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Investigations on Change Detection in Chandpur (M.S.) Watershed area by using RS and GIS

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Abstract

Investigations on spatial and temporal land use/land cover (LULC) changes at regional scales is essential for a wide range of applications such as landslide, erosion, land planning, global warming, Hydrologic phenomenon and their effects on ecological processes, runoff, soil erosion and sedimentation and soil conditions etc.. The LULC alterations (based especially on human activities), are observed to negatively affect the patterns of climate, the patterns of natural hazard and socio-economic dynamics in global and local scale. In the present study an attempt has been made to investigate LULC changes by using of Remote Sensing(RS) and Geographic Information Systems (GIS) support in respect of Chandpur reservoir. For this purpose, firstly a hybrid classification technique is applied to satellite images acquired for the years 2004, 2007 and 2012 and the image Classification of six reflective bands of four IRS-P6 images is carried out by using maximum likelihood method and with ground truth data obtained from GPS points in fields of year 2012. The second part focused on land use land cover changes by using change detection comparison (pixel by pixel). In third part of the study, the land cover changes are analyzed by vegetation sensitivity analysis NDVI classification and the GIS functions. The results indicate that severe and drastic land cover changes have occurred from the year 2004 to 2012. Degraded forest increased from 7.96% in 2004 to 12.71% in 2012 which is nearly 5% change and the Crop land area increased nearly by 2%. The evergreen forest accounted for 23.02% earlier in 2004 is found to be 15.98% later in the year 2012 thereby indicating nearly 6% change. These changes may cause negative impacts on watershed catchment especially on runoff and sediments which must be analysed to arrest its further degradation.

Key words: *LULC, NDVI, RS GIS*

1.0 Introduction

A Geographical Information System (GIS) is a set of tools for collecting, storing, retrieving at will, transforming and displaying of spatial data from the real world. It is capable to identify, locate, perform change studies, pattern analysis and modeling for natural resource management such as action plan for integrated sustainable development, locating waste disposal sites, natural hazardous sites, identify and analyze minerals, land and water resources. It can also help pull together various types of disparate data such as remote sensing (RS) data, census data, and records from different administrative bodies, topographical data and field observations to assist researchers, planners, project officers and decision-makers in resource management.

A combination RS and GIS can be implemented wherein the information derived from satellite data, topographical maps and other socioeconomic data could be stored in GIS as a database. GIS enables effective and efficient manipulation of spatial and non-spatial data for scientific management of watershed and develop alternatives of development model for the benefit of local people. It also facilitates modeling to arrive at locale specific solution by integrating spatial and non-spatial data such as thematic layers and socio-economic data.

2.0 Literature

A time series analysis of seasonal NDVI have been used to estimate net primary productivity, phonological characteristic of vegetative surface, length of growing season and dry drown periods. **(Ramsey *et al.*, 1995). Lyon *et al.*, (1998)** have developed vegetation indices to understand the relative abundance of the vegetation. As many as of 20 vegetation indices are in use. The most popular one is NDVI. **(Yamagata, 1999).**

LULC governs the characteristics of landscapes in terms of their structure, functions and dynamics. It has become vital to understand the interaction between humans and the landscape to better understand the characteristics because of the increasing risk of major alterations through anthropogenic activities. Change evaluation shows many aspects of LULC such as the causes and driving forces which can then be used effectively for prediction. (**Jianguo Wu and Richard Hobbs, 2002)**.

The natural environment especially in watershed ecosystems is sensitive to the negative impacts of land cover changes. Forest cover reduction through deforestation and conversion for agricultural purposes can alter a watershed's response to rainfall events, that often leads to increased volumes of surface runoff and greatly increase the incidence of flooding and sedimentation of receiving water bodies. The detection of these changes is crucial to provide information as to what and where the changes have occurred and to analyze the impacts of these changes. **(McColl and Aggett, 2007).**

A balanced ecosystem consisting of soil, water, and vegetation is essential for the survival and welfare of human race. However, over-exploitation of natural resources creates disturbances in ecosystems and at times induces natural hazards. High rates of erosion and sedimentation are increasingly realized as major and critical issues in disrupted ecosystems. Gross runoff response as a result of complex interactions between climatologic and physiographic factors usually affects erosion in watersheds. (**Rai and Mathur**, **2007**).

