PRELIMINARY ASSESSMENT ON SUSTAINABLE MOUNTAIN ENVIRONMENT USING MULTI TEMPORAL AND MULTI SPECTRAL LANDSAT DATA: A CASE STUDY OF NAUNGMON TOWNSHIP, PUTAO DISTRICT, KACHIN STATE, MYANMAR

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ABSTRACT: Naungmon Township is located in the northern most township of Myanmar and northern most part of Kachin State. Mount Khakaborazi and Khakaborazi National Park is situated in this study area. It is the highest peak in Myanmar (19,315 feet or 5,887 meter) always covered with snow all the year round. This park is the most northerly, biggest and highest ecotourism site in Myanmar and Southeast Asia region (3,812 square kilometers). Mountains are among the most fragile environments on the earth. The purpose of this research was to study the environmental situation of mountain environment especially changes of land cover spatially and temporally (1995 and 2019). Landsat 5 TM and Landsat 8 OLI/TIRS image data with 6 reflective bands, 30 meter spatial resolution is very excellent data source for image classification and mapping. There have four major steps for this image data analysis: image data pre-processing, image classification, accuracy assessment and chage detection analysis. In this analysis, selection of classification algorithm, training areas and post classification was done for smoothening classified image. Editing and checking was applied by using google earth and UTM maps for the validation of result. The result of satellite image analysis showing over 20 percent of vegetation disappeared within 24 years indicated the deforestation of this study area from 1995 to the year 2019. Overall accuracy of classification is estimated over 77 percent. Therefore, remote sensing is an effective method to implement the objective of this research paper. According to this method, estimate the vegetation cover with high accuracy without doing field experiments. Methodology proposed in this research provides a good solution, save in time and money for the sustainable management of mountain environment.

INTRODUCTION

Remote sensing data are primary sources for analyze environmental processes in local or global scale. These data are used to find out change detection in recent decades. Remote sensing data such as Landsat data, Sentinel data, Spot image etc. are very useful for visualization, classification and analysis of study area.

Study Area

The study area lies between north latitudes 27° 15′ and 28° 30′ and between east longitudes 97° 15′ and 98˚30′. It is located on the northern most township in Myanmar and northern most part of Kachin State. It is bounded on the north and northeast by China, northwest by India and south by Machanbaw Township, southeast by Khaunglanhpo Township, southwest by Putao Township (Figure 1). It has an area about 13,025.21 square kilometers. Mount Khakaborazi and Khakaborazi national park is situated in this study area. It is the highest peak in Myanmar with 19,315 feet (5,887 meter). It has always covered with snow all the year round (Figure 2).

Climatic factors also influence on the mountainous area. The study area falls within the sub-tropical monsoon climate with low temperature and abundant rainfall. It lies outside the tropic. The study area is a mountainous and densely forested region. The weather in this area is characterized by various irregularities during the seasons of the year. Winter is long while summer is short with low temperature. Rain fall is generally high with some intermittent showers during summer. Rain fall is generally high and average rainfall is 206.23 inches (1995 to 2019). Average rainy day of the study area between this study period about 90 to 150 days per year. As a result of the mountainous region, areas are saturated with moisture during most of the year except in April and May because of the strong northeasterly winds. Daily mean humidity is over 87 percent in monsoon season.

The population of Naungmon Township is doubled in the period from 1995 to 2019. Where population was 3,515 in 1995 and it increased to 7,531 in 2019. It increased in population from 1995 to 2019 refers to the natural increase and the effects of ecotourism potential in this area.

Aim and Objectives

The main aim of this study is to sustain the mountain environment by using satellite image data from the image analysis. Major objectives are to analyze the changes of past and present land cover as spatially and temporally from 1995 to 2019 and to monitor the changes of land cover in this study area.

Data and Method

The satellite images were used as a source of basic information for land use and land cover classification. Three Landsat 5 Thematic Mapper (TM) images acquired on the year 1995, and three Landsat 8 Optical Land Imager (OLI/TIRS) images acquired on the year 2019 were used for image data analysis. Digital image processing of raw satellite data (Layer Stack) by combining the image data in different spectral bands in a single file (an image file) to have a multi-spectral image ready for enhancement, further processing, classifications and interpretation. Mosaicking the individual satellite images were produce a continuous image covering the study area. The process of mosaicking with three Landsat images into a single mosaic. Spatial subset the mosaic image, the exact dimensions of the study area by applying the study area extent.

