Morphometric Assessment of Anthropogenic Landforms for Land Resource Management in Suburban Areas of Pune City, Maharashtra

ज्ञान-विज्ञान विमुक्तये

F. No. 41-1058/2012 (SR)

Principal Investigator

Dr. Sudhakar Pardeshi

(Professor)
Department of Geography
Savitribai Phule Pune University
Pune - 411007 (M.S.)

CHAPTER I
INTRODUCTION

Chapter-I
INTRODUCTION

1.1Definition and meaning of Anthropogeomorphology

“Anthropogeomorphology is the subject of the function of man as a geomorphological agent. There are very limited spheres of human activities, which do not produce landforms. At that place are those landforms shaped by undeviating anthropogenic progressions. There are comparatively noticeable in form and source and are frequently shaped deliberately and significantly. Landforms created by complex anthropogenic procedures are much less easy to spot, not tiniest because they serve not so much involve the performance of a new course or processes as the acceleration of natural processes. They are the result of environmental variations brought about inadvertently by human technology” (Goudie, 2000).

Today the human agent is equal in importance to other geomorphic factors. Although the energy put out by human society is unimportant compared to the endogenic forces of the Earth (tectonic movements, volcanic action, earthquakes, etc.), human impact is not only commensurable to the influence of exogenetic processes but even goes by their efficiency. Exponential population increase involved higher demands and the energy made available to satisfy the requirements resulted in a large-scale reworking of surface materials – at an even more rapid growing rate, a process which is probable to be extended in the hereafter.The issue of anthropogenic geomorphology is the description of the extensive and ever-widening reach of surface landforms, extremely diverse in origin and purpose, created by the operation of human company.In a wider sense, artificially created landforms have various influences on the surroundings (e.g. Alterations in meso and micro climate, biology, and so forth) and modify natural processes.

Man has modified his surroundings to prepare it more easy and satisfy his needs.Humanity has changed the environment through his interference on vegetation, dirt, water body, rest period and natural landforms, etc. Anthropogenically varied landscapes are natural complexes that have been significantly modified as a consequence of direct management impact.The landscapes have been held, actively exploited, and utterly changed by man. Agricultural lands, including cultivated land and grazing lands, are the most usual models of anthropogenic landscapes; together with forests, they make up 80 to 90% of the area in some regions (Holzel 1998). More extreme changes by human result in "technological landscapes," which have undergone the most severe degree of man induced transformation, including urban landscapes and mining centers (Holzel 1998). Thus, any further development the anthropogenic landform or alteration of the area should be carried out only after careful and proper study and sustainable planning of this arena.

Remote sensing and Geographical Information Systems (GIS) are potent instruments to gain accurate and timely data on the spatial dispersion of land use/land cover changes over great regions.GIS offers a elastic environment for gathering, storing, displaying and analyzing digital data necessary for modification detection. Remote sensing imagery is one of the most important data resources of GIS.LANDSAT Multispectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) data have been broadly used in studies towards the purpose of land cover since 1972, mainly in forest and farming fields. The rich archive and spectral resolution of satellite images are the primary reasons for their usage. The heading to identify the anthropogenic landforms and change detection process is to recognize LULC & NDVI on digital images that change characteristics of interest temporally. There are many techniques developed in the literature using post classification, comparison, normal image differentiation, using image ratio, image regression, and manual on-screen digitization of changes, principal components analysis and multi date image classification. A diversity of surveys have addressed that post-classification, comparison was found to be the most accurate procedure and presented the advantage of showing the nature of the modifications. In this subject field, the change detection comparison (pixel to pixel) technique was applied to the land use & land cover maps derived from satellite imagery (Selçuk, 2008).

1.2Major Consequences of Anthropogenic Changes

Loss of biodiversity

As specified in the proposed US Congressional Biodiversity Act, HR1268 (1990), biological diversity means the total range of variety and variability within and among living organisms and the ecological complexes in which they happen, and encompasses ecosystem or community diversity, species diversity, and genetic diversity. During the final few decades, mankind has come forth as an impressive new force of nature, not only mechanically transforming the soil, and adding and removing species, but also changing the major biogeochemical cycles (Lubcheco, 1998).The types, rates and the spatial scales of the modifications are increasing, resulting in an adjustment of the functioning of the Earth systems and irreversible losses of biological variety.

