Land use land cover change and People's perception on the effect of the change in Leuti Khola Watershed, Dhankuta District Nepal

Sandeep Sharma

Kathmandu Forestry College
Institute of Forestry
Tribhuvan University
Kathmandu, Nepal

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Forestry

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Researcher
Exam roll no
Sandeep Sharma
T.U. Reg. No. – 2-1-17-27-2004

Advisor
Him Lal Shrestha

Co-Advisor
Ravi Kumar Shrestha

Kathmandu Forestry College
Institute of Forestry
Tribhuvan University
Kathmandu, Nepal

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E-mail: sndpsrma@gmail.com

Tribhuvan University
Kathmandu Forestry College, Kathmandu
P.O. Box 9594, Amarawati Marga, Koteswor, Kathmandu, Nepal
Website: www.kafcol.edu.np

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DECLARATION

I, Sandeep Sharma, hereby declare that this thesis entitled **“Land Use Land Cover Change and People’s Perception on the effect of the change in Leuti Khola Watershed, Dhankuta District, Nepal”** is my original work and all other sources of information used are duly acknowledged. I have not submitted it or any of its part to any other university for any academic award.

…………………………..

24, November 2011

Sandeep Sharma

Kathmandu Forestry College

www.kafcol.edu.np

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LETTER OF ACCEPTANCE

The thesis entitled **'Land Use Land Cover Change and People's Perception on the effect of change in Leuti Khola Sub-Watershed, Dhankuta District, Nepal'** prepared and submitted by **Sandeep Sharma** in partial fulfillment of the requirement for the Degree of Bachelor of Science in Forestry under my supervision is hereby accepted.

…………………
Him Lal Shrestha
Remote Sensing Analyst
ICIMOD
Kathmandu, Nepal

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Abbreviations

DFRS	Department of Forest Research and Survey
DoF	Department of Forest
ETM	Enhanced Thematic Mapper
FAO	Food and Agriculture Organization
FECOFUN	Federation of community forest user's group Nepal
GIS	Geographic Information System
GPS	Global Positioning System
GoN	Government of Nepal
Ha	Hectare
IFP	Interim Forestry Project
IUCN	International Union for Conservation of Nature and Natural Resources
IOF	Institute of Forestry
Km	Kilometer
LULCC	Land use land Cover Change
M	Meter
MoFSC	Ministry of Forest and Soil Conservation
MSS	Multispectral Scanner
NDVI	Normalized Differential Vegetation Index
NP	National Park
PA	Protected Area
RS	Remote Sensing
TU	Tribhuwan University
TM	Thematic Mapper
UTM	Universal Transverse Mercator
VDC	Village Development Committee
WGS	World Geo-referencing System

ABSTRACT

Land use land cover change is the most important variable of global change. It has immense impact on the global environment and ecosystem. Land use is the most fundamental key factors that reflect the environmental risk and main input for the land use planning. Thus, it is very crucial to monitor the land use land cover changes. Remote sensing and GIS technique are very important for monitoring these changes. This research entitled "Land use land cover change and people perceptions on the effect of the change in Leuti Khola sub-watershed of dhankuta district" was carried out to measure the areal extent of land use land cover change; to prepare the land use land cover change map and to assess the different land use.

The research analyzed the temporal change in land use land cover by comparing two Landsat thematic mapper satellite images of different dates (1992 and 2010) coupled by GIS analyses. Landsat images, topographical maps and questionnaire survey (open ended) were used as primary data. For data analysis, ERDAS IMAGINE 2011 and ArcGis 10 were used. Global positioning system (GPS) was used for ground truthing. The maximum likelihood supervised classifier was used for image classification. The land use land cover classes that were considered in image classification are forest, cultivated land, sandy area, landslide, bush shrub land and others (settlement, water bodies, and barren land). GPS locations, topographic maps, aerial photo and rapid eye image served as the basis for signature assignment. These classified images were exported to Arc GIS 10 for spatial analysis. Classification accuracy was assessed using overall accuracy and Kappa coefficient. The data on people's perception was analyzed individually with discussion with advisor and co advisor. Results were presented in easily understandable forms such as maps, tables and charts using Microsoft Office 2007.

Result revealed that during 18 years period, cultivated land, Bush Shrub land and other type of land use increased by 48.09, 120.619 and 105.8211 ha respectively, whereas forest, sandy area and landslide decreased by 109.9, 134.273 and 30.051 ha respectively.

Land use land cover change should be monitored time and again. Further research should be conducted to identify the different factors responsible for the land use land cover change. Illegal extraction of sand, boulder, stone from watershed area should be checked.

Key words: Land use, Land Cover, GIS, Remote Sensing, Watershed

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Chapter One: Introduction

1.1. Background

Land is a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.) (FAO, 1995).Land is very important natural resource which provides basis of life to flora and fauna. Land use is one of the main factors through which human influence the environment. It involves both the manner in which the biophysical attributes of the land are manipulated and the intent underlying that manipulation – the purpose for which the land is used (Turner et. al., 1995). Land cover implies the physical or natural state of the Earth's surface. It embraces the quantity and type of surface vegetation, water, and earth materials (Meyer and Turner, 1994).It corresponds to the physical condition of the ground surface whereas land use reflects human activities such as the use of the land for different purpose like industrial zones, residential zones, etc. This definition establishes a direct link between land cover and the actions of the people in their environment, i.e., land use may lead to land cover change (Phong, 2004).

Land use and land cover change means quantitative change in the aerial extent (increase or decrease) of a given type of land use or land cover, respectively. Land use change may involve either (a) conversion from one type of use to another – i.e. changes in the mix and pattern of land uses in an area or (b) modification of a certain type of land use. Land cover and its change is a key to many applications such as environment, forestry, hydrology, agriculture, geology and as well as the Socio-economic status of local people. The land-cover changes occur naturally in a progressive and gradual way, however sometimes it may be rapid and abrupt due to anthropogenic activities. This change could be regarded as change in biotic diversity, actual and potential productivity, soil quality, run-off and sediments rates (Steffen et al., 1992).

Land use and land cover changes have long been viewed as continuous and slow process, but recent studies show that this is not always the case. In the global change newsletter, Lambin and Geist (2001)describe land cover change as a disjunctive process, with periods of rapid change and often triggered by shock event which if not checked initiates other changes along the system. Changes in land cover by land use do not necessarily imply a degradation of the land. It might be presumed that any change produced by human use is an improvement, until demonstrated otherwise, however there is growing concern globally about negative impacts resulting from land use and land cover changes (Meyer, 1995). Though land use and land cover changes are usually local and place specific, their impacts collectively add up to global environmental change, which includes: desertification, biodiversity loss, global warming and eutrophication, (CIESIN, 2002; Leper et al 2004; Rudelet al, 2005).

The studies of changes in land use and land cover is important in developing our understanding of global environmental change. This is because land use land cover change is the most important variable of global change affecting ecological systems. The characteristics of Landover have important impacts on climate, biogeochemistry, hydrology, and the diversity and abundance of terrestrial species. Hence, being able to project future states of land cover is a requirement for making numerical predictions about other global changes (CIESIN, 2002).Land use land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The research on land use land cover change provides an accurate evaluation of the spread and health of the world's forest, grassland, and agricultural resources (Zubair, 2006).There are various methods that can be used in the collection, analysis and presentation of resource data but the use of remote sensing and geographic information system (RS/GIS) technologies can greatly facilitate the process (Gautam, et. al., 2003). A combined use of RS/GIS technology can be invaluable to address a wide variety of resource management problems including land use changes and landscape changes. Repeated satellite images and aerial photos are useful for both visual assessment of natural resources dynamics occurring at a particular time and space, physical features such as land use, soils, vegetation, stream networks, and landforms at different time scales (Awasthi, 2004) as well as quantitative evaluation of Land use/Land Cover changes over time (Balla, et. al., 2007). Satellite remote sensing data has been used in Nepal since past two decades in specified areas and its importance is increasing (Sharma, 2002). Land cover change detection based on remote sensing data allows the identification of major processes of change and, by inference, the characterization of land use dynamics. One of the widely used methods to determine the temporal dynamics of land use is the analysis of satellite images covering the same area acquired on different dates (Mulders, 2001).

Watershed management has become an increasingly important issue in many countries including Nepal. Government and non-governmental agencies in Nepal have been struggling to find appropriate management and adaptation approaches for improving productions from natural resource systems to overcome the changes. One of the major causes of degradation of watershed is the improper use of land and natural resources. Accurate measurement of land use land cover and geo-morphological parameters are important for evaluating watershed conditions (Awasthi, et. al., 2002).Therefore, the study of land use land cover change is important for watershed management. The research on land use land cover change in the watershed area provides an accurate evaluation of the forest, grassland, and agricultural resources in that area. Thus, watershed being a naturally delineated area, this type of research provides the managers with an effective confine to work on.

Therefore, this research attempt to map out the changes in the status of land use land cover of Leuti Khola sub-watershed between 1990 and 2010using remote sensing and GIS techniques. Also, peoples‟ perception towards the effect on this change will be studied in this research.

1.2. Problem statement and justification

Land is the source on which all human activity is conducted. Human use of land resources gives rise to "land use". Land use varies with the purposes it serves such as food production, provision of shelter; recreation, extraction and processing of materials and so on, as well as the bio-physical characteristics of land itself. Hence, land use is shaped under the influence of two broad sets of forces – human needs and environmental features and processes. None of these forces remain constant. Rather these are in a constant state of flux. Changes in the uses of land occurring at various spatial levels and within various time periods are the material expressions, among others, of environmental and human dynamics and of their interactions which are mediated by land. These changes have at times beneficial, at times unfavorable impacts and effects. The latter being the chief causes of concern.

One of the main land cover changes on increase is forest degradation often as a result of change in land use (Lambin and Geist 2001; Rudel*et al* 2005). From a world perspective, agricultural expansion and infrastructural development contributes 37% of forest deforestation which is one third of the causal factors for tropical deforestation (Geist and Lambin, 2001).Most of the developing countries face serious environmental degradation induced by large scale deforestation. Nepal is not an exception. Nepal, with an area of 147,181 sq. km, consist 29% forests, 10.6% shrubs, 12% grasslands, 21% farmland, 7% uncultivated inclusion, 2.6% water, streams & river beds and 17.8 % urban and industrial area (Nepal Forestry Handbook, 2010) . Although community based forest management models have been successful in conserving some forests, deforestation and degradation in government managed forests is taking place at an alarming rate. The Land Resource Mapping Project survey of 1979 and the national forest inventory of 1999 show that Nepal's deforestation rate is 1.7%, with the Hilly region having higher rate (2.3%) than the national average.

Desertification, eutrophication, acidification, greenhouse effect, biodiversity loss, climate change are some of the major environmental problems to be considered. In all of them land use change is implicated to a greater or lesser extent. The impacts of these environmental problems are serious in both short and long term. In short term, human vulnerability is at stake, whereas, in the longer term, the viability of earth is being threatened. Hence, it is impetus to study global environment change in general and land use change in particular. Estimating temporal land use and land cover changes is essential to assess the rate at which these changes advance and the problems or impacts they cause and, hence, prediction of future impacts and trends (Lambin, 1997).Studies have shown that there remain only few landscapes on the Earth those are still in their natural state. Due to anthropogenic activities, the Earth surface is being significantly altered in some manner and man's presence on the Earth and his use of land has had a profound effect upon the natural environment resulting into an observable pattern in the land use land cover over time. The land use land cover pattern of a region is an outcome of natural and socioeconomic factors and their utilization by man in time and space (Zubair, 2006). The land cover changes due to human land use activities are regarded as the main reason for global environmental change, so the study on them become the forefront and hot spots of research to scholars (Liu, et. al., 2002).

