Land Use and Land Cover Classification from ETM Sensor Data : A Case Study from Tamakoshi River Basin of Nepal

Uttam Sagar Shrestha, PK Campus, Tribhuvan University,

Email: usashrestha@gmail.com

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ABSTRACT: The mountain watershed of Nepal is highly rugged, inaccessible and difficult for acquiring field data. The application of ETM sensor Data Sat satellite image of 30 meter pixel resolutions has been used for land use and land cover classification of Tamakoshi River Basin (TRB) of Nepal. The paper tries to examine the strength of image classification methods in derivation of land use and land classification. Supervised digital image classification techniques was used for examination the thematic classification. Field verification, Google earth image, aerial photographs, topographical sheet and GPS locations were used for land use and land cover type classification, selecting training samples and assessing accuracy of classification results. Six major land use and land cover types: forest land, water bodies, bush/grass land, barren land, snow land and agricultural land was extracted using the method. Moreover, there is spatial variation of statistics of classified land uses and land cover types depending upon the classification methods.

The image data revealed that the major portion of the surface area is covered by unclassified bush and grass land covering 34.62 per cent followed by barren land(28 per cent). The knowledge derived from supervised classification was applied for the study. The result based on the field survey of the area during July 2014 also verifies the same result. So image classification is found more reliable in land use and land cover classification of mountain watershed of Nepal.

1. Introduction

Land use refers to the land, which is used for specific purposes with some sort of management practice and land cover is the biophysical state of the of the earth surface captured in distribution of vegetation, water, desert, ice and other physical features of land including those created by human activities such as mine exposure and settlements (Baulies and Szewach, 1998). Land use involves both manner in which the biophysical attributes of land are manipulated and the intent underlying the manipulation- the purpose of which the land is used (Turner et. al 1995).

The remotely sensing is only means for studying a spatial variation of attributes of land use and land cover. Optimum land use planning is perceived as indispensible factor for ensuring food security, environmental sustainability and economic development (Houet et al, 2006). The analysis of land use and land cover is crucial for planning any development actives in river basin. The spatial information science could only provide actual data for the analysis. In the recent years the data analysis from the remotely sense is increasing. There are various types of data available for analysis. " Despite the great potential of remote sensing data and it advancement , the degree of information to be assessed depends upon the specific purposes, selection of sensor, availability of data and particularly computer –assisted image classify action schemes(Jensen, 1996). The classification of date acquiring through pixels based classification is more prominent in the country like Nepal, though other types of data are also available. 'Pixel based classifier are prime mechanism under classification procedure of satellite imagery based on multi-spectral classification techniques. Under this procedure, a pixel is assign to class based on statistical similarities of reference with respect to set of classes (Gupta, 2003). The river basin is composed different types of land use – forest, agriculture, settlement, snow land, bush and other types. With consideration all these classification supervised and unsupervised were used for examining the land use and land cover thematic classification. The present paper attempts to discuss coverage of land by different land in Tamakoshi river basin.

2. Methods and materials

2.1 Study Area

The study area is located in Dolakha and Ramechhap districts, Janakpur Zone in the Central Development Region (CDR) of Nepal. Geographically it lies between the latitudes 28^0 10′ 00″ N and 27^0 50′ 00″ N and longitudes 86^0 15′ 00″ E and 86^0 05′ 00″ E. The area is accessible from Kathmandu via 190 km long asphalt road.

Tamakoshi River is snow -fed and has river basin area of 2,700 sq km and originates from China. It is one of the tributary of Koshi drainage basin. Snowmelt and monsoon rain are the main sources of run-off with a mean annual basin precipitation of about 1,153mm (Department of Meteorology and Hydrology ICIMOD, 1996). The River basin is surrounded by the Gauri Shankar Himal in the north; Khimti, Likhu and Dudh Koshi basin in the east; and Sunkoshi basin in the west and south. The river consisting of two land forms: narrow gorge in the northern parts which are mostly rugged mountain and U-shape with river valley in the south.

The climatic variation is also varied in the corridor ranging tropical in Biteni, confluence between Tamakoshi and Sunkoshi to temperate in the upper side. The maximum average temperature of the area is 34 ^{0} celsius and minimum 8^{0}cesius (Department of Meteorology and Hydrology, 1996).

