as well as the conversion of land use without control has a great impact on the flow regime in the catchment. Floods occur more frequently in Binh Dinh province [6]. Therefore, updating of land use mapping is important work and required to various departments. This study focuses on the changes of land use from 1990 to 2017 of Kon – Ha Thanh rivers catchment. The state and trend of changing land use are presented.

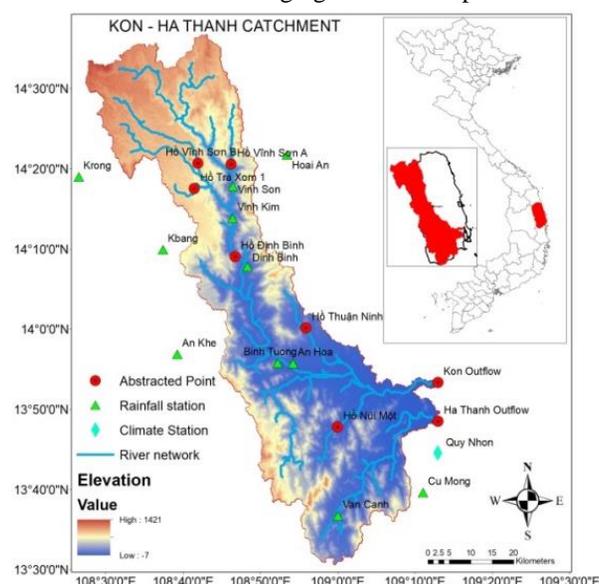


Figure 1. Study area

2. Methodology

Landsat and other remote sensing satellites have provided digital images in infrared spectral bands, with the help of computer tools, humans can clearly identify the

range of water-land regions. Image processing techniques are growing and have provided a viable solution to some of the issues of creating and updating maps [8]. Lands at imagery is increasingly being applied to land-use planning because of its advantages over more traditional methods.

In order to analyze land use change in 28-years the Lands at satellite image of 1990, 2000, 2010 and 2017 was obtained from official website of USGS, see Table 1. The analysis process is performed according to the diagram as shown in Figure 2. The “Vegetation Index Differencing” (NDVI) analysis was used to initially assess the change of land use in pre-classification process. In supervised classification, the maximum likelihood technique was used to obtain land use category.

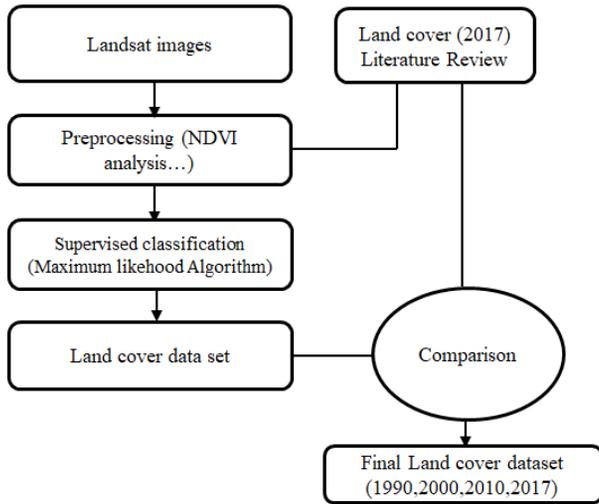


Figure 2. Data analysis flow chart

Table 1. The information of satellite images

No	Satellite id	Sensor id	Path/ row	Acquisition date	Spatial resolution
1	Landsat 5	TM	124/50	13/02/1990	30 m
2	Landsat 7	ETM	124/50	04/03/2000	30 m
3	Landsat 5	TM	124/50	04/02/2010	30 m
4	Landsat 8	OLI	124/50	07/02/2017	30 m

As stated above, the author used the normalized differenced indices to distinguish land use classes in preprocessing. In this study area, vegetation is the most common feature so NDVI analysis was performed to identify the change between the variables of vegetation cover. The NDVI is a standard vegetation index and it is determined based on the reflective properties of the areas covered by vegetation. This indicator shows the distinction between different types of land use by taking into account the variation in the value of green biomass, canopy water stress and chlorophyll content [3]. The value of the NDVI band varies from -1 to +1. The highest values represent vegetation zones while low values indicate the absence of vegetation, (see Figure 3).

Land use features were obtained using a supervised classification. The Supervised Maximum Likelihood classification is considered to be the most popular method of remote sensing image data analysis [9]. This method helps identify and locate land use types. The algorithm is

able to classify a pixel taking into account the variance and covariance of the spectral response pattern of each type. It creates probability density functions for each spectrum type, used to classify an unknown pixel by calculating the probability of the pixel that belongs to each class. The pixel is then assigned to the class with a higher probability [1].