Unplanned changes in land use practices in Nepal has increased land degradation and other serious environment hazards such as soil erosion, flooding, landslide, rapid sedimentation and excessive surface runoff. Agriculture has been extended at the cost of forest/shrub land, marginal and sub-marginal areas with very steep slopes without due consideration for the suitability of these lands for cultivation (Tiwari, 2000).Nepal has witnessed remarkable deforestation in all areas with the expansion and growth of haphazard developmental activities especially in urban areas. This has therefore resulted in increased land consumption and modification and alterations in the status of land use and land cover over time. Changes in land use and land cover have important consequences for natural resources through their impacts on soil and water quality, biodiversity, and global climatic systems (Awasthi, et. al., 2002). The number of people dependent on agriculture is rising as a result agricultural land has increased, mostly by encroaching upon the forest areas (UNEP, 2001). Especially mountain region of Nepal is subjected to deforestation and agriculture expansion in the marginal lands (Awasthi, et. al., 2005). One of the major challenges faced by the country is the way to conserve the forest resources and to carry the existing land use practices on the planned way.

Thus, it is important to understand the status of land use resources especially forest resources in terms of use and misuse. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Information on land use land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. Thus, assessing land use land cover change and identifying existing land use system is an ideal situation for any land management objective and is necessary in the current country context.

Advancement of technologies like GIS and Remote Sensing has proved to be an important tool for observing and recording the land use changes. The capability of GIS to integrate and analyze temporal data helps in quantifying the land use changes. Similarly, Remote Sensing is a valuable tool for monitoring the temporal changes in land use land cover especially in areas of rugged topography and poor accessibility. Indeed, attempt has been made to document land use land cover change in the past. In recent times, the land use land cover change in the area requires more powerful and sophisticated systems like GIS and Remote Sensing which provides a general extensive synoptic coverage of larger areas.

Unwanted extraction of sand, boulder, stone and other river material, illicit felling of trees, construction of un deigned roadways within the watershed leads to the horrific condition of watershed area. This research entitled “Land use land cover change and local people’s perception on effect of change” will effort to find out the temporal changes in the study area by the application of GIS techniques on remotely sensed data. Local people’s insight over the changes in land cover and land use will also be studied during the research as the study would be incomplete without their involvements who are the primary users of that area.

1.3. Research Question and objective

1.3.1. Research Question

This research was designed to answer the following questions:

1. What is the rate of change in land use and land cover from 1990's to

   2010?

2. What is the past and present trend of land cover and land use change?

3. What is the social perception towards the changing condition of forest cover and land use?

1.3.2. Objective

The General Objective of this study is to detect and document changes in major land use land cover.

Specific Objective

- To find the temporal changes in Leuti Khola Watershed area.
  Main Questions:
  1. What was the initial scenario of the area in 1992?
  2. What is the current scenario of the area in 2010?
  3. Has the area extended or is compressed?
  4. Which area is the mostly affected?
  5. What is the change composition over various land uses?

- To understand local people's perception towards land use and land use cover change.
  Main Question:
  1. Which areas (Land use) are the most significantly changing to the watershed area?

2. What are the main causes of land use cover change in the area?
3. What are the likely impacts of land use change in the area? (In terms of productivity, grazing, and other infrastructure related facilities etc.)
4. How the landuse change has impacted their normal livelihoods? (In terms of their occupation, income mode etc.)
5. Do they want to regain the precious status of landuse or just modification as usual?

1.4. Research Approach

Watershed is defined as hydrologic and geomorphic area of land that drains to a particular outlet. Since water flows in a definite flow course, Watershed becomes a basic geographic unit. It is that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community. Nepal's land use and land cover around the biological watershed is gaining tremendous pressure from the both natural disaster (landslide, erosion, flood, fire etc.) and artificial disturbances (illegal feeling, encroachment, agriculture expansion, infrastructure development etc.). Therefore, land use and land cover change analysis of such type of biological watershed is very important and essential for its further planning on its conservation, management as well as environment and ecological balance. Integrated approach (Figure 1) of remote sensing and geographic information system such as image classification, change detection techniques, perceptual comparison was applied for assessing the land cover and land use change in Leuti Khola Watershed. Land cover and other land use assessment is the foundation to manage the biological watershed and this study will provide necessary information for its conservation and further management.

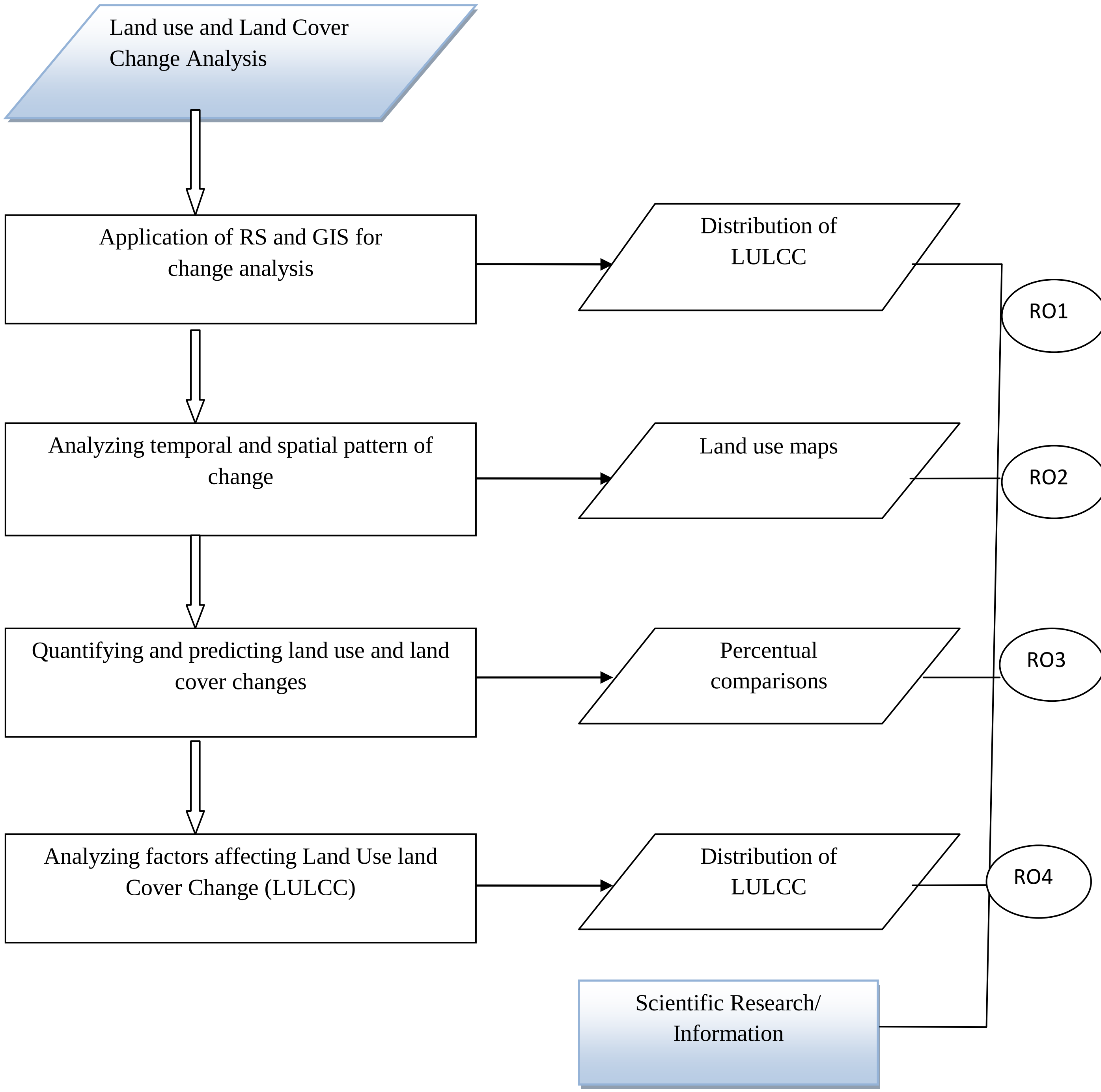

Figure 1: Research Conceptual Framework

1.5. Organization of thesis

It is important to have a mental roadmap about the relationship between various chapters. Chapter one deals with the general background; problem statement; research questions; and objective and research approach designed to analysis land use and land cover change in Leuti Khola Watershed in Dhankuta district (Nepal). Chapter two primarily deals with the state of art on remote sensing and Biological watershed, Image preprocessing, image classification and change detection techniques. Chapter three describes the study area: Leuti Khola sub-watershed with respect to location, climate, and biodiversity resources distribution. Chapter four is concerned with the materials and methods used in this research such as image classification and change detection techniques applied. Chapter five presents the result and discussion of land use land cover monitoring .Chapter six summarizes overall results and discussion and recommends on the areas of improvements. Finally five appendices are also included in the back of the thesis to illustrate study area, data and output in detail.

Chapter Two: literature review

Demographic, economic and social changes around the world continue to exert considerable pressure on forest cover and condition. After recognition of importance of people's participation in Natural Resource Management and with the successes of the community forestry approach, several complementary models of participatory community based resource management came in operation, such as Leasehold.

Forestry (LF), Collaborative Forest Management (CFM), user group based watershed management and buffer zone forest management. At present, Nepal's success in community forestry (especially in hill regions) has become as a good inspiration for other countries and regarded as innovative policy in Forest Management (Nagendra, 2002). Despite this, demographic, economic and social changes around the Leuti Khola Watershed exert considerable pressure on forest cover and condition. The development activities like expansion in education and health services, the development of roads and electricity, improvements in irrigation and agricultural and related technologies, and the penetration of commercial forces are drastically affecting land cover and ecosystems of the area. Each of these factors contributes with varying degree to the change dynamics of that area as well as a contributory factor may be applicable in one area, but not in another. Past studies carried out by Brandon & Bottomley, (1998), Chen (2000), Diouf & Lambin(2001), Kuntz &Siegert (1999), Lambin (1999), Mendoza S. & Etter R., (2002), Vance & Geoghegan (2002) have emphasized the importance of investigating land cover dynamics as a baseline requirement for sustainable management of natural resources. The knowledge of "where are the changes" and "what are causes of the changes" is essential for the formulation of appropriate management strategies. The understanding of land cover change process and driving forces will help policy makers/ resource managers to decide where the action should be taken and what kind of intervention is needed.

