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Quantitative Assessment of Forest Cover Change of a Part of Bandarban Hill Tracts Using NDVI Techniques

Biswajit Nath*

Department of Geography and Environmental Studies, Faculty of Biological Sciences, University of Chittagong, Chittagong, Bangladesh
*Corresponding author: nath.gis79@gmail.com

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Abstract Bandarban Hill Tracts is facing grave environmental problems with fast depletion of its natural resources which is ultimately threatening the existence of forest cover. Monitoring the change of forest cover using multi temporal Landsat TM data (i.e. 1989, 2001 and 2010) for the Part of Bandarban Hill Tracts and exact evaluation of anthropogenic intervention on the natural environment can be assessed. Present research is focusing on along the middle course of Matamuhuri River's adjoining areas. The Normalized Difference Vegetation Index (NDVI) technique was applied to quantify the forest cover changes of these regions from 1989-2010. Three different time periods NDVI maps were generated and quantitative data were classified using ERDAS Imagine and ArcGIS software respectively. Finally NDVI derived maps of 1989 and 2010 were crossed to generate overall change detection map. The study reveals that forest cover of this region has changed significantly during 1989-2010 due to natural and different anthropogenic activities (i.e. hill erosion, illegal forest cutting, jhum cultivation, forest fire, tobacco farming, etc.). Out of the total area of 16852.32 hectare, the decreased category shows 15.47%, followed by some decrease 29.55%. The area needs special protection because forest cover is decreasing and some decreasing at the rate of 0.74% and 1.41% per year respectively.

Keywords: *quantitative assessment, forest cover change, NDVI, Bandarban Hill Tracts*

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1. Introduction

Bangladesh is a land of beauty and it is blessed with boundless natural objects. Alikadam and Lama are the two upazilas of Bandarban district in the division of Chittagong, Bangladesh. Alikadam, the bordering upazila consist of two unions (i.e. Chokhyong and Alikadam) with Myanmar, came into existence in 1981 as Thana. Ali's Hill or cave is the most attractive tourist spot in the study area and very small part of Lama union from Lama Upazila is also consider for this study. The geographical extent of the whole study area in between $21^{0}37^{/}12.452^{//}$ to $21^{0}42^{/}31.013^{//}$ north latitudes and $92^{0}13^{/}54.037^{//}$ to $92^{0}23^{/}40.968^{//}$ east longitudes. The study area is bounded on the north by Lama Upazila, on the east by Thanchi upazila, on the south by Myanmanr and on the west by the Naikhongchhari and Lama Upazilas. Figure 1 shows the location of the study area.

Bandarban Hill Tracts is facing grave environmental problems with fast depletion of its natural resources which is ultimately threatening the existence of forest cover. Tobacco growing is a significant cause of deforestation in Bangladesh, accounting for over 30% of annual deforestation in Bangladesh-putting the country third internationally in terms of the severity of the problem (Islam, Tapan and Nayan, 2010). According to Environmentalists, at least 60 to 70 thousand metric tones of firewood are being burnt in 2,000 tobacco processing kilns every year, causing depletion of reserve and natural forests, threatening environment and ecology in the hills.

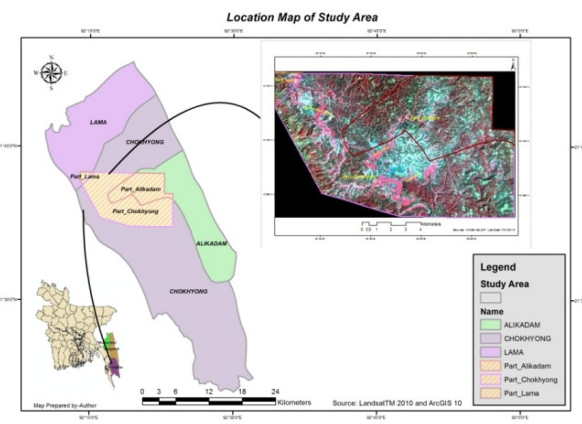

Figure 1. Location Map of Study Area

Monitoring the change of forest cover using multi temporal Landsat TM data (i.e. 1989, 2001 and 2010) for the Part of Bandarban Hill Tracts and exact evaluation of anthropogenic intervention on the natural environment can be assessed. The authors claim that present research work

(NDVI based forest cover change detection) is the pioneer work in the history of this area.