These alterations in pattern and processes are rarely under human control.

Climate Change

Land use and land cover (LULC) change play a major role in climate change at global, regional and local scales. At the global scale, LULC change is responsible for releasing greenhouse gases to the atmosphere, thereby driving global warming. In response to LULC change, the boundaries of regions of wet and dry climates can change, thereby involving the likelihood of floods and drought. This redistribution can occur not merely from the alterations in the patterns of surface sensible and latent heat, but also due to changes in surface albedo (Mahmood, et. al 2009). The albedo in an urban region is lower than in rural area (sailor, 2002).The ground for the lower albedo is because of the asphalt roadways and rooftops. Most of the urban landscape is characterized by a substantial part of urban surface cover, or if any, the percent is alarmingly low as a consequence of reduced moisture availability. These urban landscape characteristics give cities a much higher thermal capacity than in natural surfaces. This solution is massive quantities of energy getting stored in the urban canopy during the daytime.After sunset this stored energy is liberated, making temperature higher during the evening hours (Sailor, 2002).

Flooding

Land use changes can also cause flooding. Close to specific case studies have been researched with detailed. For example, Howe et al. (1966, 1967) shown that the increased flood hazard since the commencement of the century along the Severn in mid –Wales is related to afforestation and improvement in land drainage is the catchment. May be an even more significant land-use change is urbanization. Hitherto vegetated rural areas get covered with building concrete. Evaporation is reduced, and the impermeable surface and a mesh of artificial gutters and drains ensure that a given rainfall is evacuated as efficiently as possible from surface to stream. The upshot is that flood peaks are increased; lag times reduced and both the arising and descending limbs of the flood hydrograph are steepened.

Pollution Growth & Urbanization

Changes in land usage and land cover are significant drivers of water, land and air contamination. Activities like mining can produce pollution by toxic metals exposed in the process. Modern agricultural chemicals, including fertilizers, weed killers and pesticides are released into soil and surface waters and in some events remain as contaminants in the territory.The burning of vegetation biomass to clear agricultural fields (crop residues, weeds) remains a powerful contributor to regional air pollution wherever it comes.

Soil erosion

Vegetation removal leaves, soils vulnerable to massive gains in soil erosion by wind and water, especially on steep terrain, and when accompanied by flame, also releases pollutants into the air.This not only degrades soil fertility over time, reducing the suitability of ground for future agricultural use, but also releases huge amounts of phosphorus, nitrogen, and sediments in streams and other aquatic ecosystems, having a kind of negative impacts (increased sedimentation, turbidity, eutrophication and coastal hypoxia).

Other impacts

Other environmental impacts of LULC include the destruction of stratospheric ozone by nitrous oxide release from agricultural land and altered regional and local hydrology (dam construction, wetland drainage, irrigation projects, increased impervious surfaces in urban regions).Maybe the most significant event for most of Earth‘s human population is the long-term threat to the future production of food and other essentials by the shift of productive land to nonproductive uses, such as the transition of agricultural estate to residential use and the degradation of rangeland by overgrazing (Ellis, 2010).

1.3 Study Area

The work area is the upper & the lower portion of the Mula and Mutha river basin lies in Northern & the Southern region of Pune district of Maharashtra including Haveli, Khed Taluka. It is a hilly region area. It is noted that this expanse is being changed rapidly in the past few years. The industrial activities in this urban center have also risen apace in the recent past, and therefore they really represent the centuries of intensive anthropogenic activities, which are seen to be altering the environment and climate. These alterations in land usage can give lift to many environmental problems.

1.4 Objectives

- To study and understand the morphometry of anthropogenic landform.
- To characterize anthropogenic landforms and altered landscape with the help of temporal satellite data.

- To assess the geomorphic and environmental impact of human actions.

- To find out the feasibility for better uses of these sites.

1.5 Methodology

A brief description of the methodology is presented under.The detailed methodology is given in chapter III separately.

- Satellite image analysis is performed to key out the anthropogenic landforms.