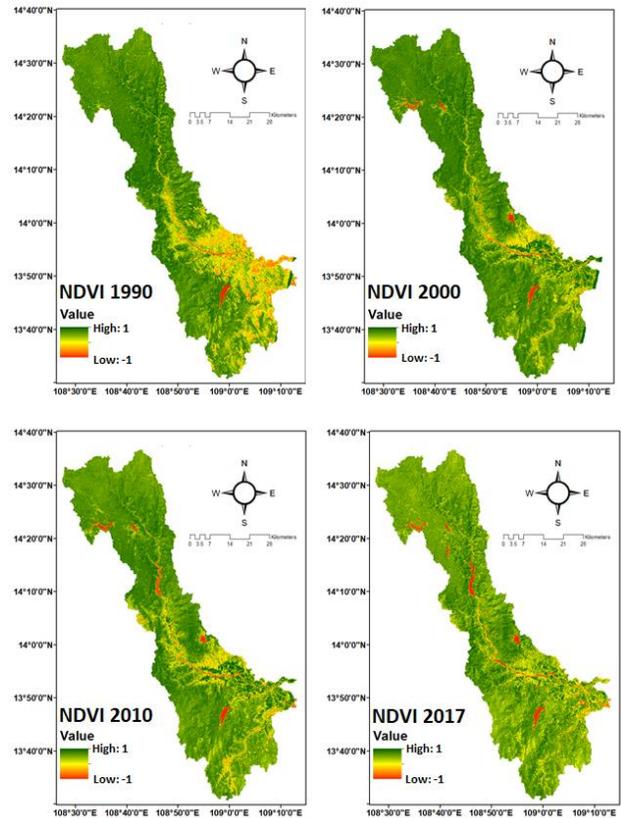


Figure 3. Normalized difference indices NDVI (of vegetation)

We categorized 4 land use types based on the information of geography in this research area. This area consists mostly of forests and is located mainly in the highlands. The trees in the forest are mainly broadleaf trees and they occupy a large area. Table 2 shows the land use types.

Table 2. The description of land use types

No	Land use types	Descriptions
1	Forest	Natural forest, plantation forest,
2	Mixed agricultural land	Land agriculture, paddy, barren
3	Built-up area,	Houses, villages, artificial infrastructure, roads
4	Water bodies	River, permanent open water, reservoir

3. Results and discussions

3.1. Validation of the results

The overall accuracies of the land use maps in 2017 is shown in Table 3. The classes with highest accuracies in land use maps are water surface and forest areas. The difference between actual area and predicted area of forest area and water surface area are about 3.3% and 0.76%, respectively. The built-up and mixed agricultural land are two types that have the lowest accuracies (74.49% and 78.69% respectively). The low accuracies of mixed agricultural and built-up areas can be explained based on

the similarity of spectral characteristic. Mixed agricultural land has high possibility to mix with urban areas. Moreover, this low accuracy can also be explained by the fact that these areas are small, resulting in poor satellite image analysis. In terms of land use map 2017, built-up area and mixed agricultural land occupied 8.1% and 15% in total area, respectively. For the land use types occupying small area, the coarse resolution of satellite image has been considered as a major factor to reduce the accuracy of the processing performance. These soils are also often identified with low accuracy in previous studies [5].

Table 3. Land use area considered for validation

Land use types	Actual area (ha)	Predicted area (ha)	Accuracy (%)
Forest	227804	235328	96.70
Mixed agricultural land	59804	47062	78.69
Water bodies	5194	5233	99.24
Built-up area	20299	25477	74.49

The authors also compared the result with the land use map provided by Binh Dinh Province Department of Planning and Investment. Figure 4 shows the official data in 2017 for comparison. It can be seen that the land use map generated in this study (see Figure 5, year: 2017) is in good agreement with official map.

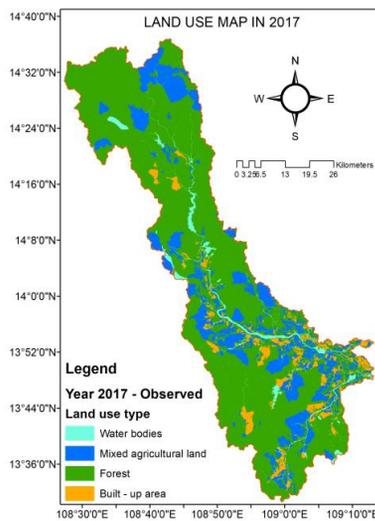


Figure 4. Land use map provided by Binh Dinh Province Department of Planning and Investment

3.2. Mapping land use

The technique validated in Part 3.1 is used for classifying the land use in Kon – Ha Thanh catchment in different periods. The land use map is generated and shown in Figure

5. It shows four classes of land use: forest, mixed agricultural land, built-up area, and water bodies. The area of land use categories are presented in Table 4. It can be seen that, approximately 75% of Kon – Ha Thanh River catchment's total land area was forested in 2017. The forests appear on large areas on the mountain which have higher altitudes.

