LAND USE/COVER MAPPING OF MOUNTAINOUS AREA USING KNOWLEDGE BASED CLASSIFICATION APPROACH – CASE STUDY IN BACKAN PROVINCE, VIETNAM

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ABSTRACT

Mountainous area in Vietnam is mostly dominated by ethnic groups which rely on various agricultural activities composed of lowland and upland cultivation. The upland cultivation is one of traditional methods of how local people use the land. This activity, however, has great impact on environment due to forest cutting, exploitation of vegetation cover for household usage such as fuel consumption, house building material etc. One of the way for monitoring shifting cultivation including distribution of upland crop is usage of mutitemporal remote sensing images. To facilitate better change analysis, the single date remote sensing data should be analyzed by consistent methodology so that classification results of different times can be comparable to the other. In this study, the author proposes a so called knowledge based classification approach for land use/cover mapping. In this research, the SPOT image is segmented at first into bare and vegetated land (mask image). The bare land is further divided into upland and lowland areas by using hydrographical network. This model is based on the fact that all lowland is situated along rivers or streams. Because lowland is limited to valley areas that have been long time exploited so we could assume that there is no change. By subtraction of lowland crop from the mask image we could generate upland cultivated areas that is important for monitoring mountainous environment as well as vegetation degradation rate. By using land use model typical for ethnic people in study area we can further extract mosaick /orchard from the classified image. The final land use/cover map that is featured by classes: forest, bush land, grassland, upland crop, lowland crop, mosaick, water body and bare land (transition and built up) is used as input for subsequent change analysis.

1. Introduction

Vietnam is a country with about 3/4 of land area dominated by mountainous terrain. This mountainous terrain contains all forest resources and watersheds that play important roles in the environmental processes such as drought, flood and soil erosion etc. Therefore, monitoring of land use in this area is an urgent requirement to gather timely information on sustainable development of the country. Land use mapping in mountainous area is quite difficult due to low accessibility in the field. Remote sensing data has been applied frequently recently. However, due to scatter characteristics of shifting cultivation and difficulties in separation of upland from lowland, the land use interpretation on remote sensing data is often time consuming and requires many auxiliary information. To improve quality of the image interpretation and to enable better change analysis, the author has proposed a so called knowledge based interpretation approach for land use/cover mapping. In this research, the SPOT image is segmented at first in to bare and vegetated land (mask image). The bare land is further divided into upland and lowland area by using hydrographical network. This model is based on the fact that all lowland is situated along rivers or streams. Because lowland is limited to valley areas that have been long time exploited so we could assume that there is no change. By subtraction of lowland crop from the mask image we could generate upland cultivated areas that is important for monitoring mountainous environment as well as vegetation degradation rate. By using land use model typical for ethnic people in study area we can further extract mosaic /orchard from the classified image. The final land use/cover

map is featured by classes: forest, bush land, grassland, upland crop, lowland crop, mosaick, residential area, water body and bare land (transition and built up).

2. Study Area

The study area is located in the north of Vietnam covered by two SPOT scenes 268-305 and 268-306 taken on December 23, 2001. The study area belongs to Backan province which has population of 276,689 residents with density of 57.4 persons / km2. The population is composed of five ethnic groups as Kinh, Tay, Nung, Dao and San Diu. Except the Kinh, the other ethnic groups exploit prevalently forest resources for their basic leaving including food production, household building materials and fuel consumption. There are two main cultivation customs: water rice in lowland and upland crops with rice, maize and been cultivation. The upland cultivation with shifting characteristics has caused loss of forest cover and increase soil erosion in general. The terrain is hilly with average elevation of 500 m above sea level and covered by evergreen broadleaf vegetation. The climate of Backan is divided into two seasons: dry season from November to April and raining season from May to October. Location of study area in Vietnam is shown on figure 1.

Figure 1. Location of study area in north of Vietnam (left)

3. Materials

The input data is composed of two SPOT scenes taken on December 23, 2001. Scene parameters are given in the table 1. The observation time was in the beginning of dry season. Most of cultivation in the north of Vietnam at that time is after harvest so crop land appears almost as bare land with typical bright cyanic color on standard false color composite. The image quality is very good without any clouds. The only thing which can impact the image analysis is the incident angle of HRV instrument is a little bit large that could result some errors in geometric correction.

