Trans-KARST 2004, Proceedings of the International Transdisciplinary Conference on Development and Conservation of Karst Regions, Hanoi, Vietnam, 13-18.9.2004.
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REMOTE SENSING AND GIS ANALYSIS OF THE LANDCOVER IN TROPICAL KARST SUOIMUOI CATCHMENT IN VIETNAM

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Keywords: remote sensing, GIS, landcover, change detection analysis.

1 Introduction

One of the most effective tools for environmental studies in mountainous areas, especially tropical karst mountainous areas, is remote sensing and GIS. Remote sensing and GIS technologies are scientifically established tools, but are not yet routinely used in environmental analysis, monitoring and impact analysis. The here presented remote sensing and GIS supported environmental analyses consist of methods for image transformation, image fusion, time series, and change detection analysis. In this paper different remote sensing and GIS techniques are applied with the purpose to deduce geological and hydrological information. Landsat multispectral bands were integrated with the high resolution Landsat ETM panchromatic band. Time series and change detection analysis is applied for studying land cover changes.

2 Study area

The study area, the Suoi Muoi River catchment, is situated northwest of the city of Son La, between longitude 103°33’ E and 104°00’ E and latitude 21°20’ N and 21°29’ N, covering 284 km² (Fig. 1). The Son La karst area is part of the Son La-Thuan Chau karst highland, a mountain range extending over 300 km in NW-SE direction and with an average width of 10-30 km. The karst landscape is characterised by the absence of permanent surface flow, closed depressions, caves, the existence of large springs, and the presence of sinkholes into which entire streams, like the Suoimuoi River, disappear underground. In the Suoimuoi catchment, the karst landscape occurs mainly in the central part and stretches from northwest to southeast, averaging 10 km wide and ranging from 500-850 m high. The landscape is characterized by a peak cluster morphology (*cf.* Chinese Fengcong), blind valleys, deep dolines, narrow valleys, chained sharp peaks and many swallow holes exiting underground into caverns. In the middle part of the area, mainly peak forest landscape dominates with residual karst peaks and tower karst, which emerge here and there above the dissolution-erosion valleys (Tuyet, 1998). The climate characteristic of the Suoimuoi catchment is humid subtropical with summer rainfall and a monsoon regime. The major climate characteristics in the research area are summarized in Table 1.

The area is mainly inhabited by ethnic minority groups. The Thai, the major ethnic group, is poorly economically developed and suffers from low living conditions. Regular life threatening conditions as droughts, floods, earthquakes and epidemic diseases occur.

3 Methodology

Image fusion is defined as “The combination of two or more different images to form a new image in a certain algorithm” (Carper *et al.*, 1990). The definition of image combinations and techniques depends on the characteristics a data set should have in order to serve the user. As our purpose is integrating different images from different sensors to facilitate visual interpretations, pixel based fusion provides a useful tool. It can be grouped into two main classes: color related techniques and statistical/numerical techniques. The second group uses statistics about individual channels for correlation analysis. The color related methods deal with the transformation between display-device and perceptual color spaces. The most popular color related technique is based on the intensity – hue – saturation (HIS)