The index of Landsat 8 OLI/TIRS satellite images (132-41, 133-40, 133-41) were downloaded from the Internet for the year 2019 and the same number of images were selected for 1995, Landsat 5 TM with 30 meter resolution were used to investigate and quantify land use and land cover changes during this period. Image data analysis with visual interpretation techniques were employed in the study for mapping of land cover in this area. Supervised classification was performed by selecting a number of training samples. The analysis of land cover changes was carried out the use of change detection analysis based on checked with Google Earth, UTM maps and Topographic maps of 91/H /4, 7, 8, UTM sheet no.2797 E, 2897/H, 2798/I with the scale of one inch to one mile were used for the validation of results. Then, presentations of land cover map and the results of change detection analysis of the study area.

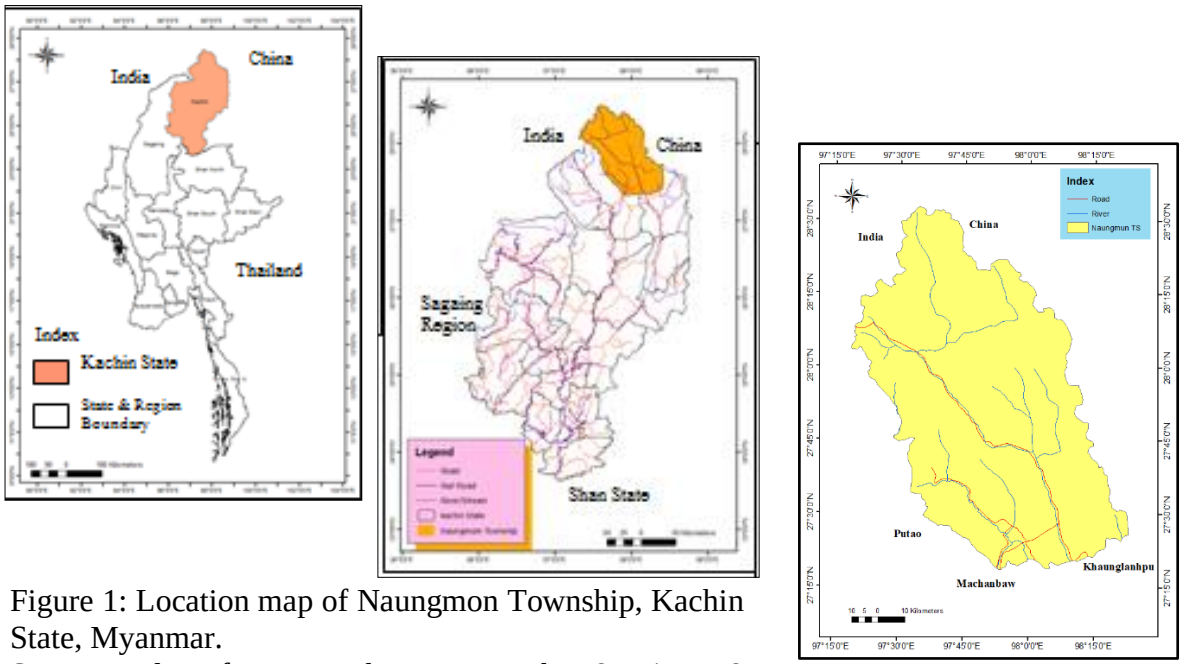

Figure 1: Location map of Naungmon Township, Kachin State, Myanmar.
Source: Index of Topographic Map number 91H/4, 7, 8 and Index of UTM Map no. 2797 E, 2897/H, 2798/I.

Figure 2: Snowcapped Mount Khakaborazi, Naungmon Township, Kachin State, Myanmar.
Source: Mount Khakaborazi, Myanmar, http://www.google.com

SATELLITE IMAGE DATA ANALYSIS

Remote sensing (RS) and geographic information systems (GIS) play an important role in monitoring and analyzing changes of the earth's surface. Remote sensing technology is an effective system for recording and monitoring phenomena on the earth's surface, while GIS manipulate and analyze the spatial data.