From 1990 to 2017, forest area decreases and other types of land use (such as mixed agricultural land, built-up area, and water bodies) increase gradually. For 1990 - 2000, the built up area increased significantly. The occurrence of hydropower reservoirs in the river catchment has caused the water surface area to increase rapidly between 1990 and 2017. This change was also depicted visually in Figure 6 through the replacing forest land with water bodies when Vinh Son A, Vinh Son B, Tra Xom, Thuan Ninh Nui Mot, Dinh Binh hydropower reservoirs were built. In mountainous area, people tend to live near rivers and do farming in narrow plains along those rivers. The agricultural areas around the river are also submerged in water when the reservoirs are built. People have been relocated and new resettlement villages will be formed [10].

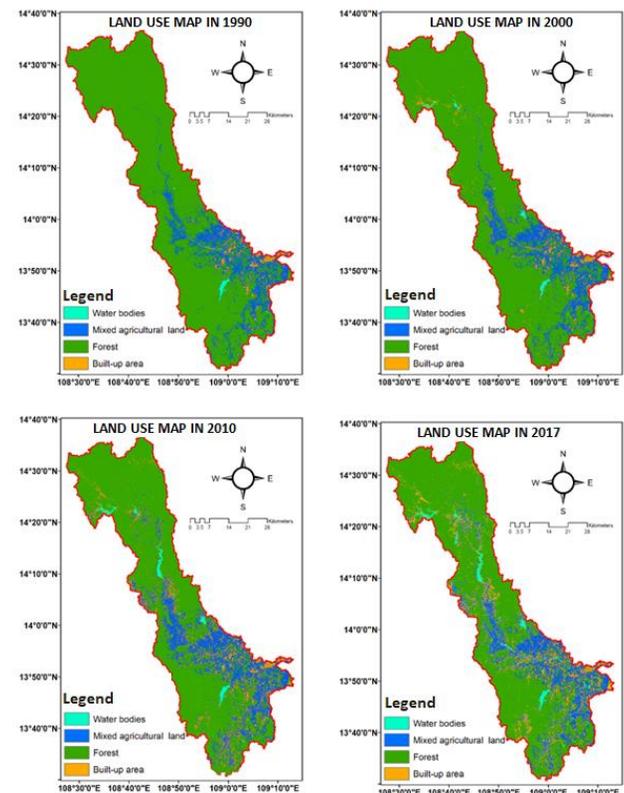


Figure 5. Land use map of Kon – Ha Thanh rivers catchment (1990-2017)

Table 4. The area of land use types during 1990-2017

Land cover types	1990		2000		2010		2017	
	area (ha)	Percentage (%)						
Forest	260842	83,31	246729	78,80	240632	76,85	235328	75,16
Mixed agricultural land	42585	13,60	43612	13,93	46517	14,86	47062	15,03
Water bodies	1312	0,42	1929	0,62	3521	1,12	5233	1,67
Built-up area	8361	2,67	20830	6,65	22431	7,16	25477	8,14

The process of urbanization as well as the appearance of residential areas near the reservoir area also leads to an increase in urban land area. Built-up area increased by 3 times from approximately 8000 ha in 1990 to 25000 ha in 2017. This shows that the process of urbanization is extremely rapid in the study area, especially at downstream and estuarine areas. It is well known that the estuarine area provides a good condition to develop socio-economic activities. Therefore, it has a high density of settlements, including Quy Nhơn city. Mixed agricultural land increased slightly from 42000 ha to 47000 ha during this period.

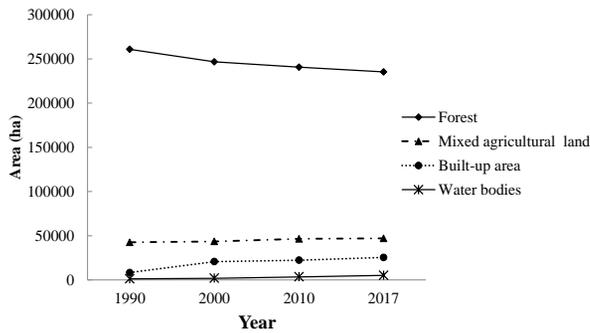


Figure 6. The change of the land use in Kon - Ha Thanh rivers catchment

4. Conclusions

In this study, the author used satellite remote sensing data to map land use types in Kon – Ha Thanh rivers catchment. For 2017, the land use type had the highest producer's accuracy (over 90%) in forest and water surface, whereas the type of built-up area and mixed agriculture area had a relatively lower value of around 75%. The analysis showed that there is an increase in water bodies, built-up areas and mixed agriculture, and a decrease in forest area from 1990 to 2017.

The results are expected to introduce land use data at

different times for the Kon river basin - Ha Thanh. The data is essential for models involving flow, erosion, and other regional studies. The study outcomes can provide important information for planning, zoning, and sustainable development activities in this region.

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