The data for the study has been derived from Land Sat Image 8 group from measurement by medium resolution. The resolution value of the image is 30 meter. The data is compatible in other sensors such as MODIS, Spot and Landsat ETM+ (Tucker, Pizon, and

Brown 2005; Brown, Pinzon, Didan , et al, 2006)

The methodology is based on remote sensing image classification of the study area. The Land Sat- spectral ETM+ senor covering whole TRB area of date February 2014 was obtained from the global land facility. The spatial resolution of the image was 30 meter and sensor was selected for the study as it is freely available and the image is free of cloud. The scanned top sheet were imported in ERDAS Imagine 2011 and geo-reference with the parameter of Modified Universal Traverse Mercator's (MUTM) used by Survey Department. The resultant root mean square error (RMSE) was reduced to less than a pixel. Absolute pixel error of more than one pixel can be caused of concern in multi-temporal studies (Symenoskie et. al, 2006). Geo-coding is essential for comparing spatially corrected maps and vector overlay analysis. Map to image registration was performed to rectify the 2001 ETM + image to the top sheets with the MUTM projection parameters using first degree polynomial equation of image transformation.The digital vectors of Tamakoshi River Basin (TRB) prepared by Survey Department was imported to ERDAS imagined and rasterized with same geo-reference of the image required for raster calculated after generating attribute map from table.

3. The Satellite Data and Image Processing

3.1 Ground Reference Data

Sufficient ground reference is required for image classification. For this, sufficient accuracy assessment were obtained from integrated use of GPS, Google earth, ETM + image, aerial photographs , top sheets ere used ruing the field survey from July 11 to 18 , 2014. These ground reference data were used for preparing signature of classification training samples and for evaluating the accuracy of classified maps.

4. Classification system

A land use and land cover classification system providing a framework for categorization. . Knowledge- based visual interpretation and Normalized Difference Vegetation Index (NDVI) were carried out. Ground reference data collected were employed in preparation of classification system. Six categorization of land use and land cover were to be extracted as thematic information from ETM+ sensor image.

4.1 Digital Image Processing

In process of preparation of land use and land cover thematic map, a large number of approaches have been adopted by many researcher assign satellite image for classification studies. In the present investigation supervised classification was used for classification. ERDAS professional software for image processing has been used for data analysis. After pre-processing phase of image analysis, following algorithms were used for classification

4.1.1 Supervised Method

Supervised classification begins with identification of sample pixels as a representative sample for land use/land cover classes and then these previously labeled sample pixels were used to train the algorithm to find similar pixels based on statistical parameters derived. It has the assumption that the sample pixels as a. training data statistics in each band are normally distributed (Jansen, 2005**).** 20-30 areas in the image for each class were selected as the sample signature of training sets using different band combinations for obtaining appropriate indication of discrimination among the classes. Maximum likelihood classifier, as the most commonly and widely used algorithm was run to classify the pixels in the image. Smoothening of the resultant classified images to remove the salt and pepper appearance was achieved using a 3x3 majority filter.

5. Land Use/Land Cover Classification Accuracy Assessment

Classification accuracy assessment is considered an essential step in evaluation of different techniques in image classification (Foody, 2002). It establishes the performance of derived classified thematic map with ground truth or other geographical reference data set. A total of 200 test samples were randomly selected for accuracy assessment.

6. Results and Discussions

The standard false color composite map of medium spatial resolution sensor (ETM +) TRB of an input data is shown in Figure 1. In a visual color display, the false color composite image clearly shows unclassified bush (vegetation) and grass in light green, forest in dark green, agricultural land in yellow, snow land in white, water bodies in dark blue and barren land in pink. The study area was classified into six main classes like forest, water bodies, bush grasses, barren land snow and agricultural land in supervised classification techniques. Separation of road and built-up area in standard false color composite was difficult in medium spatial resolution satellite image, even though it is visible in other false color composite (521 as RGB) but it was mixed with dry/exposed farm land and bare soil. Such separation can be done in hybrid image classification integrating both of these methods and ground truth reference data.

The thematic map of the study area and quantitative spatial extent of different land use/cover types is depicted in Table 1. The quantitative spatial statistics derived from supervised classification methods has been shown in Table 1 in figure 1. The bush land with grass dry exposed land stands as largest land use among all other types representing 34.62% and followed by barren land 27.93 % respectively.