The use of remote sensing data in recent times has been of immense help in monitoring the changing pattern of vegetation. Change detection as defined by Hoffer (1978) is the temporal effects as variation in spectral response involves situations where the spectral characteristics of the vegetation or other cover type in a given location change over time. Singh (1989) has described change detection as a process that observes the differences of an object or phenomena at different times.

According to Macleod and Congalton (1998), cited by Rahman, M. M., (2013), in general, remote sensing considers following four aspects of change detection (a) detect the changes, (b) identify the nature of change, (c) measure the areal extent of change, and (d) assess the spatial pattern of change. Some prominent researchers have identified that the increase in vegetation cover has resulted in increased rainfall (Sarma et al., 2001; Dengiz et al., 2009) and decrease in forest cover has direct relationship with socio-economic status/marginal work force (Murali, 2002). There are various methodologies for studying seasonal changes in vegetation through satellite images, one method of which is apply vegetation indices relating to the quantity of greenness (Chuvieco, 1998).

Vegetation indices among other methods have been reliable in monitoring vegetation change. One of the most widely used indices for vegetation monitoring is the Normalized Difference Vegetation Index (NDVI). The NDVI is a measurement of the balance between energy received and energy emitted by objects on earth. When applied to plant communities, this index estalishes a value for how green the area is, that is, the quantity of vegetation present in a given area and its state of health or vigour of growth (Tovar, C.L. Meneses, 2012). Data on vegetation bio-physical characteristics can be derived from Visible, NIR and Mid-Infra Red portions of the electromagnetic spectrum (EMS). The NDVI approach is based on the fact that healthy vegetation has low reflectance in the visible portion of the EMS due to Chlorophyll and other pigment absorption and has high reflectance in the NIR because of the internal reflectance by the mesophyll spongy tissue of green leaf (Campbell, 1987). NDVI can be calculated as a ratio of Red and NIR bands of a sensor system.

NDVI values range from -1 to +1, because of high reflectance in the NIR portion of the EMS, healthy vegetation is represented by high NDVI values between 0.1 and 1. Conversely, non-vegetated surfaces such as water bodies yield negative values of NDVI because of the electromagnetic absorption quality of water. Bare soil areas represent NDVI values which are closest to 0 due to high reflectance in both the visible and NIR portions of EMS (Lillesand and Kiefer, 1979, 1994 and 2000). Multi-temporal satellite data effectively improves the temporal attribute and the reliability of multi-data. This paper discusses the methods of change detection of vegetation cover utilizing multi-temporal remotely sensed data.

2. Objectives

The objectives which are considered for this study are given below:

- Identification of vegetation cover and the spatial distribution
- To produce NDVI and Spatio-temporal change maps
- To analyze the Spatio-temporal change of vegetation cover.

3. Data and Methodology

3.1. Data

Multi-temporal satellite data i.e. Landsat (TM) with 30 m spatial resolution are used in the present study. Characteristics of Landsat TM data are shown in Table 1.

Table 1. Data Characteristics of Satellite Imageries

Satellite	Bands	Date of Acquisition	Spatial Resolution
Landsat TM	4,3,2 (NIR, R, G)	02 February 1989	30 m
Landsat TM	4,3,2 (NIR, R, G)	07 February 2001	30 m
Landsat TM	4,3,2 (NIR, R, G)	05 May 2010	30 m

Source: NASA-Global Land Cover Facility (GLCF) Archive

3.2. Methodology

The main goal of this study is to reveal quantitative assessment of vegetation cover change of a part of Bandaran hill tracts using Normalized Difference Vegetation Index (NDVI). For digital image processing remote sensing and GIS based software (ERDAS Imagine 10 and ArcGIS 10) were used for image processing, classification, analysis and NDVI map generation respectively to achieve the objectives of the study. ERDAS Imagine is used to generate the false colour composite, by combining near infrared (NIR), red and green which are bands 4,3,2 together for all of the three (3) imageries (1989, 2001 and 2010). This false colour composite was used for vegetation recognition; classification, because chlorophyll in plants reflects very well in the near infrared rather than visible band. Then three individual NDVI Maps (1989-2010) were prepared. The use of the Normalized Difference Vegetation Index (NDVI) was applied to detect areas of forest cover change and different year wise NDVI derived quantitative data were generated and summarized using remote sensing, GIS software and spreadsheet. Finally NDVI derived map of 1989 and 2010 were crossed to generate the change map of vegetation cover of the study area and these are further categorized in different manner as decreased, some decreased, some increase, and increased. The method which was followed for the present research is shown in the following flow chart model (Figure 2).