There are several studies conducted in Nepal in relation to land use change and forest degradation (Awasthi and Balla, 2000; Gautam et al., 2003; Gerrard and Gardner, 2002). An in-depth study in two watersheds of western Nepal by Awasthi et al., (2002) accounted for land use changes through the transitions among the land use classes. Interestingly, they reported that significant area under agriculture in the base year 1978 was abandoned and covered by shrub and bushes. The Phewa lake watershed constitute forest (44%), agricultural land (39%), urban and wetland area (5%), pasture and barren land (5%), lake area (4%) and shrub land (3%) (DSC, 1994) . Land use has an impact on the hydrological regime and quality of water downstream. The importance of this impact varies with the type of land use, the size of the watershed, climate, soil characteristics, topography, geology, etc. The forest cover in Phewa Lake Watershed decreased from1978 to 1998 by annual 2.4% of total forest land (www.gisdevelopement.net/application/natural resource management)

Remote sensing for vegetation and land cover mapping and change detection, particularly in areas where due to accessibility, spatial extension or other factors, the conventional means of ground survey are not sufficient, is considered by several authors as having great potential and as an extremely valuable tool (Xiuwan, C. et al., 1999; Turker and Derenyi, 2000). The potential of using satellite data to detect and characterize changes in forest cover depends on the ability to quantify temporal effects using multi-temporal data sets (Bauer et. at.2000).Remotely sensed data sets are emerging as a better choice for forest managers to observe spatially explicit changes over the time period. Satellite based remote sensing offers additionally the possibility of acquiring information on a regular basis, essential in applications where a high repeat frequency is required (Pathirana, 1999 and Wyatt, 2000). Satellite remote sensing data has been used in Nepal since past two decades in specified areas with limited application. Forestry sector is one of the main application areas where this technology has been using from the beginning. Satellite remote sensing is one of the viable techniques to monitor the changing pattern of forest cover and Maximum likelihood classification is the most common supervised classification method used for land cover land use change with remote sensing image data. (Richard, 1995)

2.1. Concept and definition

2.1.1. Land Cover and Land Use

According to FAO (2000) “Land cover is the observed (bio) physical cover on the earth’s surface.” The same document also defines land use as the arrangements, activities and inputs that people undertake on a certain land cover type. According to these definitions, land cover corresponds to the physical condition of the ground surface, e.g. forest, grassland, concrete pavement, while land use reflects human activities such as the use of the land like industrial zones, residential zones, and agricultural fields. Hence, a land use class is composed of several land covers. Remote sensing data can provide land cover information rather than land use information. Land cover change can be divided into 2 forms as follow (FAO, 2000)

• Conversion from one land cover category to another e.g. from forest to grassland.

• Modification within one category, e.g. from dense forest to open forest.

2.1.2. Spatial and Temporal Change

Land-covers undergo changes due to natural or man-made causes over time. Spatial and temporal dimensions characterize changes. Temporal extent indicates the period of time when the change in any land cover takes place. The area in which the change happens defines spatial locations and extent. Spatial-temporal phenomena can be characterized by location, time and attributes. The change undergoes mainly through three process i.e. basic process, transformation process and movement process (Langran, 1992; Weir, 2002; Kandel, 2004). The basic process results in as appearance of new feature, or no change. Transformation process reveals either expansion of the feature or contraction or deformation of it. Movement process also results in as translation or rotation or diffusion. Spatio-temporal data can be used to detect and analysis change in any land cover feature or its attributes or both. They can be distinguished in four main phases i.e. change detection, change quantification, change assessment and change attribution in the analysis of image time series (Henebry et. al., 2003). Reliable information in different spatial and temporal scales can be extracted from the satellite imagery (Roy, 2003). The basic principle of change detection using remote sensing is that changes in land cover result in changes in radiance values (Mas, 1999).Analyzing spectral differences in signatures of an object (Landover), change can be detected. Thus, change detection through remote sensing can play a key role in providing spatial and temporal change information resulted by natural and anthropogenic activities in terms of time and cost effectiveness.

2.1.3 Remote Sensing

Remote sensing can be defined as any process whereby information is gathered about an object, area or phenomenon without being in contact with it. Given this rather general definition, the term has come to be associated more specifically with the gauging of interactions between earth surface materials and electromagnetic energy. (Idrisi 32 guide to GIS and Image processing, volume 1).Remote Sensing is defined as the art and science of obtaining information about an object without being in direct physical contact with the object (Jensen, 2000). It is a scientific technology that can be used to measure, assess and monitor important biophysical characteristics and human activities in the earth and its surface. People responsible for managing the earth's natural resources and planning future development recognize the importance of accurate, spatial information residing in a digital GIS. Many of the most important layers of biophysical, land use/ land cover, and socioeconomic information in a GIS database are derived from an analysis of remotely sensed data (Jensen, 2000).

Image interpretation is defined as the examination of images for the purposes of identifying objects and judging their significance (philipson, 1997). Multi-temporal analyses of surface properties are desired in order to assessing the various changes occurring at the Earth surface. Remote Sensing data collected by various instruments constitute a unique data basis ensuring a systematic local, regional, and global coverage for a range of ground spatial resolution. The examination of multi-temporal remote sensing data set is often confined to simplified change analysis schemes.

The examination of multi-temporal remote sensing datasets is often confined to simplified change analysis schemes. More powerful procedures are offered by trend analysis techniques requiring quantitative or semi-quantitative input data (Elmore et al., 2000). Application of remotely sensed data to illustrate changes in land cover and particularly forest cover over time have been reported by many investigators (Coppin and Baur, 1996). Trend analysis can be employed to calculate numerous parameters that may be derived from time series of satellite data. A combination of different parameters reveals additional information, which is not easily comprehensible through other processing schemes.

Vegetation is one of the most important components of ecosystems. Knowledge about variations in vegetation species and community distribution patterns, alterations in vegetation phenological (growth) cycles, and modifications in the plant physiology and morphology provide valuable insight into the climatic, edaphic, geologic, and physiographic characteristics of an area (Jones et al., 1998). Scientists have devoted a significant amount of effort to develop sensors and visual and digital image processing algorithms to extract important vegetation biophysical information from remotely sensed data (Huetteand Justice, 1999).

Remote sensing for vegetation and land cover mapping and change detection, particularly in areas where due to accessibility, spatial extension or other factors, the conventional means of ground survey are not sufficient, is considered by several authors as having great potential and as an extremely valuable tool (Xiuwan, C. et al., 1999; Turker and Derenyi, 2000). Remote sensing is the only way to acquire temporal and spatially change data of such large geographic areas over long periods of time.

2.1.4 Digital Image Processing

One of the important factors determining the accuracy of change detection is the precise geometric registration between multi temporal images (Lu et al., 2004). Histogram matching which converts the histogram of one image to resemble the histogram of another is useful for change detection (ERDAS, 2008). The resembling of multi spectral scanner (MSS) data to 30m pixel will be done using cubic convolution. The satellite image will be preprocessed through geometric correction and histogram matching to atmospheric and radiometric enhancement of those images.

2.1.5 Image Classification

According to Jensen (1996), digital image classification is the process of assigning pixel to classes. Usually, each pixel is treated as an individual unit composed of values in several spectral bands. By comparing pixel to one another and to pixel of known identity, it is possible to assemble groups of similar pixels into classes that match to the informational categories of interest to users of remotely sensed data. In recent year, many advanced classification approaches; such as artificial neural networks, fuzzy sets and expert systems, have been widely applied for image classification (Lu andWeng, 2007). Cihlar (2000) discussed the status and research priorities of land cover mapping for large areas. Franklin and Wulder (2002) assessed land cover classification approaches with medium spatial resolution remotely sensed data. In general, image classification approaches can be grouped as supervised and unsupervised, pixel-based and object-oriented, hard and soft classification based on whether the training samples are used or not, spatial unit of analysis, and whether parameters are used or not respectively.

Supervised classification is the process of using a known identity of specific sites (through a combination of fieldwork, analysis of aerial photography, maps, and personal experience) in the remotely sensed data, which represent homogenous examples of land cover types to classify the remainder of the image. These areas are commonly referred to as training sites (Jensen, 1996). Normalized Differential Index (NDVI) was calculated to improve the result and assist classification.

Signature can be defined as the set of pixels assigned in an image file to a class. It may be parametric or non-parametric. The theoretical lower limit of the number of pixels in a training set must be n+1, where 'n' is the number of spectral bands used (Kiefer,1994). In practice, minimum 10n to 100n pixels is used to improve statistical representation (mean vector & covariance matrix).

All images are classified individually because the images of different dates could have specific spectral properties, different from other images. Theoretically, calibration could bring all the images to the atmospheric radiance values. Merging all the radiometrically calibrated images should not produce any anomalous results after classification; however, errors are observed when all the images were merged before classification.

2.1.6 Maximum likelihood classifier

The maximum likelihood classifier is one of the most popular methods of classification in remote sensing. This classifier assigns a pixel with maximum likelihood into a corresponding class as shown in Figure 1. The likelihood (Lk) is defined as the posterior probability of a pixel belonging to class k (Japan Association of Remote Sensing, 1996).

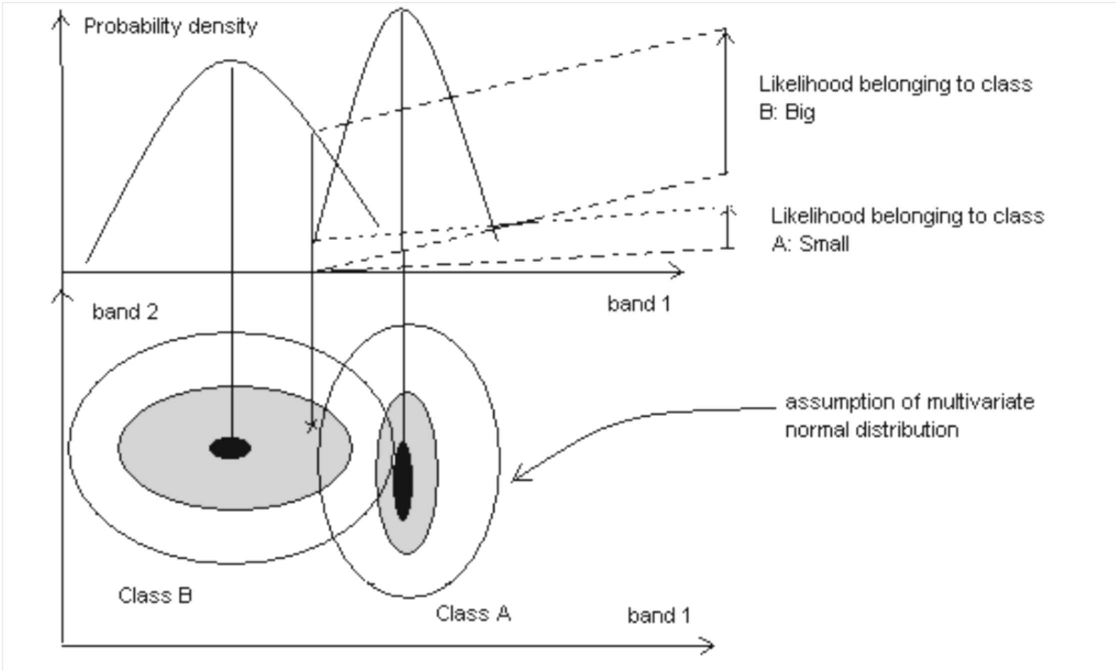

Figure 2: Maximum Likelihood Classifier

Lk= P (k/X) = P (k)* P (X/k)/ ΣP (i)*P (X/i)

Where, P (k): Prior probability of class k

P (X/k): conditional probability to observe X from class k, or probability density function

Usually P (k) is assumed to be equal to each other and ΣP (i)*P (X/i) is also common to all classes.

Therefore Lk depends on P (X/k) or the probability density function.

2.1.7 Change Detection and Analysis

Analyzing an individual date of remote sensor data to extract meaningful vegetation biophysical information is often of value. However, to appreciate the dynamics of the ecosystem, it is necessary to monitor the vegetation through time and determine what changes in succession are taking place. Relatively medium to high temporal resolution satellite data is often useful for such type of study. Researchers involved in change detection studies using satellite images data have conceived a large range of methodologies for identifying environmental changes. Change detection procedures can be grouped under three broad headings characterized by data transformation procedures and analysis techniques used to delimit areas of significant changes: (1) image enhancement, (2) multi-date data classification and (3) comparison of two independent lands cover classifications (Mas, 1998). The enhancement approach involves the mathematical combination of imagery from different dates such as subtraction of bands, rationing, image regression or principal component analysis (PCA).Thresholds are applied to the enhanced image to isolate pixels that have changed. The direct multi-date classification is based on the single analysis of a combined data set of two or more different dates, in order to identify areas of changes. The post-classification comparison is a comparative analysis of images obtained at different moments after previous independent classification.