Image Data Pre-processing

The process of classification of digital images is the most important step in digital image processing as the ultimate goal of these operations. It is considered one of the most prominent benefits of using image processing, whether computerized or using visual interpretation of multispectral images.

The present study is based on interpretation of multi spectral Landsat 5 TM and Landsat 8 OLI/TIRS images (1995 and 2019) of Naungmon area with 30 meter resolution was selected for land cover classification. Landsat images of dates 1995 and 2019 are considered for digital image processing. The procedures for the image analysis are shown in (Figure 3).

Firstly, image preparation and enhancement of these images. After that, mosaicking and edit mosaic image (Path-Row 132-41, 133-40, 133-41) into a single mosaic for the study area. The steps followed for image special subset by map coordinate. RGB (Red, Green, Blue) colour composite was prepared. Rectification is done in World Geodetic System (WGS 1984 Datum) with Universal Transverse Mercator (UTM Zone 47 North) map projection system.

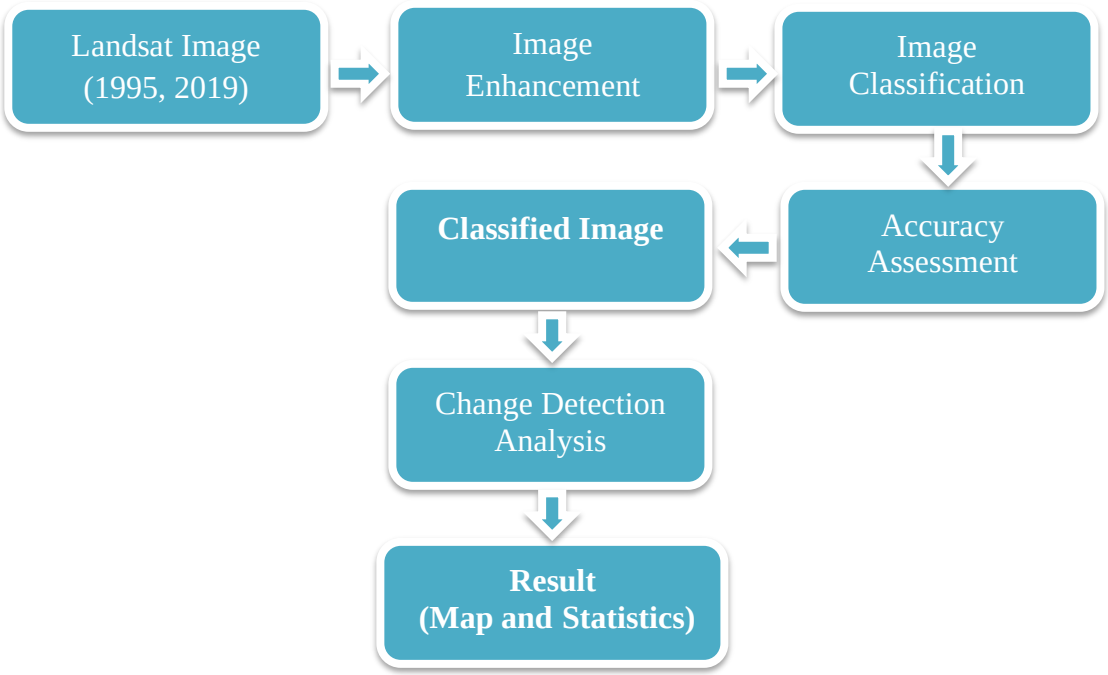

Figure 3: Procedure for Satellite Image Data Analysis.
Source: Author's draft.

Image Classification

Image classification is of two main types; supervised classification and unsupervised classification. Each satellite scene was individually classified; focusing first on separating categories, selection of classification algorithm by using standard supervise classification techniques with maximum likelihood classifier based on region of interest.

There have five types of land use and land cover were identified using spectral signatures and then training areas were selected with the aid of auxiliary thematic maps. These types include snow cover, vegetation cover, settlement area, bed rock and water body. Band Ratioing was done for this study area to reduce the shading of mountain effect. Preparing mosaic and subset image for the study area to show the changes of land use and land cover through the time. After that post classification was done with majority/ minority analysis and clump classes for smoothening classified image.