4. Results and Discussion

The remote sensing data is used extensively for large area vegetation cover change monitoring. Typically the spectral bands used for this purpose are visible and near IR bands. Various mathematical combinations of these bands have been used for the computation of NDVI, which is an indicator of the presence and condition of green vegetation. These mathematical quantities are referred to as Vegetation Indices. There are three such indices, Simple Vegetation Indices (SVI), Rational

Vegetation Indices (RVI) and Normalized Differential Vegetation Indices (NDVI) (Anji Reddy, M., 2006). At the regional scales, seasonal weather patterns and green up from logging were the primary driving force of observed increases in NDVI values. It may be said that the vegetation change i.e. positive or negative is mainly due to intense pressure of human population, different economic activities or as a result of anthropogenic activities (Morawittz, Blewett, Cohen and Alberti, 2006).

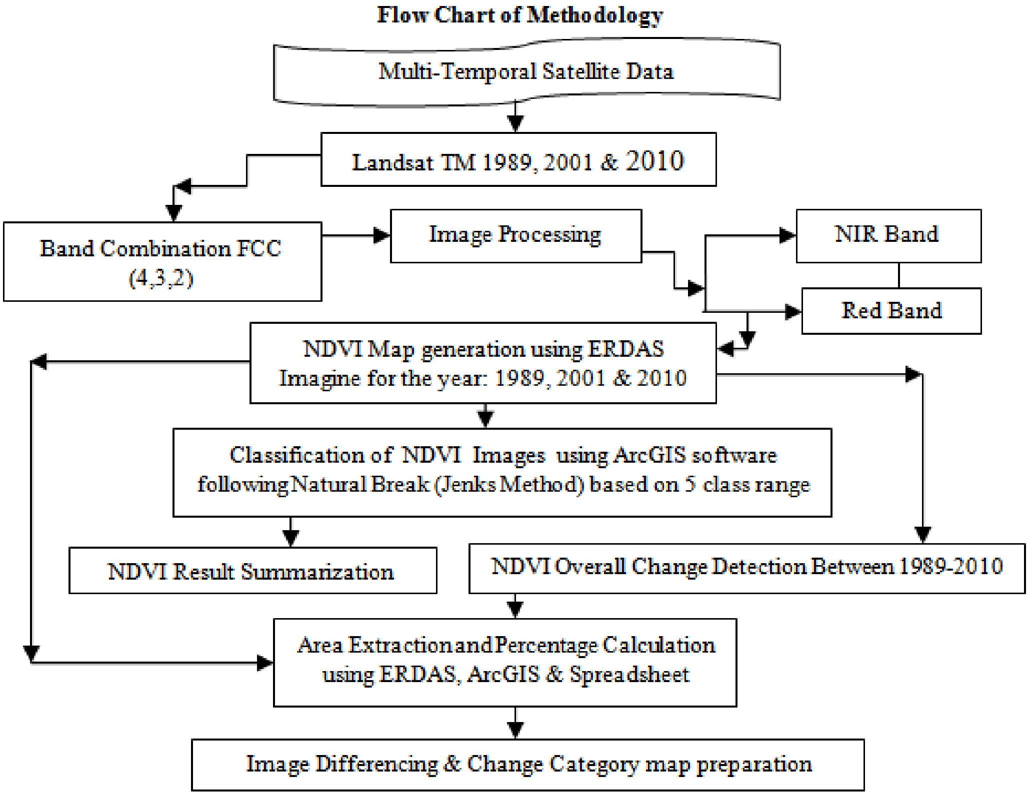

Figure 2. Flow Chart of Methodology

4.1. NDVI Calculations Using Landsat TM Satellite Imageries (1989-2010)

Normalized Difference Vegetation Index (NDVI) is used in the present study. NDVI from reflectance images is obtained by mean of channels 3 (0.63-0.69 µm) and 4 (0.78-0.90 µm). The formula for NDVI calculation is shown in equation 1.