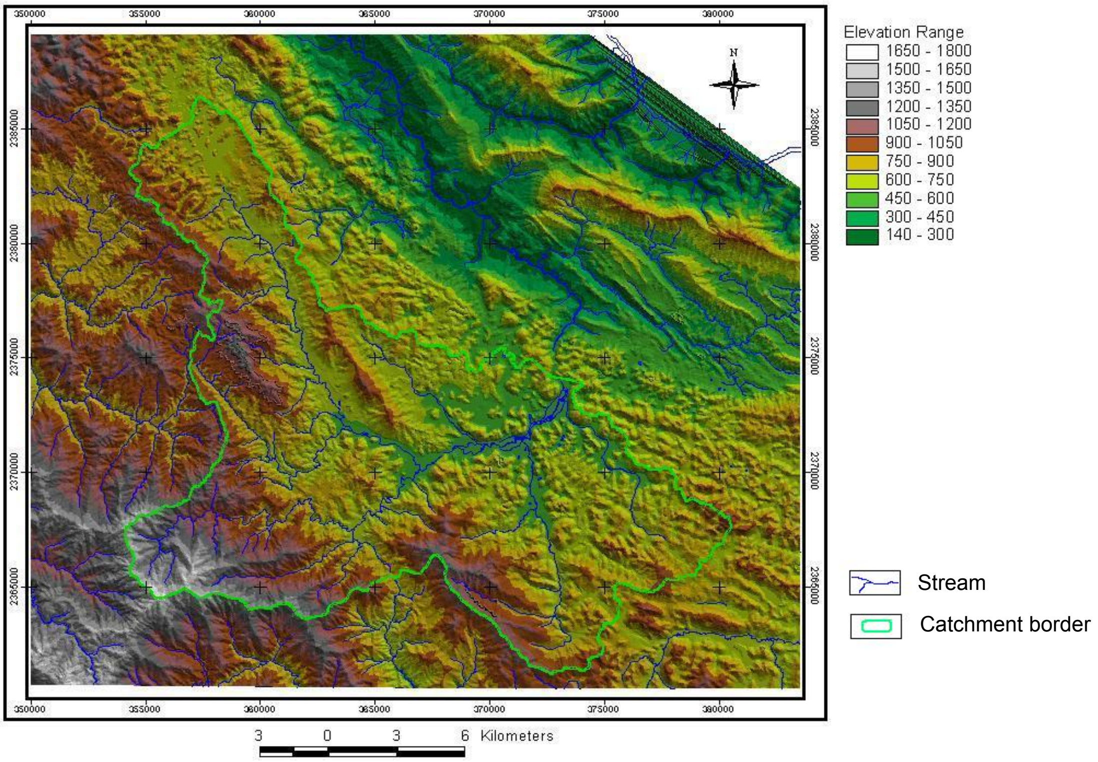

Fig. 1: Suoi Muoi River catchment.

Table 1: Summary of climatic data for the research area.

	Dry season (Oct-Mar)	Wet season (Apr-Sep)	Yearly
Mean temperature (°C)	18.0	24.2	21.1
Mean min. temp. (°C)	12.5	20.7	16.6
Mean max. temp. (°C)	24.7	29.2	27.0
Mean Precipitation (mm)	27.5	230.8	258.3
Evapotranspiration (mm)	104.2	133.8	148.0

transform. This technique transfers the composition in RGB space to the IHS space. The IHS technique can be applied to fuse images from a single sensor, or multisensor data, or image data with ancillary data. Some geoscientists have experimented intensively fusion with the IHS method using geophysical data, geochemical data, thematic data, and data compiled from fieldwork (Harris *et al.*, 1990; Schetselaar, 2000).

Change detection techniques can be roughly grouped into two categories: (1) those detecting binary change/non-change information, such as using image differencing, image ratioing, vegetation index differencing, and principal component analysis (PCA); and (2) those detecting detailed “from-to” change trajectory, such as using the post-classification comparison and hybrid change detection methods.

Vegetation indices (VI) in remote sensing are combinations of reflectance of two or more bands, usually in the visible red band and the near infrared band. The most common vegetation index is the *Normalized difference vegetation index* (NDVI).

$$NDVI = \frac{\left(R_{nir} - R_{red}\right)}{\left(R_{nir} + R_{red}\right)}$$

Where: R is the reflectance, (DN) after haze correction, of the red (R_{red}) and the near infrared band (R_{nir}). The NDVI is a ratio ranging in from –1 to +1.

For Landsat MSS sensor, the visible red and the near infrared band correspond to band 5 and band 7, respectively. For Landsat TM sensor the visible red and the near infrared band correspond to band 3 and 4, respectively.