Accuracy Assessment

The next step is to consider the output result is acceptable or not. That process is called accuracy assessment. Editing and checking was applied by using google earth and UTM maps. Ground check point data collection on the google earth image of study area for the accuracy assessment of classified image.
Image data were checked and confirm with ground truth data. Generation of confusion matrix by using ground truth data and ROIs for the validation of results (Table 1). In this matrix table row represent the classes from classified image and column represents the classes from original image. According to the result of this table overall accuracy for the classification is estimated about 77 percent.

Change Detection Analysis

Change detection is a process to measure the extent of the change in the characteristics of a particular area, and the disclosure of this change involves a comparison of aerial photographs or satellite images of the area taken at different time intervals to measure the urban development and environmental changes using two or more of the scenes that cover the same geographical area over two or more times. The changes in land use and land cover over time may be due to many factors including the economic and social development and the desires and the needs of public and population. Therefore, studies of land cover and land use should be achieved from time to time. This helps to display, compare, identify and monitor the various changes of land cover and land use. This process helps in the selection of optimal solutions for the development plans of research area.
In the present study, monitoring of land cover and land use changes was achieved by using two satellite images taken at different times for the years 1995, and 2019. The changes of land use and land cover occurred in this study area for these periods have been calculated by the subtraction processes.
A change matrix is a table, similar to a spread sheet that quantifies the amount of change that occurs between all of the land cover types. The matrix shows the “From” classes as rows and the “To” classes as columns. The number of rows and columns is determined by the number of classes in the land cover image. Each cell represents the area of land cover change. This matrix is critical to see the entire change analysis as one view. It is a very powerful tool for examining land cover changes. The result of change matrix table is illustrated in (Table 2) where the changes are given in square kilometre. The evaluation of land cover changes is presented in result and finding of this paper.
According to this table, snow cover has 1,650.54 square kilometer in 1995 and it decrease to 1,539.69 sq. km in 2019. Agriculture land in this area has 1,743.88 square kilometer in 1995 and it increase to 2,988.63 sq. km in 2019. Vegetation cover has 8,572.59 square kilometer in 1995 and it decrease to 7,376.05 sq. km in 2019. Settlement area has 37.23 square kilometer in 1995 and it increase to 84.83 sq. km in 2019. Water body has 1,020.97 square kilometer in 1995 and it increase to 1,036.01sq. km in 2019.

RESULT AND FINDING

Visual interpretation and digital image processing are two important techniques of data analysis which are needed to extend resources related information either independently or in combination with the other data. Then create a signature file that will be used in supervised classification method.

Table (1): Error matrix for the validation of result.

Classes	Snow Cover	Agricult-ure Land	Vegetat-ion	Water body	Settle-ment	Total	Error of Commission (%)	User Accuracy (%)
Snow Cover	73	6	3	0	0	82	11	89
Agriculture Land	7	87	15	0	4	113	23	77
Vegetation	7	12	75	1	10	105	29	71
Water body	0	0	2	20	1	23	13	87
Settlement	0	8	2	0	8	18	56	44
Total	87	113	97	21	23	341		
Error of Omission (%)	16	23	23	5	65			
Procedure Accuracy	84	77	77	95	35			

Source: Based on UTM map, Google earth map and classified image of study area.

Table 2: Result of change detection analysis (Change Matrix table from 1995 to 2019)

2015 → / 1995 ↓	Snow Cover	Agricult-ure Land	Vegetation	Water Body	Settlement	Total (Sq. Km)
Snow	167.66	1.69	1,364.72	5.62	0.0	1,539.69
Agriculture Land	1,472.39	764.33	745.28	5.37	1.26	2,988.63
Vegetation	3.51	907.41	6,423.98	6.89	34.26	7,376.05
Water Body	6.73	2.96	23.20	1,003.07	0.05	1,036.01
Settlement	0.25	67.49	15.41	0.02	1.66	84.83
Total	1,650.54	1,743.88	8,572.59	1,020.97	37.23	13,025.21

Source: Landsat 5 and 8 images (Path-Row 132-41, 133-40, 133-41) classification.