Eldho T.I. (2009) mainly dealt with characterization of watershed for key parameters such as drainage, slope, Land Use (LU) / Land Cover (LC) by using RS and GIS. A GIS is successfully employed to prepare the finite element grid map and input files such as Manning's roughness and slope used in the model of watershed.

J.R. Santillan et. al., (2012) discussed about integrating remote sensing, GIS and hydrologic models for predicting land cover change impacts on surface runoff and sediment yield in Taguibo watershed, Philippines.

3.0 Objectives of the study and Study Area

In the light of literature cited, the objectives of the present study primarily include improving accuracy of catchment information with the help different satellite images for reservoir area for years 2004, 2007 and 2012 and analyze spatial and temporal changes, creating data input for hydrological analysis and obtain NDVI classification for the Chandpur reservoir catchment in Vidarbha region of Maharashtra State. The Chandpur watershed is situated between 21.37° and 21.18° North latitudes and 79.32° to 79.56° east longitudes with a elevation ranging from 270 m to 520 m above MSL and it is extended over a total area of 62 km^2 . The mean minimum temperature is 6°C and mean maximum temperature is 45°C. The average annual rainfall in the district ranges from 1250 to 1500 mm.3.3 Climate and Rainfall. The watershed is in Bhadara district and falls under the Wainganga basin with Wainganga River being the main River with tributaries like Bavanthadi, Chulbandh, Godora and Sun Rivers**.(Fig.1)**

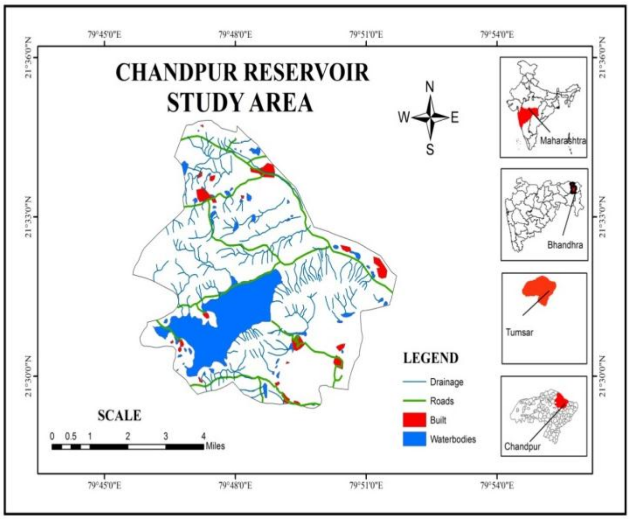


Figure 1 Base Map of Chandpur Reservoir

4.0 Methodology

The proposed methodology of the study involved various activities such as base map preparation, LULC map preparation, improvement of LULC maps using ground truth data, digitization and image processing using various software and interpretation of the outputs. The following table indicates type of data, source of data, and purpose of data collection.

Table 1 : Data collection and source

Sr. No.	Type of Data	Source	Satellite	Date	Purpose
1	Topographic Sheets	Survey of India (SOI)	-----------	1972	Bbase map
2	Remote Sensing data	NRSC, Hyderabad	IRS-P6,	2004	LULC map
			LISS-III	2007	
			LISS-IV	2012	
3	Ground Truth Data	Field Visit With GPS	-----------	2012	Improve the quality and accuracy of LULC
4	ArcGIS 9.0	NIRD	-----------	-----	Digitalization
5	ERDAS Imagine 9.0	NIRD	-----------	-----	Image Processing

Further, it is necessary to carry out ground truth verification as working on toposheets and satellite maps is not enough for RS-GIS analysis. For accurate spatial analysis and land use classification it is required to get field identification points for which GPS points of some randomly selected villages, croplands and dam were taken with a state of art GPS Device. The coordinates of these GPS points are as shown in Table 2.