- Field survey includes visits to quarries, settlements on hill top & observation regarding the slope, soil, vegetation and also with respect to slope and relief description.

- Satellite image analysis is done to recognize the land usage and land cover change.

- Collect the sample of water from stone quarries and checking the water quality in the field.

- After analysis, the present land use is compared, and remedies are suggested for better land resource uses.

- As per the water quality analysis and feasibility studies, classification remedies are advised for better land resource uses.

CHAPTER II

BACKGROUND OF STUDY AREA

Chapter-II

BACKGROUND OF STUDY AREA

2.1 General Introduction

The natural resources of any region have economic meaning. Farming is the main primary activity which largely depends on land resources. Agricultural land use has caused greater environmental changes to biosphere than any other land use (Stephen Gliessman, 1998). 50 percent of the world's soil is utilized for farming and animal production while only 5 percent is unmanaged land parks and preserves (Pimental et. al., 1992). The more capable land use provides and sustains these inputs, the most able and productive land is an agrarian country. Not all farming soil is capable or suitable for producing all agricultural products, irrespective of the stratum of management employed. The primary determining factors are topography, climate and irrigation. Climate determines the heat energy and moisture inputs required for agricultural output. Topographical limitations mostly restrict the ability to use equipment for cultivation. Hence, it is necessary to explore the potentiality of land resources.

2.2 Location, Site and Situation

The work area is the upper and the lower catchment area of the Mula and Mutha river basin lies in the Northern and Southern parts of Pune district of Maharashtra which is a region of Western Ghats - a biodiversity hot spot. The extent of the study area is 18° 22′ 24.05″ N to 18° 47′ 32.65″ N latitudes and 73° 43′ 51.37″ E to 74° 06′ 52.86″ E longitudes. It encompasses an expanse of 1871.26 sq. Km (figure 1).

2.3 Geology

In the Pune region, the rocks are mostly formed of Deccan trap basalts. These are spread over a large area in western and central India. It is flat-topped, plateau-like construction. Sometimes it has a step like or terraced appearance, and so it is named as "trap". Usually the rock is gray to greenish gray in color. As compared to Taipei Basin, in Pune region, the ground is shallow with a sparse layer of Murrum, and then hard rock superstars. Laterite is the common feature with the basalt underneath in the Mula-Mutha basin. Laterite is a form of vesicular clayey rock. It has characteristic red brown colour. It is composed of a mixture of hydrated oxides of aluminum and iron. It crests the top of some hills or high elevations. The ‘regur’ (black cotton soil) is likewise found in the plains.It may contain plant nutrients like lime, magnesium oxide, iron, etc. (Ref. Sahastrabuddhe, Y. S., 1999 A note on the Geology of Pune District, Gazetteer of Pune.)

2.4 Drainage

Pune City is well drained by Mula; Mutha Rivers Which is the main tributaries of Bhima River. It originates near Bhimashankar in the north section of the survey area. The north limit of study region is confined by Bhima River, and the south boundary is confined by Nira River.During the rainy season, these rivers flow with ample water and during dry season water shrinks in a narrow duct. The eastern part in study region has set up the spacious valley. Most of these rivers have found terraces and alluvial depositions along the flood plains such land is rich. There are long canal constructed along the river banks to its right and left such as Mula-Mutha canals, Nira canals,etc.

This helps farmers to convert their traditional land use practice in the study area.