Digital image classification uses the spectral information represented by the digital numbers in one or more spectral bands, and attempts to classify each individual pixel based on this spectral information. The resulting classified image is comprised of a mosaic of pixels, each of which belong to a particular theme, and is essentially a thematic "map" of the original image. There are two common ways of digital image classification: *supervised classification* and *unsupervised classification*.

An *unsupervised classification* method is used here, it is based on the numerical information in the data, which is then matched by the analyst to information classes. The clustering algorithms are used to determine the natural (statistical) groupings or structures in the data. Usually, the analyst specifies how many groups or clusters are to be looked for in the data. In addition to specifying the desired number of classes, the analyst may also specify parameters related to the separation distance among the clusters and the variation within each cluster.

4 Result and discussion

The result of the landuse classification is given in Fig. 2, it represents the result of NDVI classification with additional information from aerialphotos. Main land uses in Suoimuoi from 1973 to 1993 are listed in Table 2. From 1973 to 1993, more than 36% of forest area and nearly 24% of shrub area disappeared (Table 2). The lost area of vegetation cover is totally converted in arable land and bare soil. We notice the incredible speed of the losses in Fig. 2.

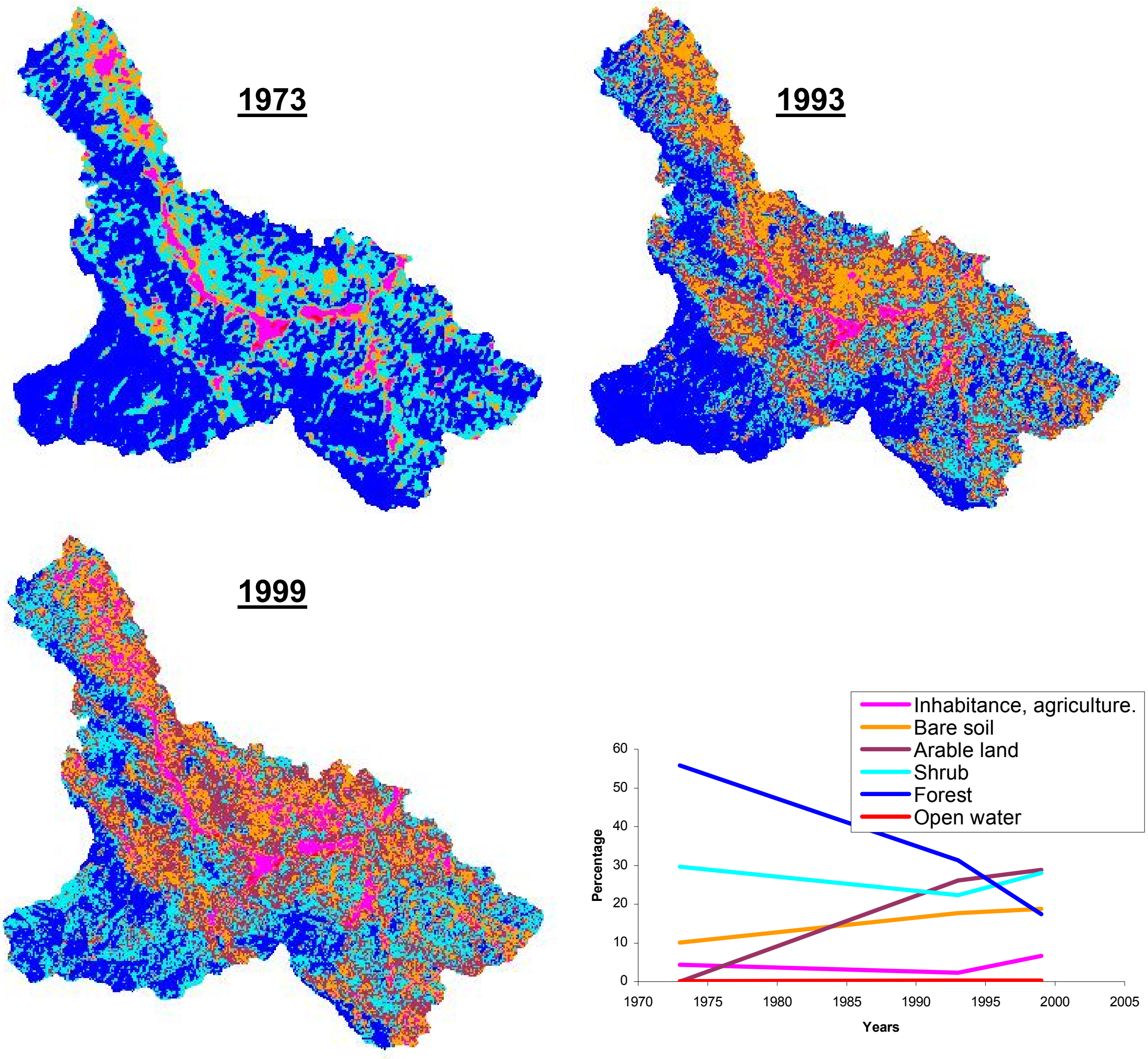

Fig. 2: Landuse map of Suoimuoi catchment in 1973 – 1993 – 1999.

Table 2: Main landuse in Suoimuoi through 1973 – 1993 – 1999.

Description	1973		1993		1999	
	Area	%	Area	%	Area	%
Open water	457200	0.16	648000	0.23	857925	0.30
Inhabitance, agriculture.	12434400	4.38	6633000	2.34	18823950	6.63
Bare soil	28540800	**10.05**	50065200	**17.64**	53157150	**18.73**
Arable land	0	**0.00**	74205900	**26.14**	81762750	**28.80**
Shrub	84078000	**29.62**	63362700	**22.32**	79653600	**28.06**
Forest	158346000	**55.78**	88938000	**31.33**	49614975	**17.48**