$$\text{NDVI} = \frac{Band\ 4 - Band\ 3}{Band\ 4 + Band\ 3} \qquad (1)$$

Vegetation indices have long been used in remote sensing for monitoring temporal changes associated with vegetation. Soil and rock have a broadly similar reflectance giving NDVI close to ‘0’. NDVI values little higher than zero, which indicates the presence of vegetation classes, moderate and high values indicate stressed vegetation and healthy vegetation respectively; whereas near zero and negative values indicate non-vegetation class such as water, snow, built-up areas and barren land. Only active vegetation has a positive NDVI being typically between about 0.1 and 0.6 values at the higher end of the range indicating increased photosynthetic activity and a greater density of the canopy (Tarpley et. al, 1984). The following algorithm is adopted to create NDVI map:

i. Computation of NDVI values for the entire study areas by conversion of spectral reflectance values into NDVI values.

ii. Conversion of these NDVI values to a scaled channel values by using density-slicing method that measures apparent reflectance to sensor values.

iii. Display of image with NDVI and creation of a legend keeping the threshold values.

The greenness range is divided into discrete classes by slicing the range of NDVI values into six ranges by fixing the thresholds for NDVI classification and the method used is Natural Breaks (Jenks). Similar step was followed for all the three (3) different years image classification. A cursory examination of pseudo color image of NDVI and classified output of NDVI image reveals that along the water bodies, built up lands yield negative values, their reflectance being more visible rather than near IR wavelengths. This technique is applied for comparison of vegetation cover change from multiple dates of Landsat TM derived NDVI imageries. Figure 3 (a, b & c) shows resultant maps generated from NDVI classification.

It shows that high reflectance of vegetation in 1989 image, with an increase in NDVI values but the vegetation reflectance is low in 2010. NDVI image derived statistics for the three different years are shown in Table 2.

The NDVI value based statistics are categorize in the following manner i.e. no vegetation, less vegetation, less-moderate vegetation, moderated vegetation, dense vegetation, highly dense vegetation and these NDVI values differ significantly from 1989-2010. The NDVI derived values (0.452-0.600 and 0.385-0.452) of 1989 image shows northern, north-eastern and south eastern part and few areas of western regions of the study area were covered by highly densed vegetation whereas densed vegetation areas were found in close atachment with highly dense category in the same direction (shares 15.29% and 24.73% respectively of total land of the study area) and NDVI value 0.313-0.385 represent moderate type of vegetation (stressed condition; shares 19.36% of land) found along the both bankline of middle course of Matamuhuri River, Twin Khal and its close proximity forest regions (indicating central, north-east and north-west region) due to overexplotion of forest resources and extraneous pressure on forest and agricultural land by tobacco industries for the production of tobacco. Large scale timber extraction and regular tobacco cultivation in different seasons had put pressure on forest resources in this areas, which sign and its impact is still present and observed at ground level (survey conducted September, 2013). Whereas this range was not found in 2001 and 2010 image. Highly dense forest coverage was found in 2001 image with sharply reduced the NDVI value 0.386-0.568 (shares 20.70%) which indicate some changes occured and changed the scenario from highly dense to dense coverage category (Table 2).