Table 2. Field GPS points

Sr. No	Field	GPS Points (Decimal Degree)
1	Reservoir	21.518N 79.811E
2	Dam	21.517N 79.813E
3	Canal	21.514N 79.827E
4	Crop land	21.504N 79.826E
5	Village	21.509N 79.823E
6	Waste land	21.506N 79.834E
7	Scrub land	21.497N 79.808E

The satellite imagery acquired from the satellite IRS P6 - LISS IV (Linear Image Self Scanning) are having resolution 5.8m whereas few satellite images acquired from the IRS P6 -LISS III are having resolution 30.8m. Year wise account of the same is mentioned in Table 3.

Table 3. Satellite (Remote Sensing) Data Source

S. No	Date	Path/Row	Year	Satellite	Sensor	Source
2	03-Dec-04	100/57	2004	IRS- P6	LISS 4	NRSC
3	25-Oct-07	100/57	2007	IRS- P6	LISS 3	NRSC
4	25-Feb-12	100/57	2012	IRS-P6	LISS 3	NRSC

Figure 2.LISS-III Satellite Images 2012 (Source: National Remote Sensing Centre)

In order to achieve the objectives of the study, the methodology and processes adopted are as indicated in the flowchart **(Fig.3.)** The processes include meticulous works such as **scanning** of collected toposheets using a flat scanner. **Geo-referencing** of toposheets, Mosacing (Joining part of study area toposheets together), **Clipping** (Cutting required study area watershed from toposheets) to prepare base map on 1:50,000 scale, **Indicating** drainage, transportation network and watershed maps using SOI topographical maps and updating with the satellite data (Using ERDAS 9.1 and ArcGIS 9.3 software), **Generation of digital contour map** with twenty meters interval using SOI 1: 50,000 topographical maps, Correction, modification and **transfer** of **post field details** of hydrogeomorphology, soils and LULC **on to original maps.**

Data Preparation and Satellite Image Analysis

The temporal Satellite imageries are collected from NRSC, Hyderabad. Each image is having four different bands which are merged together in ERDAS Imagine software. For analysis purpose bands are adjusted in false color combination (FCC).

The data preparation and satellite image analyses include extraction of IRS satellite compressed format image by merging all bands together in ERDAS Imagine 9.0, Rectification of geometric corrections and set geometric model in polynomial and geographic projection, Verification of the co-ordinates of features in toposheets and satellite image by GCP tool in ERDAS, Joining the total area covering images together and clipping out study area watershed boundaries and enhancing the image quality by histogram equalization and refinement and adjustment to approximate true color combination for analysis.

In present study Hybrid classification is adopted. In Unsupervised classification, the image classification is done by taking approximately 100 classes according to color and pixel value. Based on spectral reflectance of different land use about 100 classes are clubbed/grouped into 8 classes such as Crop land Fallow land, Waste land, Scrub land, Dense forest, Semi dense forest, Water body by taking into consideration class reduction toposheets and GPS points. In further Supervised classification, after selecting training sites and checking statistics a signature file was created based on information obtained about distribution of LU/LC features in images through initial field reconnaissance and unsupervised classification. As per (Chow et al, 2005) thumb rule of minimum 50 pixel per training set and 10 samples per class was adopted. Results of unsupervised classification and facts collected from field visits were incorporated during selection of training sites for supervised classification. Finally, the supervised classification was carried out using Maximum Like hood Classification module available in ERDAS Imagine 9.0 digital image processing software. Total 8 classes of NRSA level-III are identified and final LU/LC maps are produced. Also areal extent of each LU/LC features with accuracy and kappa statistics are calculated. Fuzzy convolution procedure using 5X5 windows with equal importance to all layers (bands) was applied on classified image to reduce the salt and paper effect in the map. Further raster to vector conversion was rendered so as to use LU/LC map in a GIS environment.(**Arun Kamat V et. al., 2011)**)