Changes of these land use and land cover in the period from 1995 to 2019 was evaluated of changes. According to the result of image analysis both agriculture land, settlement and water body area were increased in the order of 1,244.75 sq.km, 47.6 sq.km and 15.04 sq.km respectively on the expense of the other types of the land use and land cover where vegetation and snow areas were decreased in the order of 1196.54 sq.km and 110.85 sq.km respectively. The type of changes (decrease or increase) is also shown in table 3, (Figure 4 and 5). This study shows the past and present information about the land cover of Naungmon area in the northernmost township of Myanmar. The result of map for study area between 1995 and 2019 are also shown in Figure (6). Major factors of these changes are increase of population and over cutting of forest in this study area.

Satellite image analysis of this study area showing over 20 percent of natural land cover disappeared within 24 years indicated the deforestation of this area (1995 to 2019). The decreases in the actual forest area of the study area for the past 24 years were going on at the rate of about 1 percent per year. This is an alarming situation, so the vegetation cover of this mountain environment should be saved in time.

According to the results of the study, monitoring these types of changes might be endanger the surrounding vegetated land in this area. It is crucial to protect and rehabilitate for this research area. Therefore, it is urgently needed to implement the sustainable management system for this mountain environment.

Table 3: Changes of land cover in the period from 1995 to 2019 for the study area.

Name of Class	**Area (Sq. km)**			**Type of Changes in Area**
	1995	2019	Changes in Area	
Snow cover	1,650.54	1,539.69	- 110.85	**Decrease**
Agriculture Land	1,743.88	2,988.63	+ 1,244.75	**Increase**
Vegetation	8,572.59	7,376.05	- 1,196.54	**Decrease**
Water body	1,020.97	1,036.01	+ 15.04	**Increase**
Settlement	**37.23**	**84.83**	**+ 47.6**	**Increase**

Source: Based on the result of change detection analysis, change matrix table 2.

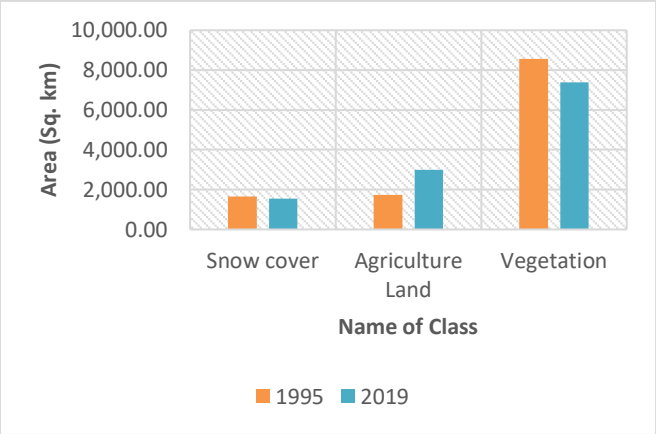

Figure 4: Changes of snow cover, bedrock and vegetation cover (1995-2019)
Source: Based on Table 3.

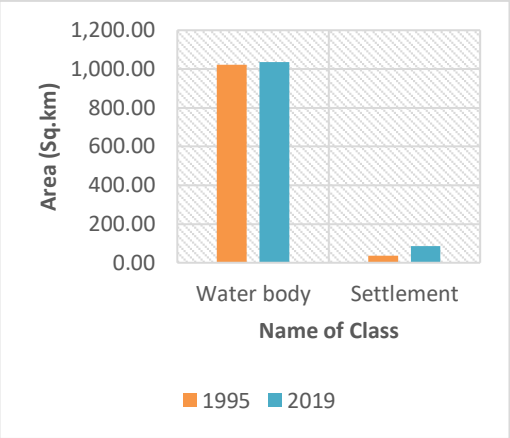

Figure 5: Changes of water body and settlement area (1995-2019).
Source: Based on Table 3.