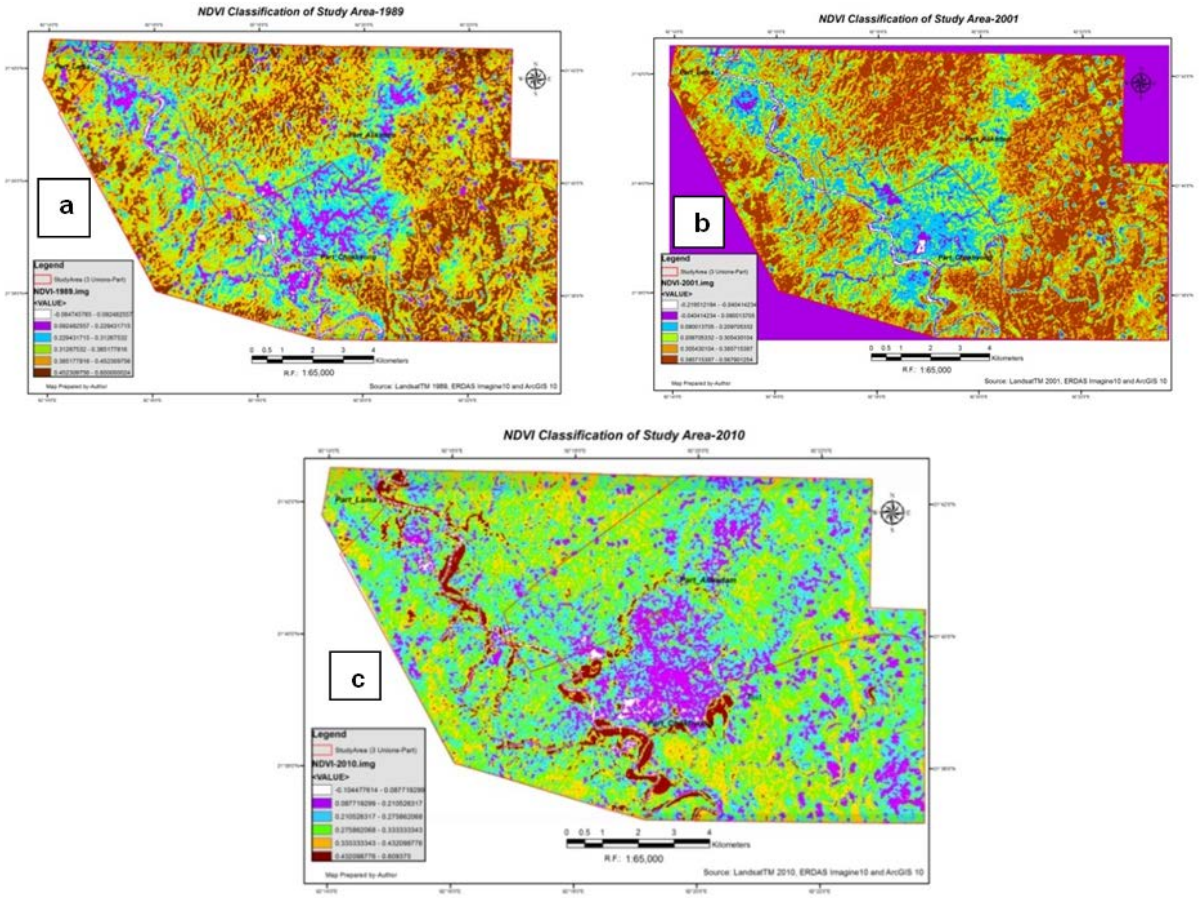

Figure 3. (a, b & c) NDVI derived classified map of Study areas for three different years (1989, 2001 & 2010)

Table 2. NDVI derived changes statistics of the Study Area during 1989-2010

NDVI Value based Category	NDVI Value 1989	% of Category	NDVI Value 2001	% of Category	NDVI Value 2010	% of Category
No Vegetation	-0.085 - 0.092	20.45	-0.219 - -0.040	0.43	-0.104 - 0.088	20.37
Less Vegetation	0.092 - 0.229	7.25	-0.040 - 0.080	22.02	0.088 - 0.210	11.59
Less-Moderate Vegetation	0.229 - 0.313	12.92	0.080 - 0.209	12.10	0.210 - 0.276	24.10
Moderate Vegetation	0.313 - 0.385	19.36	0.209 - 0.305	19.11	0.276 - 0.333	25.81
Dense Vegetation	0.385 – 0.452	24.73	0.305 - 0.386	25.64	0.333- 0.432	14.98
Highly Dense Vegetation	0.452-0.600	15.29	0.386-0.568	20.70	0.432-0.609	3.15
		100		100		100

Source: Data computed by author using NASA – GLCF LandsatTM Imagery (1989, 2001 & 2010), ERDAS Imagine 10 & ArcGIS 10)

NDVI values sharply decreased in the year 2001 which ranges from -0.219 to -0.040 and -0.040 to -0.080, whereas in 2010 less, less to moderate and moderate type of vegetation was identified and its share was 11.59%, 24.10% and 25.81% of land respectively. In comparison with the above year, 2001 and 2010 NDVI value of highly dense and dense category shows decreasing trend scenarios which ranges from 20.70% to 3.15% and 25.64% to 14.98% of land respectively. This type of change is observed in the entire middle course of Matamuhuri river’s both bankline, Twin khal adjoining areas and the north-eastern, eastern, south-eastern and western part of the study area respectively (Table 2 and e.g. Figure 3).