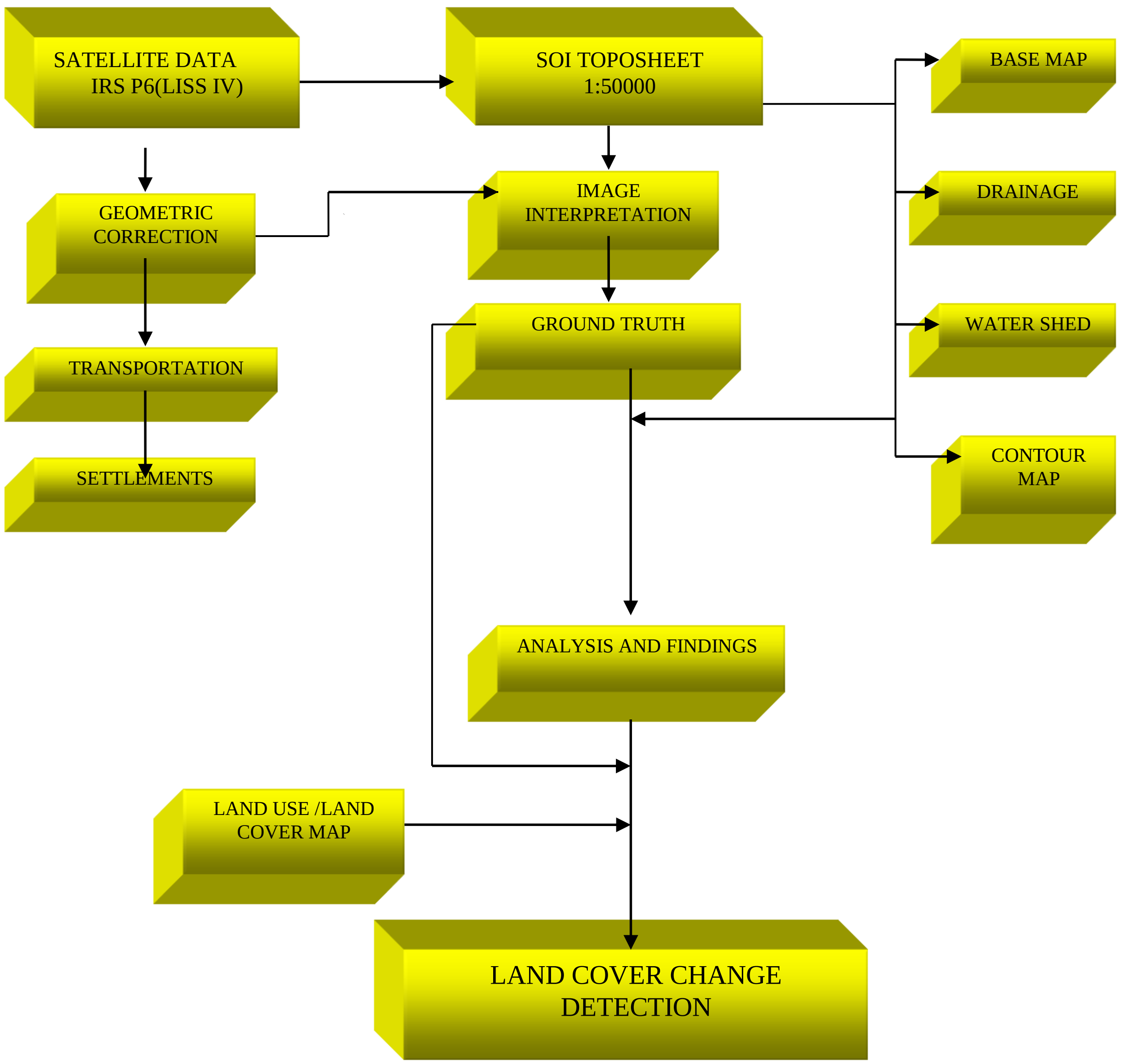


Figure 3 Flow Chart Depicting Broad Methodology

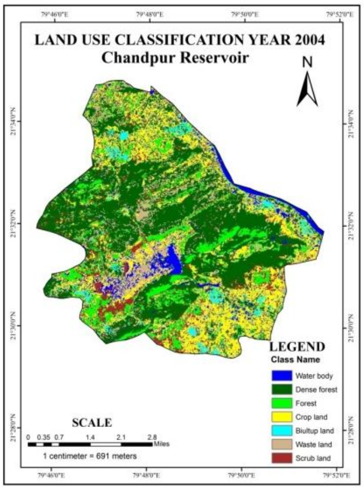
5.0 Change Detection

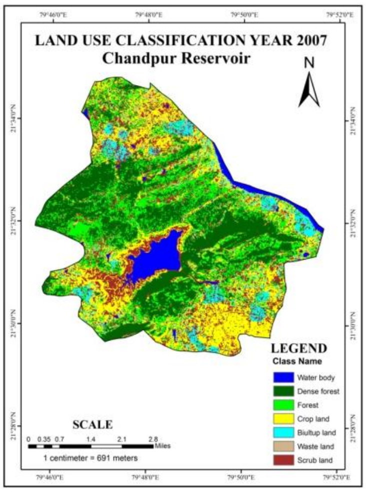
Change detection analysis for 2004, 2007 and 2012 was carried out with the help of Change Detection Matrix provided with ERDAS imagine. By giving classified image of two different periods as input, the model automatically finds out the area where changes have occurred. Statistical analysis were also carried out for identifying changes occurred in various land use classes.

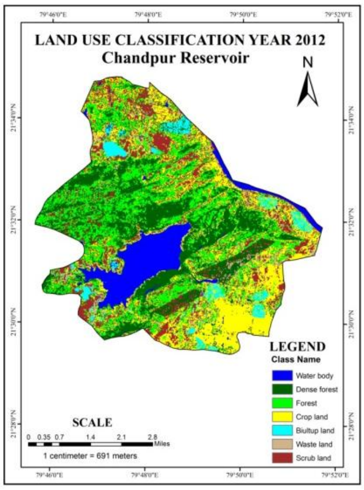