Change detection techniques using remote sensing techniques involve the use of multi-temporal satellite data sets to discriminate areas of land cover change between dates of imaging (Lillesand Kiefer, 2008). It can provide up-to-date spatio-temporal information about forest resources status that supports in making decision on appropriate intervention (policy formulation, planning and management). The basic principle of change detection using remote sensing is that changes in the land cover result in changes in radiance values (Mass, 1999). Analyzing spectral differences in signatures of an object (land cover change) can be detected. Thus change detection in remote sensing play a key role in improving spatial and temporal change information resulted by natural and anthropogenic activities in terms of time and cost effectiveness. The applicability of semi-automated and object-oriented approaches for satellite remote-sensing data has been the subject of many recent studies (Zhan, 2003)

Post-classification techniques have significant limitations because the comparison of land-cover classifications for different date’s does not allows the detection of subtle changes within land-cover categories (Macloed and Congalton, 1998). Change detection will be performed using post-classification comparison method which produced acceptable results. The post classification, change-detection technique of image differencing was applied on subsequent pairs of the classified single date images so that image difference data was obtained for the three time interval. The classified images of the various dates on the ERDAS Imagine will be converted to vector (ESRI Shape file). Again, the vector files will be converted to the raster grid by using Spatial Analyst extension of the Arc GIS 9.2

Chapter Three: Study Area

3.1 General Description

Leuti Watershed is located, southern part of the Tamor river and north of the Sunsari district likewise east to the Dandabazar vdc and west to the Mahabharat vdc in Dhankuta district. The Dharan-Dhankuta highway has been vertically intersecting the sub-watershed area. It is located between the latitude of 26^0 53'to 27^0 19' N and the longitude 87^0 8' to 87^0 33' E. The sub-watershed covers an area of 5000 hectors.

VDCs and Wards within Sub-watershed Area

S.N.	Name of VDCs	Fully encompassed wards	Partially encompassed wards
1	Facsib	5 to 7	1,3,8 and 9
2	Mahabharat	0	1 to 4
3	Dandabazar	1 and 7 to 9	2,5 and 6
4	Budhimorang	1	2 and 8
5	Bhedetar	1 to 9	

Source: Topographic Map, FINNIDA Project 1994/98.

Table 1: VDCs and Wards within Sub-watershed Area

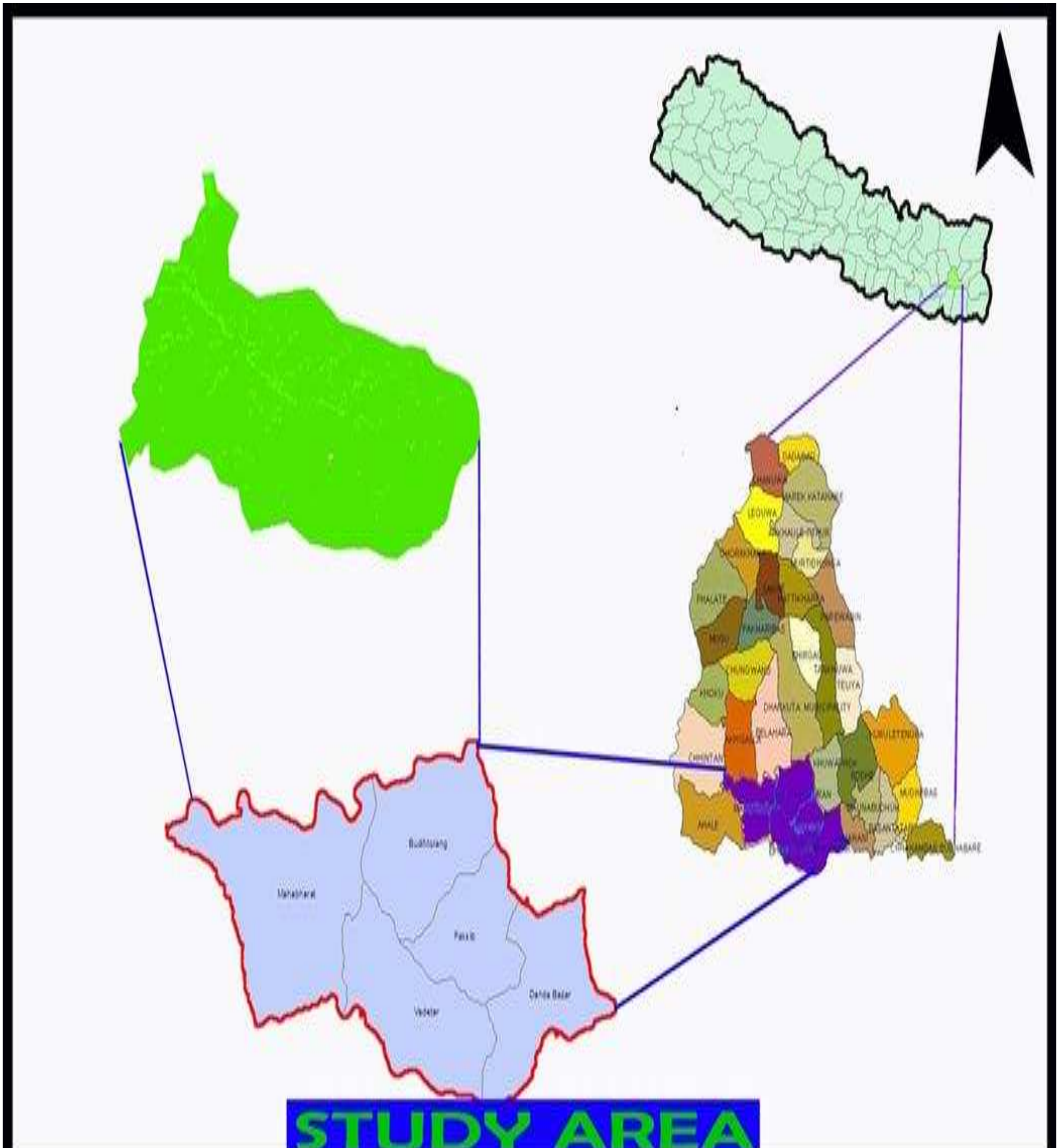

Figure 3: Map of Study Area

3.2 Bio-physical information

3.2.1. Climate

The climate of the Watershed area is sub-tropical to temperate with maximum temperature before monsoon and tropical dry winter. Average annual precipitation is about 2150 mm with higher rates along the inner part. The area is noted for its hot in lower height and cold in higher elevation and wet monsoon. Maximum daily temperature goes more than 32^{o}cand minimum daily temperature 5^{o}c. Average daily maximum temperature is 20.56^{o}c and minimum daily temperature is 16.6^{o}cin the sub-watershed area (District Profile of Dhankuta, 2066).

3.2.2. Geology

Physiographically the sub-watershed area lies within the middle hills region. The major geology of the sub-watershed is metamorphic rocks, micasceist, sandstone, shale and mudstone. It consists of tertiary unconsolidated and highly erodible fluviatile sediments.

Based on lithology, this watershed can be divided into two groups.

I) Middle hill: consists of hard rock in the south but weak due to anthropogenic activities and becomes erodible.

II) Upper Siwalik: consists of soft sandstone inner bedded with thin layers of clay bed (shale), pebbles and coarse sands in the north.

3.2.3. Soils

As per Land system Map prepared by Land Resource Mapping Project, following order and sub-order soil types are present within the sub-watershed area. Soil order and groups are presented in Table.

Soil Type in the Sub-watershed Area

S.N.	Soil Order	Soil Great Group
1	Entisol (Soil with no or very little profile development)	a) Ustorthents b) Psamments c) fluvaquents
2	Inceptisol (Soils showing signs of weak profile development)	a) haplaquepts b) Ustochrepts c) Dystrochrepts
3	Mollisol (Soils with a mollicepipedon, often calcareous)	a) Haplustolls
4	Alfisol (Soils with argillic horizon and high base)	a) Rhodustalfs

Source: LRMP, 1984

3.3. Socio-economic information

3.3.1. Household and population

Households and Population by VDC

S. N.	Name of VDC	Households no.	Male	Female	Total population
1	Bhedetar	493	1484	1305	2789
2	Facsib	355	1199	1047	2246
3	Budhimaorang	637	1858	1652	3510
4	Dandabazar	533	1642	1451	3093
5	Mahabharat	722	2155	2013	4186
	Total:	2740	8338	7468	15824

Source: DDC profile, 2066.

Table 2: Household and Population of Watershed area

Chapter four: materials and methods

4.1. Source of data and information

4.1.1. Spatial Data

Topographical map sheets (Analogue map) of scale 1: 25,000 covering Leuti Watershed area of Dandabazar, Bhedetar, Mahabharat, Budhimaorang and facsib VDCs of Dhakuta district, published by Government of Nepal, Department of Survey, National Geographic Information Infrastructure Program (NGIIP), were used as sources of important spatial information about the study area for socio-economic study during fieldwork. Besides that, digital data sets were extensively used for GIS analysis of the study area as per requirement. The topographic digital data sets prepared by Survey Department are in GIS environment. These data sets are based on World Geo-referencing system based on Universal Transverse Mercator (UTM) projection using Everest 1884 spheroid with UTM Zone 45 and the central meridian of 87^0 N. Two Landsat satellite images were used as the main data in the research study. These images were captured on 1992 and 2010.These data sets were processed using GIS and Image processing software for further analysis.

4.1.2. Social Information

To assess the people perception different type of social survey was done to collect data on people's perception. Household survey, key informant survey, direct observation, questionnaire survey was done to obtain information.

4.2. Method of data collection

4.2.1 Secondary data collection

Secondary data sources included journals and thesis of various individuals and published reports of government offices such as Ministry of Forests and Soil Conservation (MOFSC), Department of Water Induced Disaster Prevention (DWIDP), Department of Soil Conservation and

Watershed Management(DSCWM), District development office, District forest office (DFO), District Soil and Water Conservation Office, and other concerning NGO‘s and INGO‘s such as Integrated Centre for Integrated Mountain Development (ICIMOD) and various other concerned agencies. Various web sites and documents through internet will also be studied during the secondary data collection and literature review.