Table 1. Scene parameters of SPOT images

Scene	268-305	268-306
Date	12/23/01	12/23/01
Time	03h51mn40s	03h51mn49s
Instrument	HRV 1	HRV1
Processing level	1A	1A
Orientation angle	010.0	010.0
Incident angle	L11.4	L11.4
Absolute calibration gains	1.28754 1.02603 1.40642	1.28754 1.02603 1.40642

A set of topographical maps 1:50000 in UTM projection were used for GCP collection and geometric correction. These SPOT scenes were at first mosaicked together then geo-rectified using selected GCP. Geo-referenced images were finally combined with vector GIS database supplied by SAM-Regional program. GIS layers that were used to support image

classification are hydrographical network, map of residential areas and administrative boundaries

4. Field work

The purpose of field work is to select ground truth samples and to be familiar with land use practice in the study area.

The first field work was organized from April 15 to 20, 2002. During this field work 291 GPS photos was taken. Some interviews with local people on upland cultivation practices have been carried out.

The second field work was undertaken from May 20 to 25, 2002. This field work is to validate classification result of 2001 image and to collect some more information for better classification of shrub on south of Cho Don district. Figure 3 is an example of land use practice taken by GPS photo camera KONICA LandMaster. 313 GPS photos were taken to support validation. On figure 2. green dots represent observation points with GPS photos.

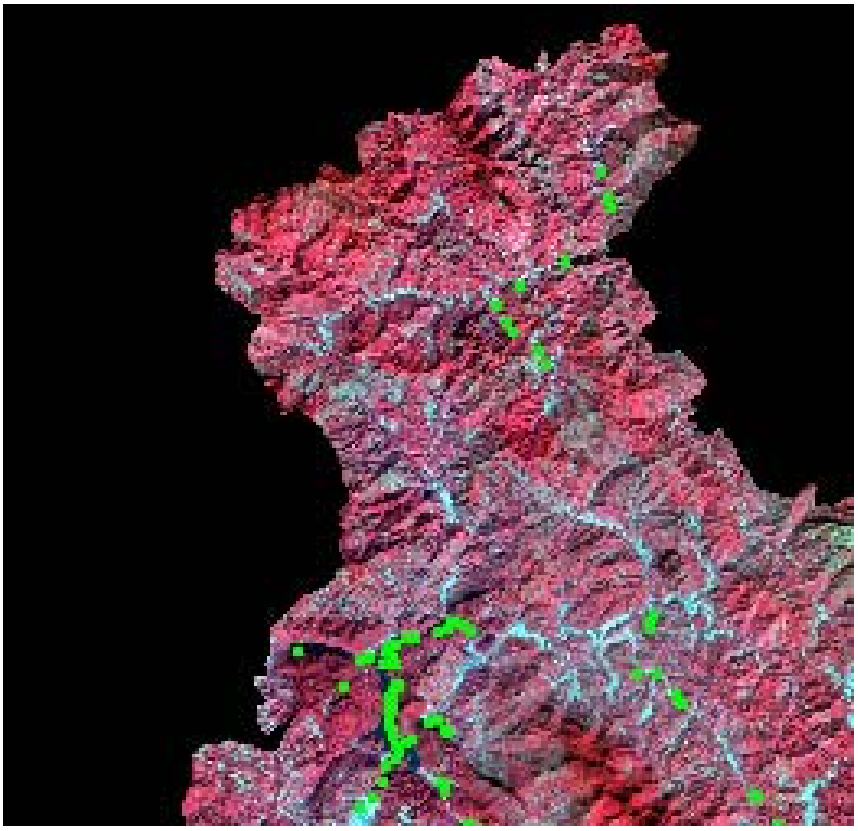

Figure 2. Observation points in field work (left)

The land use practice in Backan province is characterized by upland crop and lowland rice cultivation. Almost all lowland is used for settlement and water rice cultivation. Upland crop is situated either around lowland or scattered on hills and mountains. The way of establishment of upland crop depends on cultivation customs of certain ethnic groups for example while Tay and Nung groups settle along water bodies, the H'mong people scatter their crop cultivation on tops of hills or mountains. Around the settlement there is always a buffer area where is a mixture of different household cultivation such as garden, fruit trees, vegetables etc. This type of land use is referred further as mosaic. A model for determination of mosaic was set up. A buffer zone of 250m from each settlement was created and intersection of this zone with grassland or upland crop is counted as mosaic. Since SPOT image does not provide ability to interpret human settlement, so this information was taken from topographical maps and the field survey by staff of SAM-Regional program.