Landuse class	Area(Sq.km)	Area(in %)
Forest	527.553	19.53%
waterbodies	1.2951	0.04%
unclassified	1.9836	0.07%
Bushes and grass	935.2017	34.62%
Barren land	755.9694	27.99%
Snow	231.8184	8.58%
Agriculture land	246.9942	9.14%
Total	2700.81	100%

Table 1, Land use and land cover classification

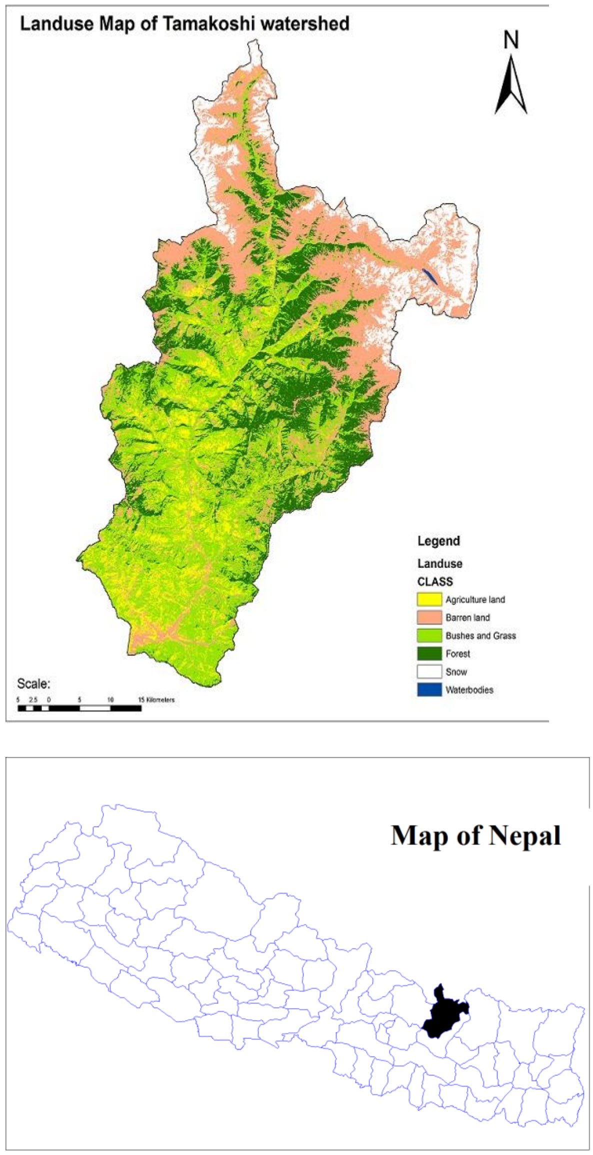

Fig 1, Land use and land cover classification

The forest land is clearly depicted but the settlement of nearby sides is also mixed with the forest type. The water bodies like river, glacier and glacial lakes are mixed in middle part of the basin. But water bodies with glacier lakes are depicted in north and north eastern part. The bush and grass land are widely distributed in northern and southern part. Snow land is widely found in the northern part. The distribution of agricultural land is concentrated in river valley, middle and southern part. The bush, grass and barren land occupied almost two third portions of total land. The portion of settlement is mixed with unclassified land. The reflection of sand, gravel, land slide are more in the upper part near Lamabagar, upper Lamabagar, Rolwaling valley, Manthali, Ranajor and Sukajor. The whole southern part of Manthali depicts either barren or bush and grasses. The nearest settlement is also mixed with this pixel.

Due to the limitation of pixel based classification in case of mixed pixels, both (supervised and unsupervised) classifications poorly scored the users and producer's accuracies (Lu and Weng 2005)). In such complexity of mixed pixels, fuzzy classification has capability to deal with those pixels and greatly improves the user's and producer's accuracies leading to overall and kappa statistics (Jansen, 2000).

In the supervised method, despite a producer's accuracy of 90 percent for bush land use class, there was actually 88.03 percent user's accuracy in that particular class which actually means at least 1.97 percent of other class pixels was wrongly classified as bush area.

7. Conclusion

Image classification in TRB using medium spatial resolution sensor data and conventional parametric classifiers is a challenging task. The complexity in TRB arises with the representation of similar spectral reflectance from different land use/ cover types exhibiting spatial homogeneity that ultimately greatly enhance the problem of mixed pixels based on pixel classification. Beside parametric, non-parametric classifiers were introduced to deal with the problem of pixel based classification. In order to achieve the accurate TRB high spatial resolution sensor image, intensive field study, selection of hybrid classifiers such as artificial neural network, fuzzy image fusion, texture measurement, decision tree, spectral mixture analysis and object based classification software should be advocated . In the present study only supervised classification method including their accuracies was examined to extract TRB land use / cover types using medium, spatial resolution sensor and ETM+ of Land sat satellite. The method was shown to be more effective in detecting thematic classes of complex TRB system.

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