The change matrix technique was used to identify the variations in the land cover over a period of time from one type to another. Using random sampling method the satellite imagery accuracy of the land use land cover results generated from the satellite imagery. The error matrix was computed at the end of the assessment and finally identifying the nature of change using different techniques.

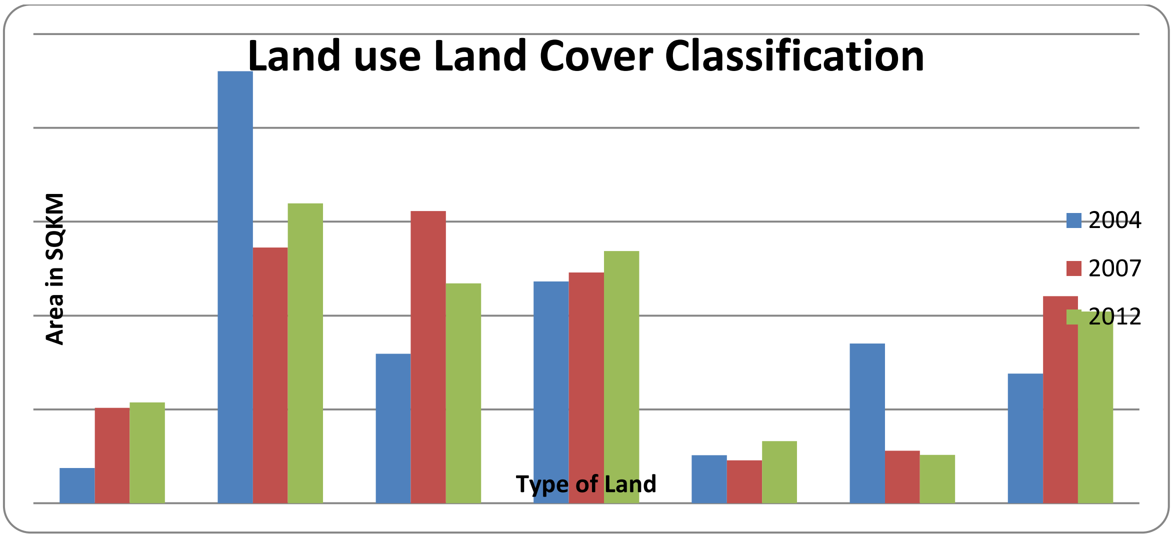
Land	2004	2007	2012
Water Body	1.885824	5.08608	5.3741
Evergreen forest	23.01984	13.62298	15.978
Degraded forest	7.960896	15.57504	11.712
Crop land	11.810304	12.28896	13.441
Built-up land	2.561504	2.283264	3.3114
Waste land	8.513856	2.800512	2.5782
Scrub land	6.917568	11.03242	10.218