The vacant areas, river and khal itself indicate no vegetation category which is represented by negative

NDVI values in the year 1989, 2001 and 2010 which shares 20.45%, 22.45% and 20.37% of land respectively. Due to anthropogenic activities (i.e. forest cutting, timber extraction, illegal forest fire, jhum cultivation and sheet erosion of surface soil as a result of excessive rainfall which was noticed during field survey, September, 2013) the forest loss of in the study area is high. To verify this sort of changes in the hill forest loss 200 checklist survey was conducted in the study area where 83.5% of the respondents told that they have seen forest loss in their areas and remaining 16.5% was not seen any forest loss in between the year 1989-2010. Due to massive jhum cultivation and rapid clearing of highly dense and dense to moderate type of forest, the land is now almost with no vegetation. The field investigation results shows, 42% respondent gave their opinion regarding high forest clearance, whereas 28% and 21.5% respondents told about severe and medium type of forest clearance was occured in their areas and the remaining 8.5% respondent told less forest clearance. This conversion started from the year 2001 and continued till now and it is being noticed in the NDVI images of 2001-2010 and needless to say that forest regeneration is quite impossible in this degraded part (Figure 3) due to extensive uses of tobacco farming through forest clearance, timber extraction, jhum cultivation, illegal forest fire, fuel wood, etc. Besides those activities 60% respondents opined that they have also seen forest planatation in their areas whereas remaining 40% told they have not seen any forest plantation.

4.2. Spatio-temporal Change Detection of Vegetation Cover

After NDVI image classification, it is necessary to know the overall percentage of change of general land surface based on NDVI derived image value. This kind of change detection helps to detect the areal change of forest cover of an area. Present research highlights the areal forest cover change of a part of Bandarban Hill Tracts indicating middle course of Matamuhuri river's adjoining areas (part of Chokhyong and Alikadam union of Alikadam Upazila and very small portion of Lama union of Lama Upazila) in between the year 1989-2010.

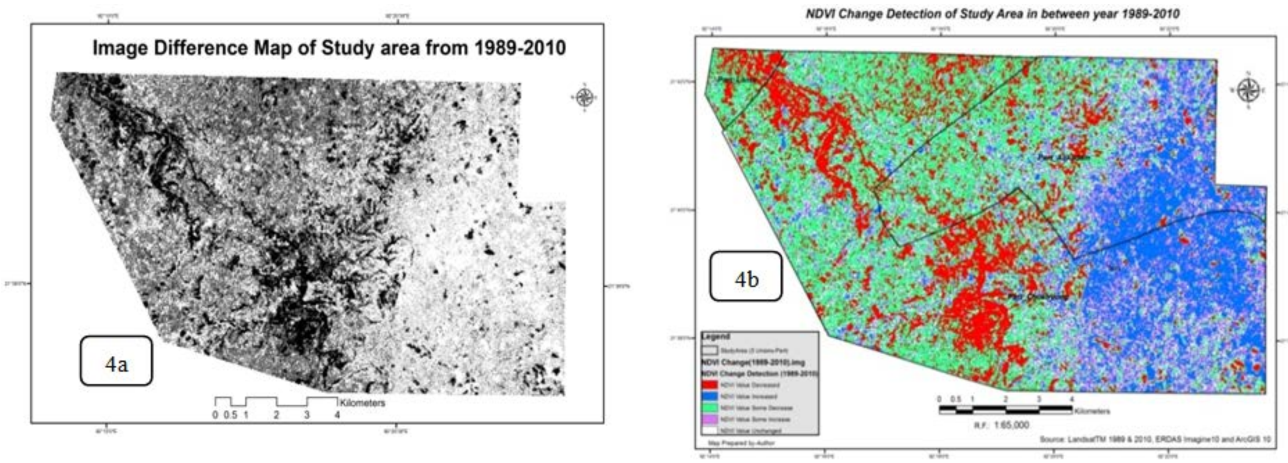

Figure 4. a: NDVI value based Image Difference Map and **b:** Change detection category map of Study area (1989-2010)

Table 3. Overall NDVI Change Detection of Study area in between year 1989-2010

NDVI Change Category (1989-2010)	Area (Hectare)	% of Change between 1989-2010	% Rate of Change
NDVI value Decreased	2607.03	15.47	0.74
NDVI value Some Decreased	4980.42	29.55	1.41
NDVI value Some Increase	2157.84	12.80	0.61
NDVI value Increased	2426.49	14.40	0.69
NDVI value Unchanged	4680.54	27.78	-
Total	**16852.32**	**100**	

Source: Data summarization computed by Author based on Landsat TM Derived NDVI Image (1989 & 2010) and ERDAS Imagine 10

The non-changed pixels lie in the NDVI decreased part with low pixel value and NDVI increase part with high pixel value. After preparation of NDVI change category map, the researcher focused on overall forest cover change in the study area which was identified from the image difference map, generated considering two different specific years i.e. 1989 and 2010 image (Table 3).