Figure 3. Example of land use practice in Bac Kan province

5. Upland and lowland extraction

Cultivated land is composed of lowland and upland crops. It appears on false color composite mostly in bright cyanic color so it can be easily extracted by visual interpretation. However, due to time limitation and to insure consistency in cultivated land extraction, a special technique has been applied.

At first the 2001 image were converted from RGB to IHS color space. All categories as cloud, shadows, bare soil and water bodies have small hue angle and different intensity levels. By multi-channel level slicing it was possible to extract cultivated land from other objects. Algorithm for cultivated land extraction is shown by the following Fortran program that is used in Modeler function of WinASEAN 4.0.

```
IF((B1.EQ.0).AND.(B2.EQ.0))GOTO 1
IF(B1.LE.Hue1)THEN
  IF(B2.LE.Intensity1)THEN
     RETURNVALUE=1 !! Water bodies and shadows
     GOTO 1
  ELSEIF(B2.LE. Intensity2)THEN
     RETURNVALUE=2 !! cultivated land
     GOTO 1
  ELSE
     RETURNVALUE=3  !! Cloud
  END IF
ELSEIF(B1.GE. Hue2.AND.B1.LE. Hue3)THEN
  IF(B3.LE.Saturation1.AND.B2.GE. Intensity3)RETURNVALUE=4 !! Cultivated land
END IF
1 CONTINUE
```

The Hue1, Hue2, Hue3, Saturation1, Intensity1, Intensity2 and Intensity3 are threshold values. B1, B2 and B3 are digital values for each spectral channels of a pixel.

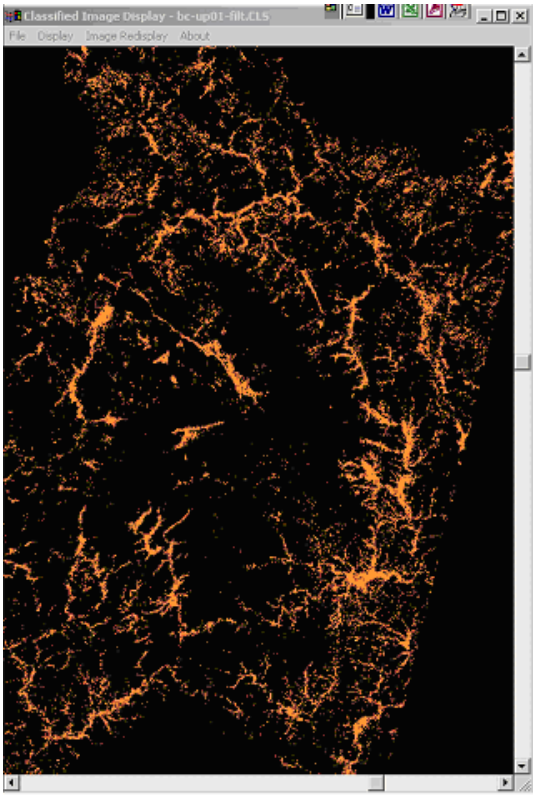

Figure 4. Mask image of cultivated land distribution in 2001 (left)

By the above algorithm, a mask images have been classified. Figure 4 shows classified images of cultivated land distribution for 2001 image. Using GIS layers of contour lines and hydrographical network it was able to separate lowland from upland. Figure 5 shows example of lowland and upland. Purple color means upland and light orange color stands for lowland.

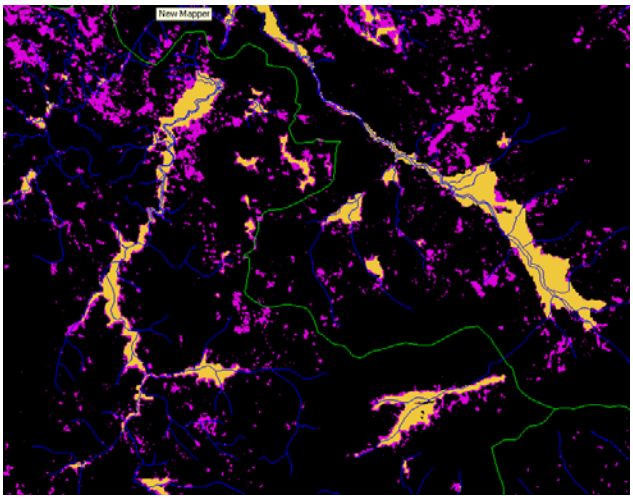

Figure 5. Extraction of lowland from upland using hydrographical network (right)

6. Image classification using land use model

The 2001 image was classified by Maximum likelihood method using WinASEAN software. At first, the 2001 image was coded to find out unique pixel vectors. There are 5403226 pixels in the 2001 image but only 47727 unique pixel vectors were found out. The use of unique pixel vectors for processing speeds up essentially classification (113 times in this case). Guided by GPS photos which were taken during field works, training samples have been selected for classification.