4.2.2 Primary data collection

i) Satellite images

In this research Landsat satellite images were used. The advantage of Landsat satellite images is copyright, which permits a legal sharing of data among government, departments, academia, and donor agencies (Muller, 2004) as well as its resolution. The primary data (satellite images) for this study were a Landsat Thematic Mapper (TM) satellite image dated 1992/11/17 (Hereafter 1992 image) (fig 4) and a Landsat Enhanced Thematic mapper (TM) satellite image dated 2010/01/09 (Hereafter 2010 image) (fig 5).Details about the images are included in the *Annexes II and III.*

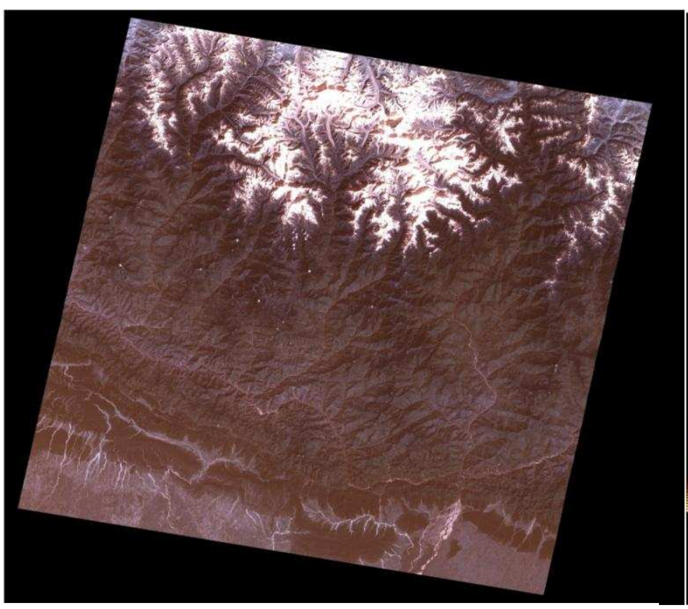

Figure 4: Landsat TM image of 1992

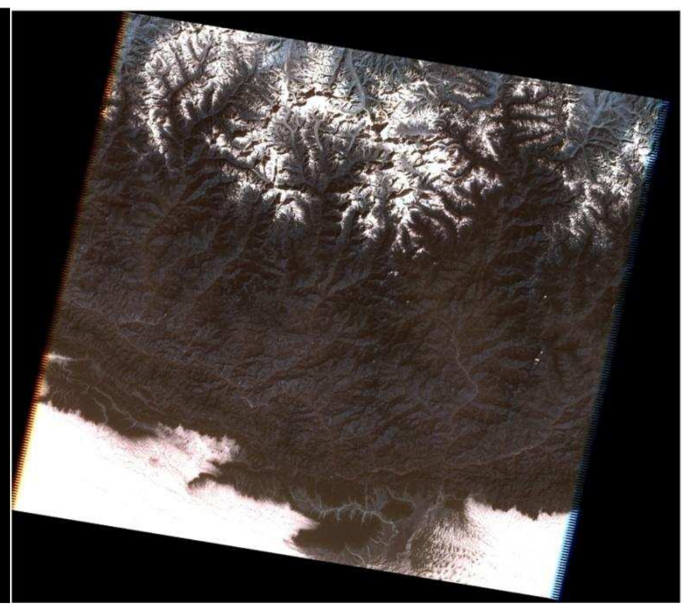

Figure 5 Landsat TM image of 2010

ii) Topographic map

Topographical map (Scale 1:25,000) of the study area was digitized by manual digitization. This map was used for boundary delineation, extracting area of interest from the whole map, ground truthing information required for supervised classification and accuracy assessment of classification of different satellite image.

iii) Key informant survey

Key informant interviews was conducted with village leaders, individuals who have been living in the area for long time and individuals affiliated to NGO‘s, CFUG’s committee, woman group. They will be questioned about the direct temporal changes which they have been experiencing and their adaptation to those impacts. The questionnaires for this purpose were open-ended to acquire both qualitative and quantitative data.

iv)Focus group discussion

Focus group discussions was conducted to gather information on past natural disaster events in the area, assess environment changes in recent years and adaptation measures adopted by local people. PRA tool was used for understanding cropping measures against the climate stresses such landslides drought and flood in recent years. The number of participants will range from 7 to 15 individuals.

v) Direct observation/transect walk

Direct observation was done along the study area through transect walk to observe directly seen changes and local adaptation practices against land use changes. The research team was walked with at least 1 to 2 local people from the watershed area. The local people who will participate in the transect walk will be one of the key informants.

vi) Household survey

Total 137 household were selected for the purpose of questionnaire survey. Simple random sampling with 5% sampling intensity was applied for household. During fieldwork it was observed that, there was very much similarity in the socioeconomic condition within same settlement. Semi-structured questionnaire is prepared to collect data about people’s perception regarding the effect of Land Use change. Open ended checklist and also supporting closed ended questions were asked.

vii) Training Samples

For acceptable classification results, training data must be both representative and complete. All the spectral classes constituting each information class must be adequately represented in the training set statistics used to classify an image (Lillesand, et. al., 2004). Training samples were collected with the help of GPS during field visit. These training samples were used for the supervised classification of the 2010 satellite image.

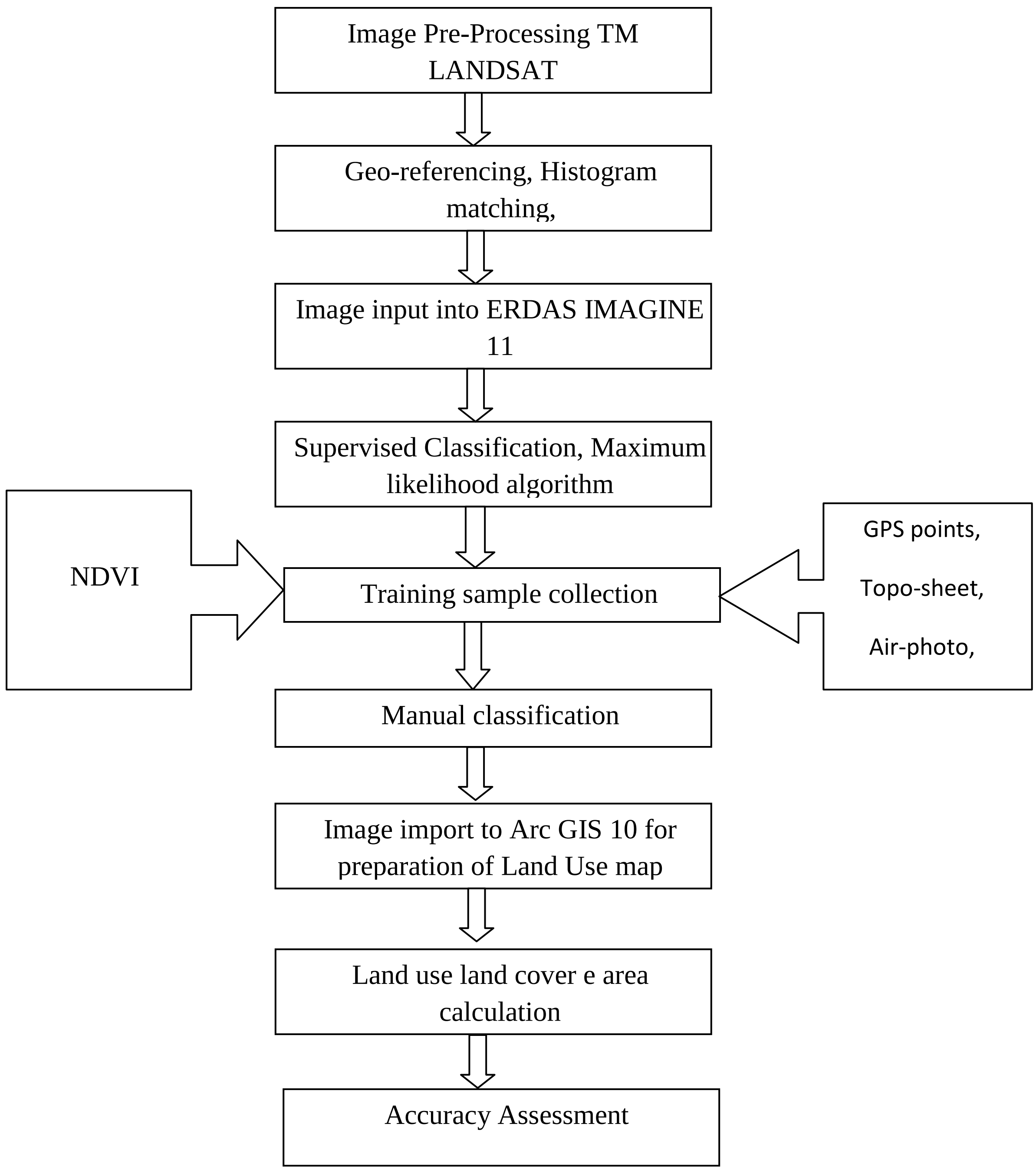

Figure 6: Image Classification Methodology

One of the most known RS methods used to determine the vegetation index is NDVI (Normalized Difference Vegetation Index). It is based on the spectral properties of green vegetation contrasting with its soil background. NDVI is a measure derived by dividing the difference between near-infrared (NIT) and red (R) reflectance measurements by their sum: NDVI = (NIR-R) / (NIR+R) Observing the histogram, the NDVI values were density sliced to delineate into two classes namely forest and non-forest and then color coded. Thus obtained vegetation map were compared and analyzed.

4.3.1 Digital Image Processing

Geometric correction

Both the satellite images (1992 and 2010) were from the same source and already orthorectified and also radio-metrically corrected. Thus, rectification was not needed. However, the digitized map was re-projected to UTM/WGS 84, Zone 45 to match with the satellite images.

Sub-setting the Satellite image

The study area was separated out from the whole scene of 172 X 183 km2 of the landsatsatellite images of both dates (1992 and 2010) using the digitized map obtained from manual digitization. Sub-setting tool of the ERDAS Imagine Software was used for this process. These separated areas were used as the AOI (Area of Interest) for the research study.

4.3.2 Land use land cover classification of Satellite images

Supervised classification was used for the classification of two images. Algorithm, maximum Likelihood classifier was used for the supervised classification. Data of the different classification items i.e. land use classes obtained from field study (GPS location) was used as training sample for supervised classification of image 2010 and that of topographical map was used for supervised classification of image 1992. The land use land cover classes that were considered in image classification are: forest land, agricultural land, settlement area and others (shrub, barren land etc.). This classification was used to prepare the land use land cover maps.

4.3.3 Accuracy Assessment

Classification accuracy was assessed using overall accuracy and kappa coefficient. Typical accuracy assessments involve verification of the randomly generated locations using reference data. For accuracy assessment, pixels in the classified image were compared to the reference pixels (ERDAS, 2008).In this study two major factors undermined this. Firstly the datasets used were not recently acquired except for one. More importantly, there was a lack of reference data to compare the classification of earlier years. The aerial photographs, though distant in time to the image, were the only reference data available. However, in case of LANSAT TM of 1992,150 randomly placed points were generated and compared with topographic map. At last Landsat TM of 2010, 150 randomly placed points were generated and compared with GPS data from field. This gave classification accuracy and kappa by error matrix which is listed below in the table no 1.

4.3.4 Post classification

The classified images (both 1992 and 2010) on the ERDAS Imagine were then exported to Arc View GIS 3.2a by converting the images to vector (ESRI Shape file). In Arc View GIS 3.2a, the vector files were again converted to the raster grid of grid size 30X30 by using Spatial Analyst1.1 extension. Further analysis for detection of land use land cover change was done in Arc View GIS 3.2.

4.3.5 Detection of land use land covers change

The raster grids of 1992 and 2010 images were finally overlaid using Spatial Analyst extension1.1 on the Arc View GIS 3.2. Change on Land use land cover was calculated by using raster calculator. Finally, the area converted from each of the classes to any of the other classes was computed. The analysis and interpretation of different aspects of the numeric data of Land Use Land Cover changes was done on Microsoft Excel 2007. The results were presented in the easily understandable forms such as maps, tables, graphs and charts.

4.3.6 Rate of forest cover and land use change analysis

Multi-date Landsat images (1992 and 2010) were classified and area was calculated for each land use land cover classes. Percentual change of land use dynamics during different study period is accompanied. From that the trend of land uses also analysis in the tabulated form.

4.3.7 Collection of people's perception towards LULCC.

During the field visit the questionnaire were asked to local people (n=137). The questions were all of open ended. At the time of GPS data collection for ground truthing, I consult with the local people and asked some informal question like as making checklist. People's perceptions towards land use and forest cover change were collected by the aid of some questionnaire. The checklist was presented in the appendix 5.

4.3.8 Limitations

i) Topographic shadow and the cloud cover in the satellite images were a great hindrance in the image classification. These reduced the accuracy of the image classification.

ii) The image resolution was another limiting factor for acquiring the accurate image classification

iii) Due to time limit people's perception was taken only of the people of river bank area from lower stream to upper stream.

iv) Only certain part of livelihood was studied due to time limit.