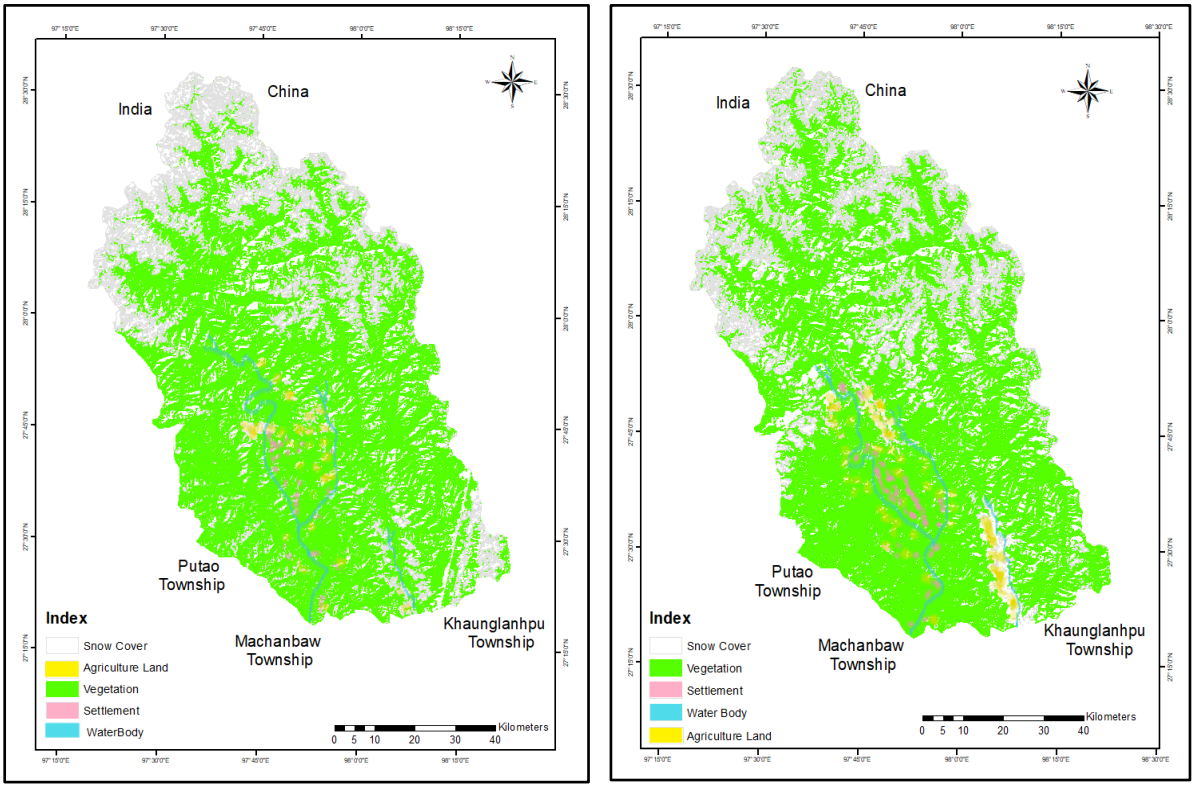

Figure 6: Land cover classified map of study area (1995 and 2019).
Source: Landsat 5 and 8 images (132-41, 133-40, 133-41)

CONCLUSION AND DISCUSSION

The purpose of this study was to monitoring the changes of land cover in Naungmon area. According to the research findings and result of structured interview shows that the most land cover area has significant changes because of over cutting of forest, extension of agricultural land increased population in study area other than before, inadequate knowledge to understand the environmental conservation, and little awareness among people, regarding the importance of ecosystem of mountain environment.

In spite of the above factors, research area has better chance for maintaining its environment, such as rapid natural regeneration is occurring in this area. At present, Forest Department has strictly banned for expansion in this area. In addition, there have many ecotourism potentials in this Naungmon area.

This paper is point out the changes of land cover in northern most part of our country. Study area should be maintaining carefully because, it is the watershed area of Ayeyawady River originates as the life artery of Myanmar. According to the results of satellite image analysis, over 70 percent is original land cover and over 20 percent is changed to other land uses. There has better chance for maintain natural environment of this research area has already conserved as Mt. Khakaborazi National Park. In addition, there have many ecotourism potentials in Naungmon area. Therefore, we need to maintain this area as present situation of mountain environment by the sustainable basis.

Therefore, remote sensing techniques by using satellite image data can be an effective tool for researchers, planners, and provide important and useful information for many resource management decisions relating to the long-term management of sustainable mountain environment.

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