For the best result of classification, 37 classes have been defined. Vegetation covers in different sites of a mountain or hill were separately selected to avoid relief influence from radiance point of view. After classification these classes were merged to formulate final land cover/use categories. Further the final result has been created by superimposition of the 2001 mask image over the classified one. Human settlement was imported from a GIS layer. A buffer zone of residential area of 250 m was done and overlaid on the classified image. Intersection of buffer area, upland crop and grassland is considered as lowland mosaic. Figure 6 shows 2001 image classified by the above explained methodology. Area of each land cover/use class is given in table 2. The 2001 classified image was validated using GPS photos taken during two filed work trips. The GPS photos were at first registered on geo-referenced 2001 image. By visual interpretation of the photos some check points that lay outside training sample polygons were defined. These points are selected for all major classes

and distributed spatially along the field work trips over 2001 image. For each check point there are two land cover values, one from interpretation of GPS photos and the other from classified image. Those points which have the same land cover values are marked as true and those points which have different values are marked as false. Percentage of number of points with true to points with false defines accuracy of the land cover/use map. 28 points were randomly selected and 26 points matched. Therefore, the accuracy is estimated as 92%.

Table 2. Class statistics of 2001 land cover/use

Image : D:\Backan\2001\Result_2001.CLS

Class	*Total Pixel*	*Area (ha)*	*Percentage*
Forest	2455920	141461	46.77
Shrub	1680316	96786	32
Grass	191761	11045	3.65
Lwlnd	220959	12727	4.21
Upland	381454	21972	7.26
Mosaic	163893	9440	3.12
Barren	2875	166	0.05
Resid	141914	8174	2.7
Water	7439	428	0.14
Shadow	5039	290	0.1

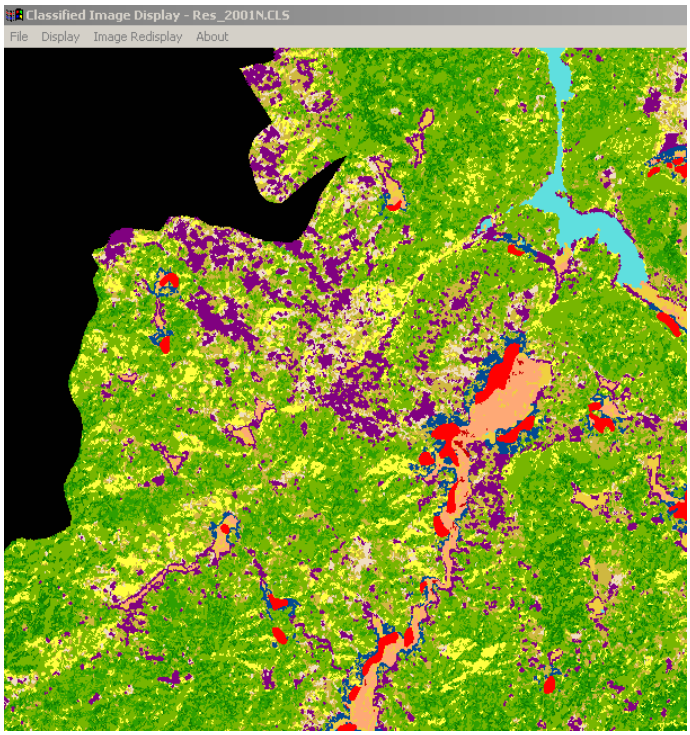

Figure 6. Land cover/use of 2001 (right)

7. Conclusion

The SPOT images of Bac Kan have been interpreted by combination of different techniques with supporting information from GIS layers. The used methodology includes Maximum likelihood classification, feature extraction in IHS space, overlay and buffering technique for residential area and separation of lowland from upland using hydrographical network. The result was validated by field work and GPS photo database. Accuracy of land use/cover map is estimated around 90%. The proposed methodology seems to be effective for land use/cover mapping in mountainous area where is a need of frequent upland crop monitoring.

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