CHAPTER FIVE: RESULT AND DISCUSSION

5.1 Results

5.1.1 Land Use Status and Change

Multi-date Landsat images (1992 and 2010) were classified and area was calculated for each land cover classes.

Land Use status in 1992

As the post classification of Landsat image of 1992 shows that the main land cover is of forest covering 48%. Agriculture land occupies 44% as second main land cover. Similarly, sandy area occupies 3% as well as other type of land use which include settlement, grass land, water bodies and barren land consists of 2% land use land cover. Landslide consists of 1% land use land cover. Bush Shrub land consists of 2% area of total land use land cover. The area in ha has been shown in table 3 and the LULC in percentage has been shown in figure 7.

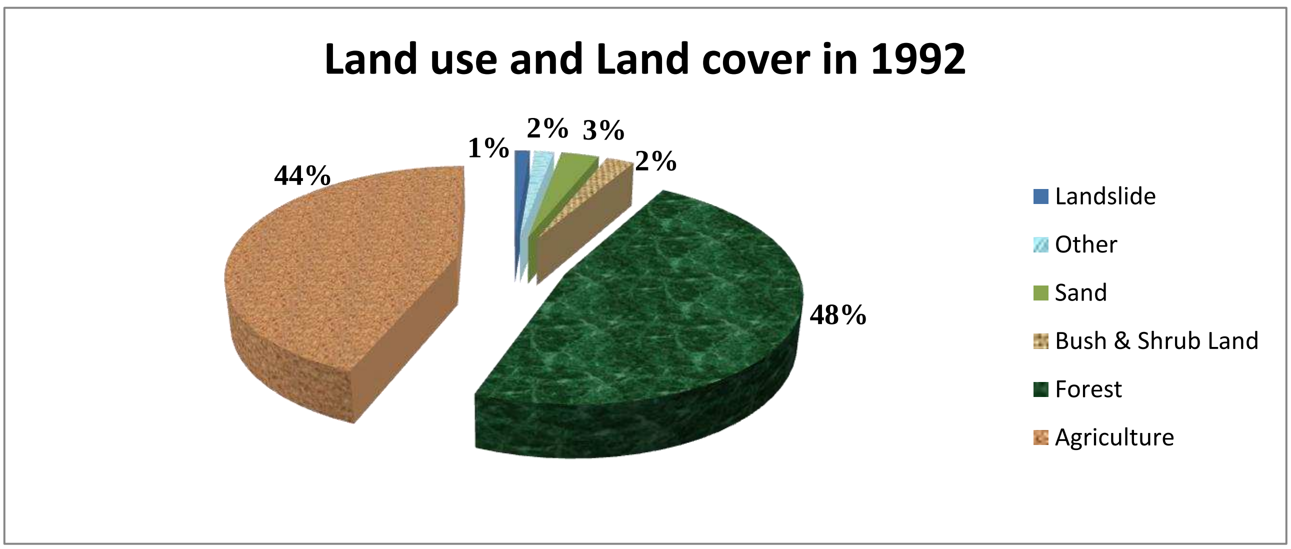

Figure 7: Figure Showing Land Cover Land Use of 1992

Land Use status in 2010

The landsat image of 2010 shows that the forest land has been decreased by 3% covering 45% of total land cover. Agriculture land has been increased by 1% covering 45% of the total land use land cover. Bush Shrub land has been increased by 3% covering 5% of total land use land cover.

Similarly, sandy area has been decreased by 2.62% covering only 0.56% of total land use land cover. Land slide has been decreased a little covering 1% of total land cover. Similarly other type of landuse consists 4% of total land cover. The area in ha is shown in table 3 and the percentual LULC is shown in figure 8.

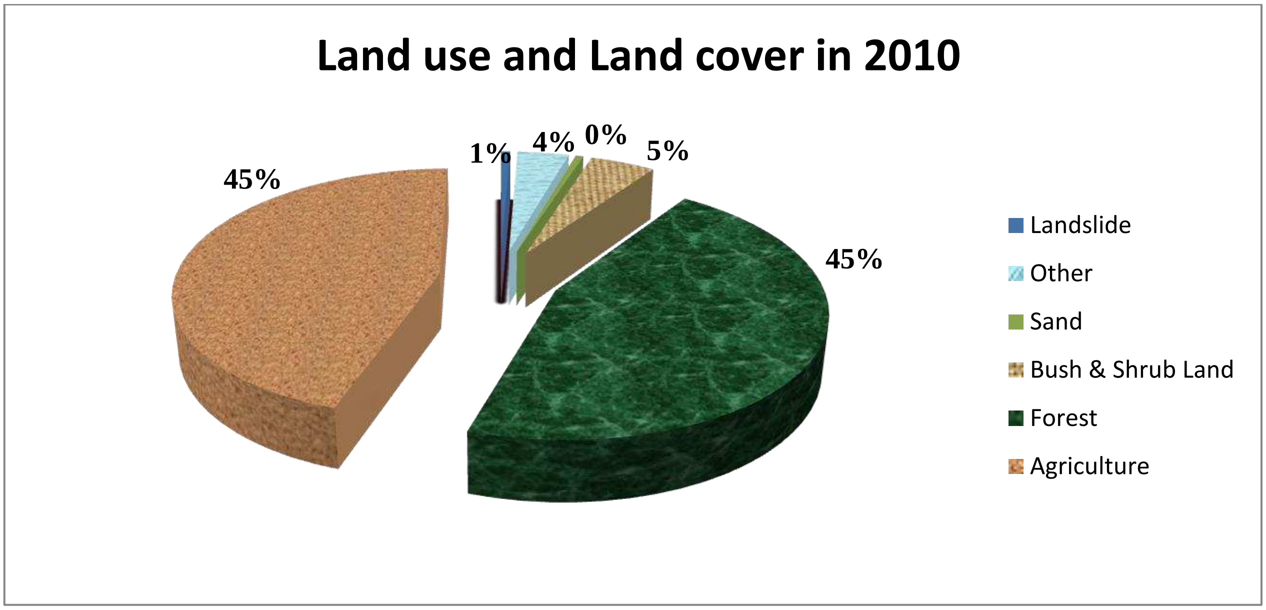

Figure 8: Figure Showing Land Use Land Cover of 2010

Change in Land Use Land Cover

Total Area and percentual rate of change of forest cover and land use Change during 1992-2010 is accompanied in figure 7 and 8 and in Table 3 respectively. The trend of change in different land use land cover has been shown in Figure 9. During 1992-2010, forest cover area has decreased rapidly with loss of 2.13%, other Land Use increased by 2.05 %, bush shrub land increased by 2.33%. landslide decreased by 0.58%, agriculture land is increased by 0.96% and sandy area decreased by 2.06%

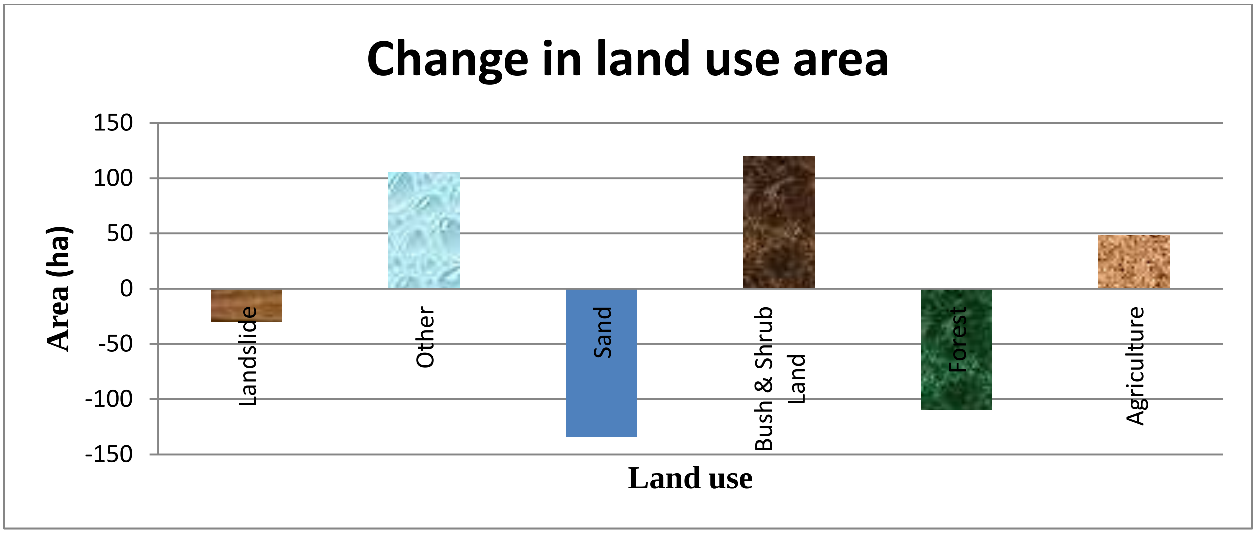

Figure 9: Figure showing change in Land use area in ha

5.1.2 People's Perception

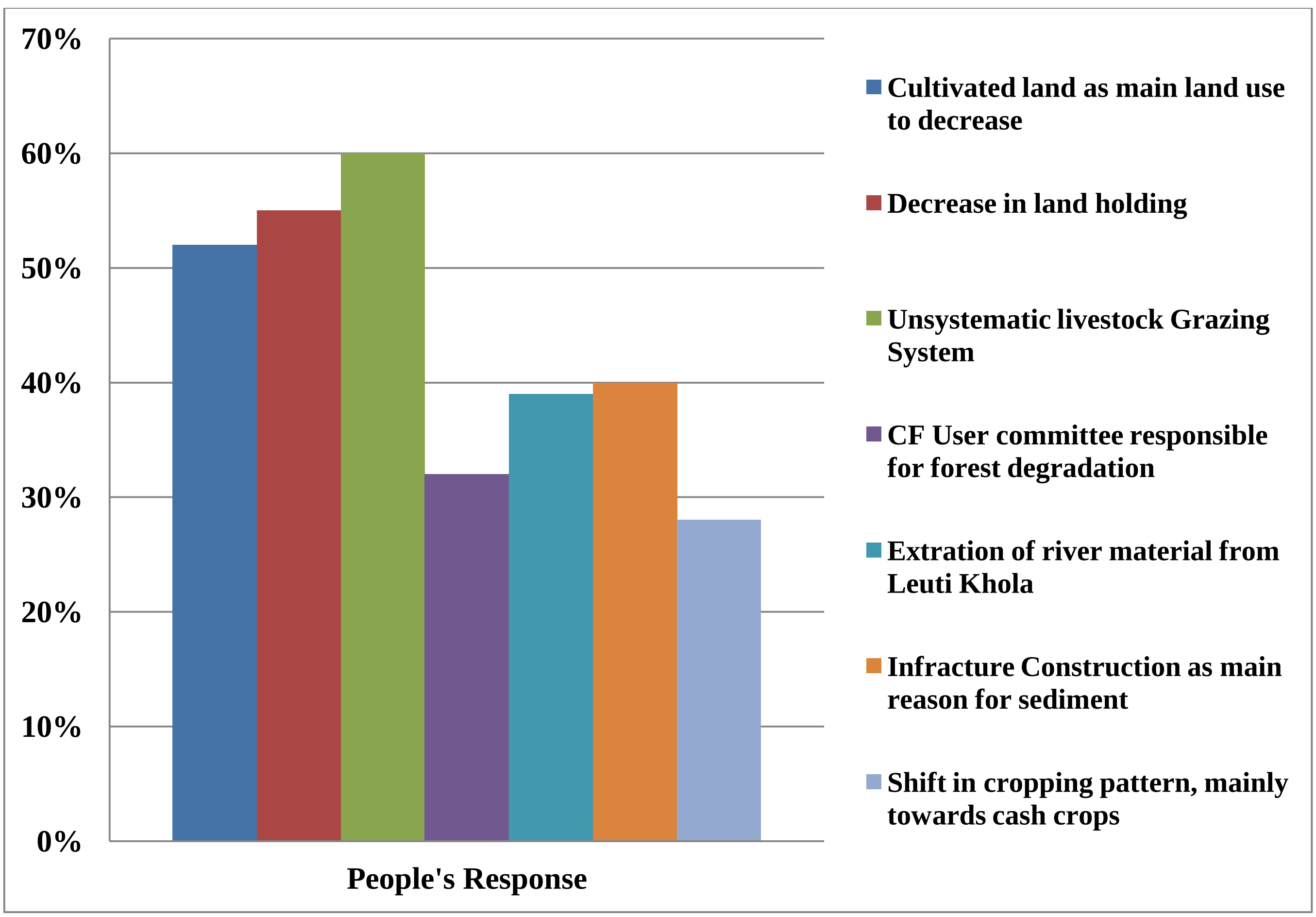

Figure 10: Figure showing different level of perception

As per the graph, there is decrease in the cultivable land and the productivity has decreased considerably due to flooding and deposition of sand and boulders in the river bank area. However, the economic condition of the local people has improved due to the extraction of sand and builders, and the local people have no regret about the decrease in the productivity as they are earning much more from extraction of sand, boulders and stones than from cultivation. Yet, the people have divided thoughts whether to protect land or not.