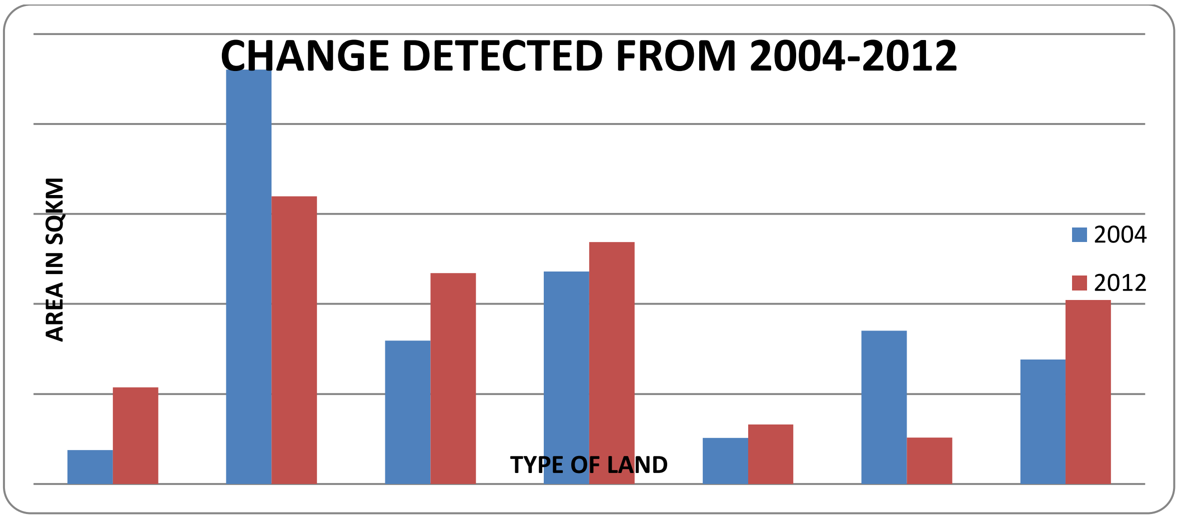
Land	2004(Area in Km^2)	2012(Area in Km^2)	Changes
Water Body	1.885824	5.374112	3.4883
Evergreen forest	23.01984	15.9776	-7.042
Degraded forest	7.960896	11.711744	3.7508
Crop land	11.810304	13.44096	1.6307
Built-up land	2.561504	3.311424	0.7499
Waste land	8.513856	2.578176	-5.936
Scrub land	6.917568	10.21776	3.3002


LAND USE CLASSIFICATION YEAR 2004
Chandpur Reservoir
N
LEGEND
Class Name
Water body
Dense forest
Forest
Crop land
Biultup land
Waste land
Scrub land
SCALE
1 centimeter = 691 meters


LAND USE CLASSIFICATION YEAR 2007
Chandpur Reservoir
N
LEGEND
Class Name
Water body
Dense forest
Forest
Crop land
Biultup land
Waste land
Scrub land
SCALE
1 centimeter = 691 meters


LAND USE CLASSIFICATION YEAR 2012
Chandpur Reservoir
N
LEGEND
Class Name
Water body
Dense forest
Forest
Crop land
Biultup land
Waste land
Scrub land
SCALE
1 centimeter = 691 meters