Σ	283852800	100.00	283852800	100.00	283852800	100.00

In only 6 years, from 1993 to 1999, the forest area decreased with 44%. The average decrease of forest loss per year in the period 1993-1999 is twice bigger than in the period of 1973-1993. If the same speed of forest loss as during 1993-1999 is maintained than around 2005 almost all the natural forest in Suoimuoi catchment will have disappeared.

5 Conclusion

Using an IHS transformation with a hue invariant in merging high resolution PAN with multi spectral Landsat ETM7 gave the potential of maintaining the spectral balance of the multispectral data set. The integration of Landsat ETM7 band 7-4-1 with high resolution PAN provided complementary information with respect to the discrimination of major geographical feature in detail. With the high-resolution image, both type of features, manmade and natural, are easy to recognize.

This investigation shows that the forest area in the Suoimuoi catchment decreases very fast. The present forest cover is a meagre 17.5% comparing to 55.8% in 1973. The main reason for the deforestation is human activities. The loss of natural forest will cause many natural disasters (flooding, landslide...) in the catchment.

6 References

Carper, W.J., Lillesand, T.M., and Kiefer, R.W., 1990, The use of intensity-huesaturation transformations for merging SPOT panchromatic and multispectral image data: Photogrammetric Engineering and Remote Sensing, v. 56, p. 457-467.

Hung L.Q., 2001. Remote Sensing Based Hydrogeological Analysis In Suoimuoi Catchment – Vietnam. MSc thesis, VUB Belgium.

Harris, J.R., Murray, R., and Hirose, T., 1990, IHS transform for the integration of radar imagery and other remotely sensed data: Photogrammetric Engineering and Remote Sensing, v. 56, p. 1631-1641.

Schetselaar E.M., 2001. On Preserving Spectral Balance in Image fusion and Its Advantages for Geological Image Interpretation. Photogrammetric Engineering and Remote Sensing journal. Vol 67, p 925-934.

Tuyet, D., 1998, Karst geology investigation of the northwest region: Hanoi, Research Institute of Geology and Mineral Resources, 251 p.