Effects of land use/cover change can be either positive or negative. The views of the local people on the effects of land use/cover change were sought in this regard and the results were as follows:

A. Negative Change around Leuti Khola Watershed as Understand by Local People

1. Decrease in their land holding

   Due to flood in Leuti Khola, the productive land along the river side is decreasing year by year. The local people who have less land holding are losing their land. Decrease in their land holding has led them to shift their cultivation practices, introducing different cash crops and also fishery. About 55% people respond that they have lost their land since last 20 years.
2. Infrastructure development is key for other developmental works. In the Leuti Khola sub watershed area, the Koshi highway and many other weak earthen road is constructed along the Leuti Khola is constructed and also in the upper stream and lower stream area. Among those roadways the “RajaRani” roadways is one which is constructed at the top of the watershed area. RajaRani roadways help people in many different ways in their daily lives but the indirect effect of the RajaRani roadways is seen in the sun watershed area. The excavation of soil and other earth materials has disturbed the sub watershed area very badly. Every year the rain causes flooding of the earth materials from and around the RajaRani roadways and the situation becomes even more destructive when it mixes with Leuti Khola and it’s tributaries towards the sub watershed area. Most of the respondents relate the RajaRani roadways as one of the major causes for the high sedimentation in Leuti Khola.
3. Grazing is an important activity for farmers in which the animals are left on their own to feed the grasses in an open area. Though the systematic way of grazing tends to

improve the vegetation of that area but unsystematic grazing leads to change in land use land cover. 60% out of 100% people respond that they have not followed systematic pattern while leaving their livestock for grazing. Such type of grazing has led to tampering of the land surface and minimizing the chances of regeneration which again results in different land cover, the main one being barren land.

4. Productivity of land in the sub watershed area is decreased mainly because of the sedimentation caused by the flood in Leuti Khola. The flood causes deposition of the sand, small boulders and also medium sized stones in the agriculture land which reduces the productive quality of the land. It also initiates the process of making land barren /useless from the view of land productivity.
5. For the purpose of production, many facilities are needed like irrigation, good seed, human power etc. Among them human power is the key for the agriculture production. Many people from the sub watershed area have migrated for employment so as to support and sustain their families. People migrate to city area in search of work, leaving their land. One of the reasons for such migrations work is because of their land holding. Migrating tendency has been noticed higher in those having little land holding which is insufficient for their livelihood. In the absence of active human power, their land remains barren. Also, the people possessing more land are also migrating to the cities or other developed areas for living comfortable lives, changing their productive land to barren land. Leaving the land barren for long time is slowly causing decrease in the land productivity. The River width is expanding every year. Lack of embankment protection, check dams, retaining wall, and breast wall are the chief causative agents for this. People in the watershed area respond that they can't do anything about it because they don't have sufficient fund to construct at their local level. However, individuals have also constructed loose stone dam to protect their land from flood but that isn't sufficient to protect from the massive flood rise in Leuti Khola catchment area and its small tributaries.
6. The forest area is decreasing day by day and also changing its cover due to illicit felling and also encroachment. Interestingly 32% of the respondents blame it to the community forest user committee mentioning the bribe and commission the committee gets from the saw business by selling the timber and other relevant forest

products. Hence, the two main reasons for the decrease in forest are repeatedly occurring natural disasters like landslide, flood, drought etc. and human activities like illicit cutting of timber and overgrazing.

7. The big landslide named BALENI VIR KO PAKHO is another source of debris which regularly causes the debris deposition in the Leuti Khola which again gets collected in the agriculture land around Leuti Khola during the flood.
8. Shift in occupation is also one of the negative impacts. The shift in occupation brings the shortage of skilled human power needed for agriculture production. People who work in field of agriculture now have started working as driver, helper and labor and are engaged in extraction of sand, boulders and stone from the Leuti Khola watershed. The available agriculture labor is insufficient which also results in the change of land use.
9. Anything in their natural state is good for sustainable future. In case of Leuti Khola 60% respondent of lower stream area don't want to regain the precious status of land use. It is a bit surprising. While people of upper stream want to regain mainly because of the natural hazards like landslide and flood which in reality destroying the area i.e. their land (bari), forest etc.
10. The river bed is rising, diverting the flow of river towards settlement area and productive land.

B. Positive change in Leuti Watersheds as Understood by the Local People

1. Local people are happy to extract sand, boulders and stones from the Leuti Khola instead of being sad for their loss of agriculture land. They are now well off then past, when they had productive land. 39% people respond that they are happy to extract the boulders rather to cultivate. They say now they have enough money by which they can sustain their livelihood. The changes in their living standard can be seen directly as they have now bikes, tractors and lands in urban parts of the district which they could have never even imagined 20 years ago.
2. Another positive consequence of land use change is that they now are changing their cropping pattern. Main reason for the change in cropping pattern is due to losses of their land by floods in Leuti Khola. They now earn more than ever. While 20 years

ago they were not earning enough, now they are earning much more than what is needed for their livelihoods. Cash crop mainly sugarcane has helped them a lot to improve their livelihood. They sell the sugarcane to the people travelling through Koshi highway by which they are earning enough to sustain their life in a standard way.

3. Infrastructure development is helping them to expand their market of boulders, sand and stones. Even the simple earthen road has helped them to transport their materials to different places helping them to increase their economic standards.
4. The river bank is also becoming home (settlement) to many emigrants who come there to work.
5. People are getting work like collecting boulders, sand and stone at the river bank which is helping them to live.

5.5 Factors affecting land cover change

Results obtained from the post classification analysis and rate of change analysis show that forest cover has been decreased in successive periods, agriculture land has increased in between 1992 to 2010. According to the spatial analysis and people's perception, the main reasons for land use and forest cover changes in the Leuti Khola watershed area include:

- Demographic factors, mainly population growth and migration.
- Infrastructural development such as road, mainly the construction of RajaRani roadways.
- Fringe encroachment by the people living in vicinity of forests mainly landless people and natural calamities victims.
- Unsystematic grazing
- Decrease in Land Productivity.
- River bank cutting and extraction of sand, gravel and boulders from Leuti foot hills.
- Natural Calamities like flood and landslides.
- Deforestation for agricultural sprawl.

- Shift in occupation resulting shortage of skilled human power needed for agriculture production.

There are also other reasons which include political instability, politician's attitude, fire, shifting cultivation, forest rewards, attitude of individuals, donors' role and government policy.

5.6. Discussion of result

Land Use	2010 (Area in Ha)	1990 (Area in Ha.)	Difference (Ha)	Difference (%)
Forest	2335.05	2444.95	-109.9	-2.14
Agriculture	2315.61	2267.52	48.09	0.93
Bush & Shrub Land	240.93	120.619	120.311	2.34
Landslide	35.01	65.0612	-30.0512	-0.58
Sand	29.07	163.343	-134.273	-2.61
Other	190.62	84.7989	105.8211	2.06
Total	5146.29	5146.29	00.00	0.00

Table 3: Table showing the difference in ha and percentage

Classification of multi-date Landsat satellite images for the year 1992 and 2010 reveals that Leuti Khola Watershed has been experiencing rapid land cover dynamics. Considerable amount of forest area (109.95) ha has decreased which was observe and revealed during the study period. Similarly, agriculture land has been increased by 48.09 ha. The loss of forest cover is replaced by other land use type so other land use types are increasing in alarming rate. It shows the difference in people perception and the real data calculation. Local people think that the main land which is changing is agriculture land but by the post classification the main land use change which tends to change is forest land within 1992 to 2010. Agriculture land has been increased by 49.76 ha. The landslide has been decreased by 0.58% which is converted into bush shrub land. The sandy area is decreased by 2.61% mainly from the river bank area which may be converted towards agriculture land and bush shrub land. As the local people think or their perception towards the agriculture land is decreasing but the post classification analysis shows that the agriculture land has been increased by 0.93% i.e. 49.76 ha. The perception of local people and the result analysis match in the fact that the forest area is decreasing 1992 to now. Bush shrub land has been increased by 2.34% which is good as the sandy area and landslide has been decreased as they are continuously converting towards bush shrub land.

5.6.1 Comparison between biophysical findings and people's perception

Land use	Biophysical findings	People's perception	Comparison
Cultivated land	Increase	Decrease	**Do not match**
Forest land	Decrease	Decrease	**Match**
Bush & shrub land	Increase	Increase	**Match**
Sandy area	Decrease	Increase	Do not match
Landslide	Decrease	Decrease	**Match**
Other	increase	Increase	**Match**

Table 4: Table showing comparison between Biophysical findings and people's perception

Comparing the biophysical analysis and the people perception, the data obtained were similar regarding land use change except about cultivated land and sandy area. The forest area, occurrence of landslide and other type of landuse decreased while bush and shrub land increased. The biophysical finding and people's perception did not match on the land use regarding cultivated land and sandy area. This may be due to the conversion of forest area into cultivated area.

Chapter six: Conclusion and recommendation

6.1 Conclusion

Land use land cover of the researched area of Leuti Khola watershed has under gone alteration and transformations from 1992 to 2010 showing that land use land cover change is a continuous process of change from one aspect to another aspect. Evaluating the result obtained by post classification analysis, accuracy assessment, change detection and people's perceptions, following conclusions are drawn with respect to each research questions formulated in the beginning of the study. Research questions are discussed with respect to research prior to this study.

6.1.1 Discussion on research question

This research was designed to answer the following questions:

Research question 1: What is the rate of change in land use land cover from 1992 to 2010?

The change analysis revealed the two important changes deforestation and extraction of sand, boulders and stones from the river.

The rate of deforestation is 6.105 ha (0.11%) per year from 1992 to 2010.

The sandy area has been decreased by 7.44 ha (0.14%) per year from 1992 to 2010.

The sandy (river bank) area has been converted to Bush shrub land and agriculture land. It shows the rate of increase in agriculture land is 2.67 ha (0.05%) per year from 1992 to 2010.

Research Question2: What is the past and present trend of forest cover and land use change?

The trend of land cover and land use change is high in the present days than in the past time. The diminishing rate of forest cover change is increasing with increase in time. The agriculture land is increasing with increase in time period. However the unproductive sandy area, landslide area is decreasing as it is starting level for the process of succession.