Land use Land Cover Classification
Area in SQKM
Type of Land
2004
2007
2012


CHANGE DETECTED FROM 2004-2012
AREA IN SQKM
TYPE OF LAND
2004
2012

Change Matrix Analysis

Table 1. Change Matrix Analysis

From	To	Area(km^2)
Unchanged Water body		1.882368
Water body	Evergreen Forest	0.200448
Water body	Degraded forest	0.145152
Water body	Crop land	0.38592
Water body	Built up land	0.050112
Water body	Waste land	0.08352
Water body	Scrub land	0.189504
Evergreen Forest	Water body	0.114624
Unchanged Evergreen Forest		9.694656
Evergreen Forest	Degraded forest	7.704
Evergreen Forest	Crop land	2.16
Evergreen Forest	Built up land	0.286272
Evergreen Forest	Waste land	0.721152
Evergreen Forest	Scrub land	2.088
Degraded forest	Water body	0.471744
Degraded forest	Evergreen Forest	1.538496
Unchanged Degraded forest		1.847232
Degraded forest	Crop land	1.257408
Degraded forest	Built up land	0.242496
Degraded forest	Waste land	0.295488
Degraded forest	Scrub land	2.23776
Crop land	Water body	1.142208
Crop land	Evergreen Forest	0.392832
Crop land	Degraded forest	1.870848

From	To	Area(km^2)
Unchanged Crop land		4.330368
Crop land	Built up land	0.585792
Crop land	Waste land	0.914112
Crop land	Scrub land	2.517696
Built up land	Water body	0.05472
Built up land	Evergreen Forest	0.130752
Built up land	Degraded forest	0.286272
Built up land	Crop land	0.562176
Unchanged Built up land		0.702144
Built up land	Waste land	0.062784
Built up land	Scrub land	0.24768
Waste land	Water body	1.562688
Waste land	Evergreen Forest	1.024128
Waste land	Degraded forest	2.058048
Waste land	Crop land	1.809792
Waste land	Built up land	0.255168
Unchanged Waste land		0.35712
Waste land	Scrub land	1.343808
Scrub land	Water body	0.57888
Scrub land	Evergreen Forest	0.465984
Scrub land	Degraded forest	1.50048
Scrub land	Crop land	1.772352
Scrub land	Built up land	0.136512
Scrub land	Waste land	0.352512
Unchanged Scrub land		1.469376