Change detection is a good indicator for characterizing and understanding changes occurring during any study period (Figure 4). The change detection which was performed using ERDAS Imagine 10 (Remote sensing software) and value based categorization was done using ArcGIS 10 are in the following manner as NDVI value decreased, some decreased, some increase, increased and unchanged (Figure 4: 4b and Table 3).

Out of the total 16852.32 hectare area, decreased category is in 3rd position, about 15.47% of land surface was changed in between the year 1989-2010, this changes was noticed in the south-eastern, major portion of southern, central and north-western margin followed by some decrease category shows top most position which is 29.55% and noticed in the northen, central and southern areas and a small percentage of land showing some increase and increasing trend than its previous period which shares 12.80% and 14.40% land surface respectively and the remaining 27.78% of land is in 2nd position found as unchanged category (e.g. Figure 4 and Table 3). The study area needs special protection in both unions i.e., Chokhyong and Alikadam bacause land surface was decreased or changed at the rate of 0.74% per year and some decreased at the rate of 1.41% per year as measured from the NDVI derived change map from 1989-2010.

5. Recommendation

From the overall assessment of this study, it has been clearly noticed that forest cover is changing in the study area. Both the present and the future generations stand to suffer bitter consequences if this trend goes on. At the rate, if necessary steps are not taken to save the forest this valuable resource will definitely get depleted. Below are some recommendations that can possibly help in curbing forest loss in the study area.

i. Re-afforestation should be done, it means the planting of trees where forests have been destroyed.

ii. The information on forest cover dynamics provided in this study can be considered a useful starting point to further analyze spatial and temporal patterns of vegetation changes in degraded areas.

iii. Proper guidance and training should be provided to the local people who knowingly or unknowingly deplete the forest resources.

iv. Educating people (especially in union level) on environmental issues will thus go a long way in creating awareness and boosting responsibility in environmental care. The environmental improvement groups and Non-Governmental Organizations (NGO's) have great potential in performing this task.

v. Environment consrvation groups need to work collaboratively with the Government in conducting tree planting where forest have been destroyed.

vi. The government should take legal action against the tobacco industries and local influencing people.

vii. Tobacco cultivation, timber extraction and extensive jhum cultivation should be permanently banned inside the forest area.

viii. bankline of river and khal areas should be free from illegal encroachment and protected from erosion by planting more trees.

ix. For maintaining ecological balance of these areas require further study to examine their vegetation potential and dynamics.

6. Conclusion

Vegetation indices among other methods have been reliable in monitoring vegetation change. One of the most widely used indices for vegetation monitoring is the Normalized Difference Vegetation Index (NDVI). Data on vegetation bio-physical characteristics can be derived from Visible, NIR and Mid-Infra Red portions of the electromagnetic spectrum (EMS). Here in the present study high reflectance of vegetation is observed in 1989 image of the study area, with an increase in NDVI values but the vegetation reflectance is low in 2010.

The change detection helps to detect the areal change of forest cover of an area. Present research highlights the areal forest cover change of study areas (three unions: part of Chyokhyong, Part of Alikadam and very small part of Lama) in between the year 1989-2010. Moreover, the change detection map shows that out of the total 16852.32 hectare area, some decreased category is in top position, means 29.55% of land surface was changed at the rate of 1.41% in between the year 1989-2010, this changes was noticed in the north-eastern, major portion of southern, and north-western margin followed by decrease category 15.47% (changed at the rate of 0.74%) noticed in the northen, central and southern areas and a small percentage of land showing some increase and increasing trend than its previous time which shares some 12.80% (rate of change 0.61%) and 14.40% land surface (change rate 0.69%) respectively and the remaining 27.78% of land are unchanged.

From the overall quantitative assessment of forest cover change from 1989-2010, researcher express his opining that Chokhyong union needs top most special protection next to Alikadam and finally for the part of Lama union. As these areas are naturally belongs in the hilly area and lots of changes have already been observed through present investigation, the author highly welcome all the relevant researcher's for its future investigation.

Acknowledgement

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