Research question 3: What is the social perception towards the changing condition of land cover and land use?

Population growth, natural calamities, construction of roadways, illicit felling of trees, political change, lack of embankment protection, lack of conservation education are the root causes of land cover land use change.

Extractions of sand, boulders and stones from Leuti river bank, construction of the RajaRani roadways at the upper stream of Leuti watershed are also the main causes for land cover dynamics.

6.2 Recommendations

Existing situation about land cover and land use dynamics have been evaluated with RS and GIS. Based on the result and existing condition, some areas of improvement about the applicability of RS and GIS for land cover and land use dynamics in any watershed or other biodiversity rich area are recommended:

- Land use land cover changes should be monitored time and again. Monitoring such changes is important for coordinated actions at the national levels.
- The management plan that has been developed should be effectively followed in order to improve the land condition.
- Construction of different preventive structure around Leuti river bank should be done.
- The conservation education should be provided to the local people around Leuti Watershed area.
- Research on different factors responsible for the land use land cover change in the researched area should be conducted.
- The use of GIS and RS in land use land cover assessment and planning should be highly encouraged. It should be increased and diversified for monitoring natural resources.

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APPENDICES

Appendix 1- Leuti Khola Watershed; An introduction

1.1 Geographical Location

Latitude: 26^0 53'to 27^0 19' N

Longitude: 87^0 8' to 87^0 33' E

Area: 5146.29ha

Altitude

1.2 Boundary

East: DandabazarVdc

West: MahabharatVdc

North: Sunsari District

South: Tamor River

1.3 Climate

Climate zone: Sub-tropical to Temperate

Average maximum Temperature: 20.56°c

Average Minimum Temperature: 16.6^{o}c

Average Rainfall: 2150mm

1.4 Administrative Division

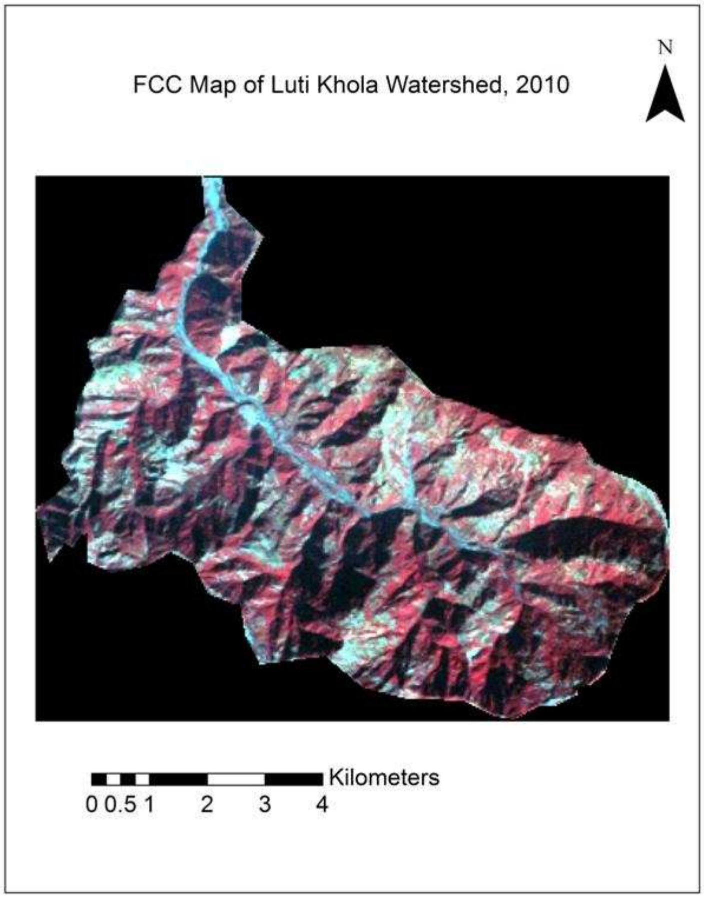
Development Region: Eastern Development Region

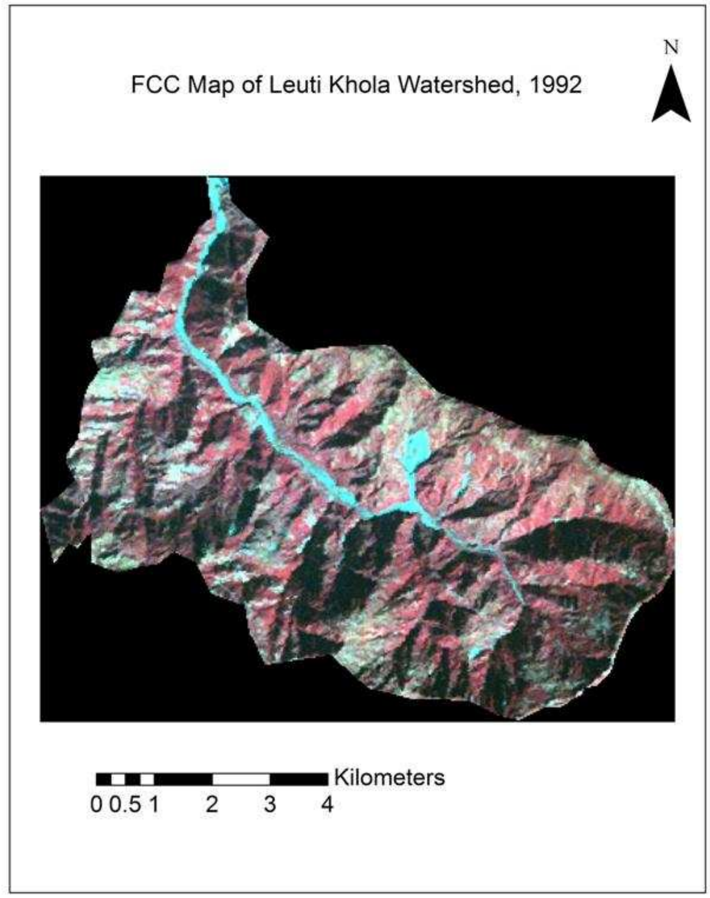
Zone: Koshi

District: Dhankuta

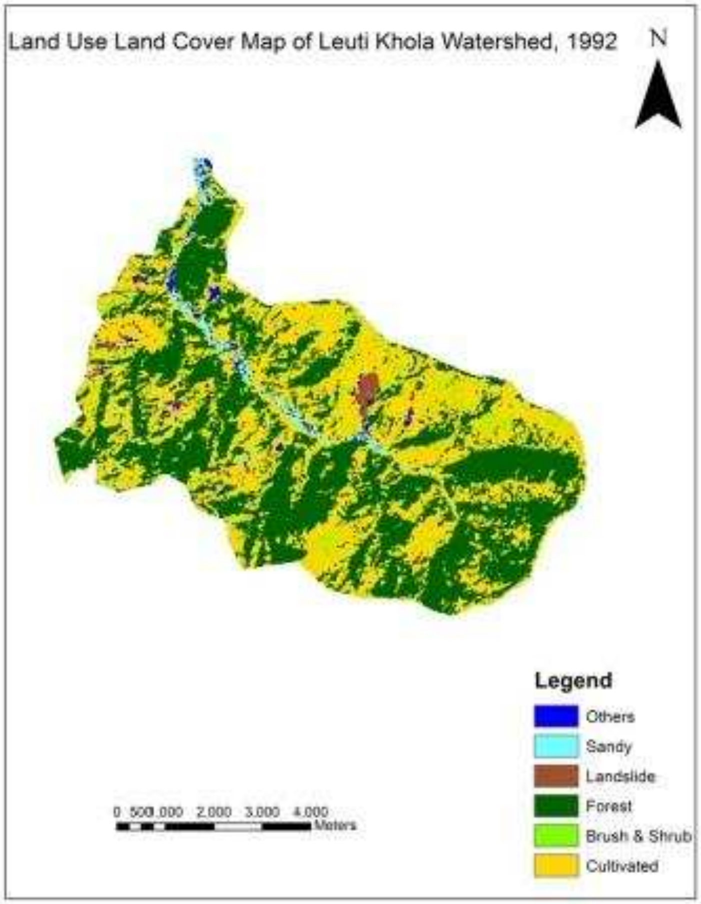
Number of VDC: 5

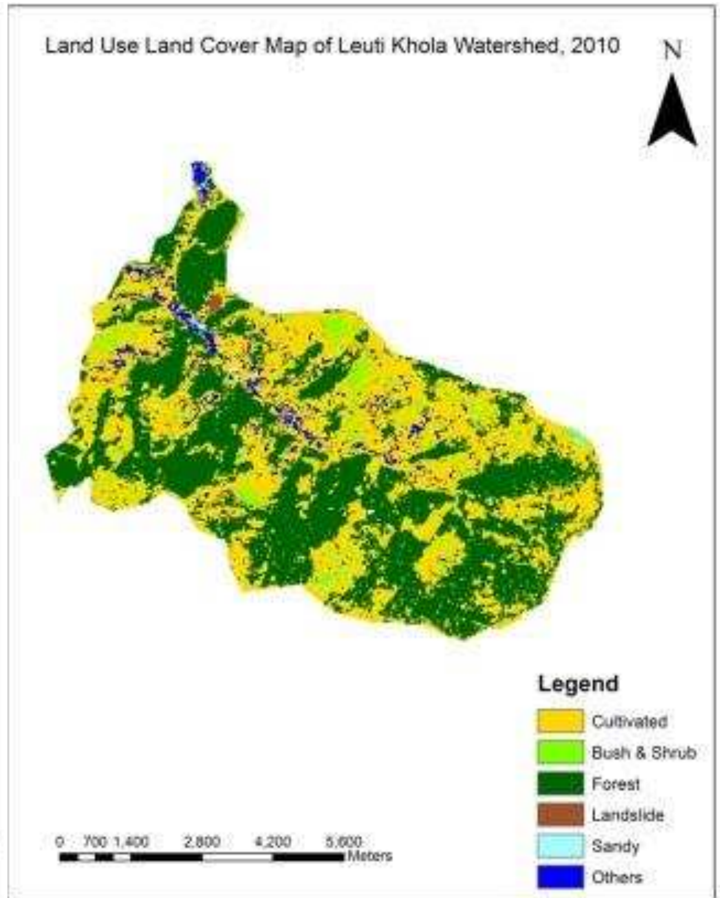
Appendix 2- False Color Composite Images





Appendix3- Classified Land Use Land Cover Map of the study Area





Appendix 4- List of Tables

Table no 1: Result of Kappa and Accuracy Assessment

Dates of Images	Overall Kappa Coefficient	Overall Classification Accuracy
1992	0.7381	82.50%
2010	0.7987	85.00%

Table no 2: Name and character of the image

Satellite	Date	Source	Spatial resolution	Band use
Landsat TM	1992/11/17	GLCF	30	1,2,3,4
Landsat TM	2010/01/09	GLCF	30	1,2,3,4

Table no 3: Metrological data

Temperature Dhankuta (Study area)												
Name of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tmax												
Tmin												
Rainfall (mm) for Dhankuta												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011												

Appendix 5- Check List

1. Which areas (Land use) are the most significantly changing to the watershed area?
2. What are the main causes of land use cover change in the area?
3. What are the likely impacts of land use change in the area? (In terms of productivity, grazing, and other infrastructure related facilities etc.)
4. How the landuse change has impacted their normal livelihoods? (In terms of their occupation, income mode etc.)
5. Do they want to regain the precious status of landuse or just modification as usual?
6. What was the initial scenario of the area in 1992?
7. What is the current scenario of the area in 2010?
8. Has the area extended or is compressed?
9. Which area is the mostly affected?
10. What is the change composition over various land uses?

PHOTOPLATES