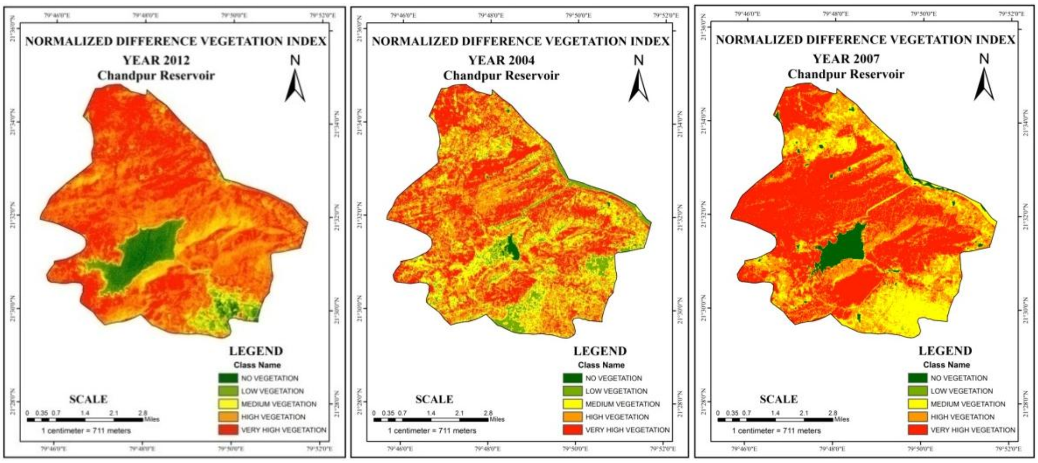
6.0 Vegetation Indices

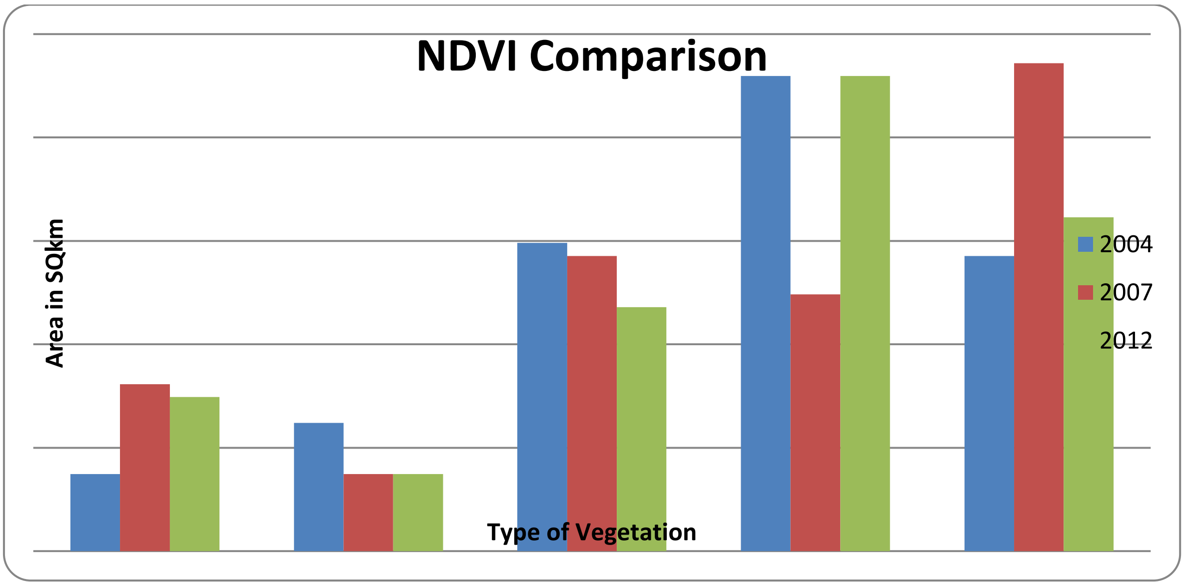
The NDVI values for vegetation range from 0.1 to 0.6, which show patterns of vegetative growth from green-up to senescence. In present study, four year NDVI images (2004, 2007, 2009 and 2012) are analyzed. The vegetation index is shown for the seasonal cropping cover and forest condition.

The Normalized Difference Vegetation Index (NDVI) shows patterns of vegetative growth from green-up to senescence by indicating the quantity of actively photosynthesizing biomass on a landscape **(after Burgan, 1996).** Such images allow for the production of maps, which indicate visual greenness and can be extremely valuable to land managers and researchers in determining changes in vegetation over time. The NDVI is the difference of near-infrared and visible red reflectance values normalized over reflectance (Burgan, 1993).

NDVI Vegetation Class	2004		2007		2012	
	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)
No vegetation	3.7242	6	8.0691	13	7.4484	12
Low vegetation	6.207	10	3.7242	6	3.7242	6
Medium Vegetation	14.8968	24	14.2761	23	11.7933	19
High vegetation	22.9659	37	12.414	20	22.9659	37
Very High vegetation	14.2761	23	23.5866	38	16.1382	26

Specifically, **NDVI = (NIR - RED) / (NIR + RED)**





7.0 Conclusions

Based on the experience on satellite image analysis, it is felt that Geo-referencing and mosiacing of toposheets can be done using softwares ArcGIS and ERDAS Imagine, but the ERDAS imagine software is found to be more accurate and reliable for this purpose. For digitalization of toposheet and for data management ArcGIS software is found suitable. The hybrid classification, LULC change detection and NDVI classification for the Chanpur reservoir area are obtained and results are tabulated. Further the Change Matrix Analysis is indicated in Table 3 and is matching with LULC change detection.

The results indicate that severe and drastic land cover changes have occurred from the year 2004 to 2012. Degraded forest increased from 7.96% in 2004 to 12.71% in 2012 which is nearly 5% change and the Crop land area increased nearly by 2%. The evergreen forest accounted for 23.02% earlier in 2004 is found to be 15.98% later in the year 2012 thereby indicating nearly 6% change. These changes may cause negative impacts on watershed catchment especially on runoff and sediments which must be analysed to arrest its further degradation.

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sensing and Spational information Science, Volume XXXVIII,Part 8,Kyoto Japan 2010.

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