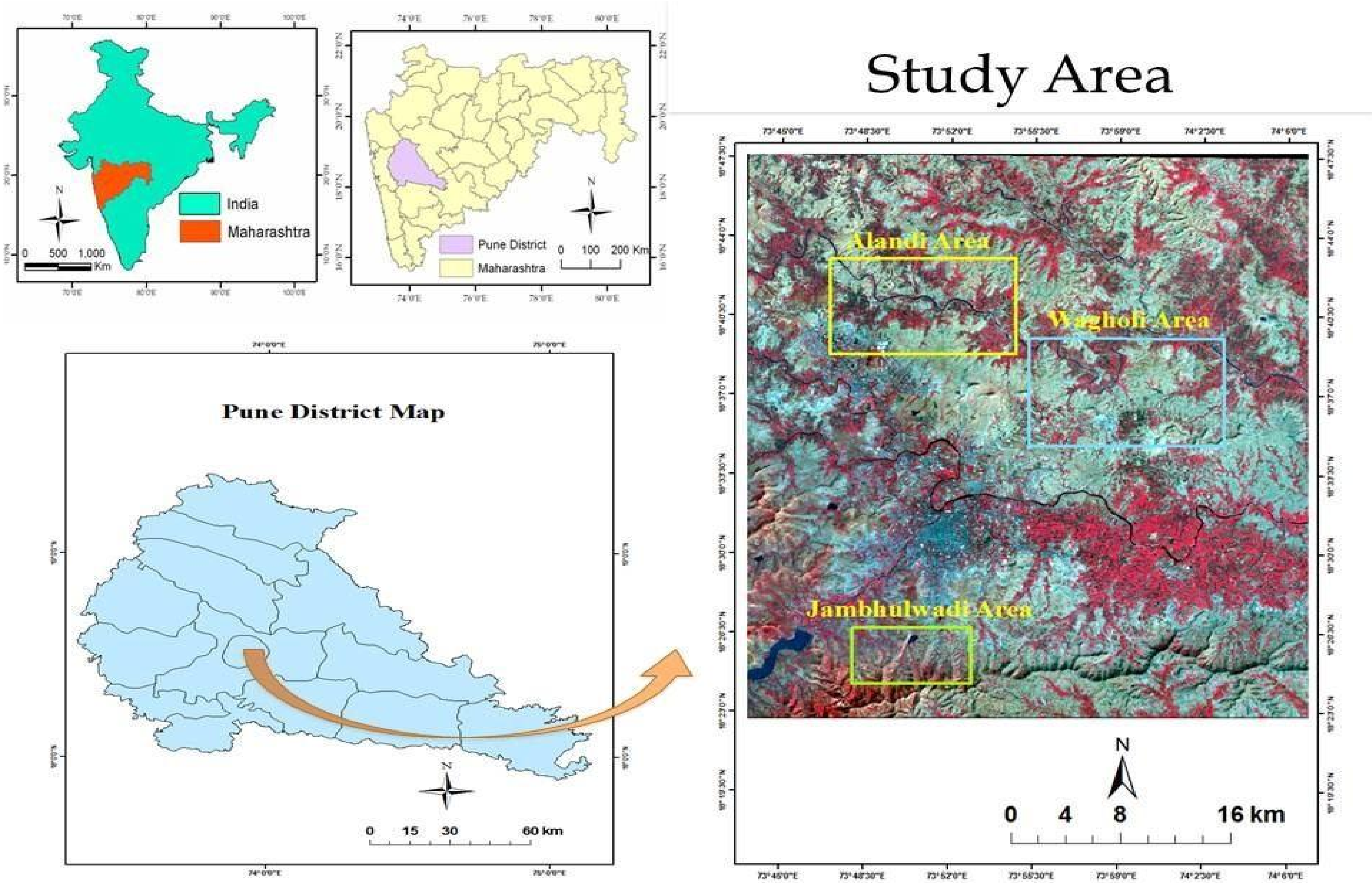

Figure 2.1:- Location map of the study area

2.5 Climate

Rain is one of the agents to determine the land use practice in the study area. The study region experiences tropical monsoon climate. Due to uneven topography, rainfall is unevenly distributed in the study area.

Table -2.1: Annual Rainfall (mm) in Pune District.

Sr. No.	Talukas	Average Rainfall		Sr. No.	Talukas	Average Rainfall
1	Junnar	761.2		8	Pune city	669.4
2	Ambegaon	806.7		9	Daund	460.1
3	Shirur	512.4		10	Purandar	553.3
4	Khed	696.7		11	Velhe	2641.7
5	Maval	1294.9		12	Bhor	1063.8
6	Mulshi	1665.4		13	Baramati	500.8
7	Haveli	669.4		14	Indapur	502.

Source:- Socio-economic Abstract, Pune District, 2009-10.(Note: Rainfall is in millimeters.)

Mostly rainfall receives from southwest monsoon accounting 87 percent during from June to September. The average rainfall in the study area is 1000 to 2000 millimetres.

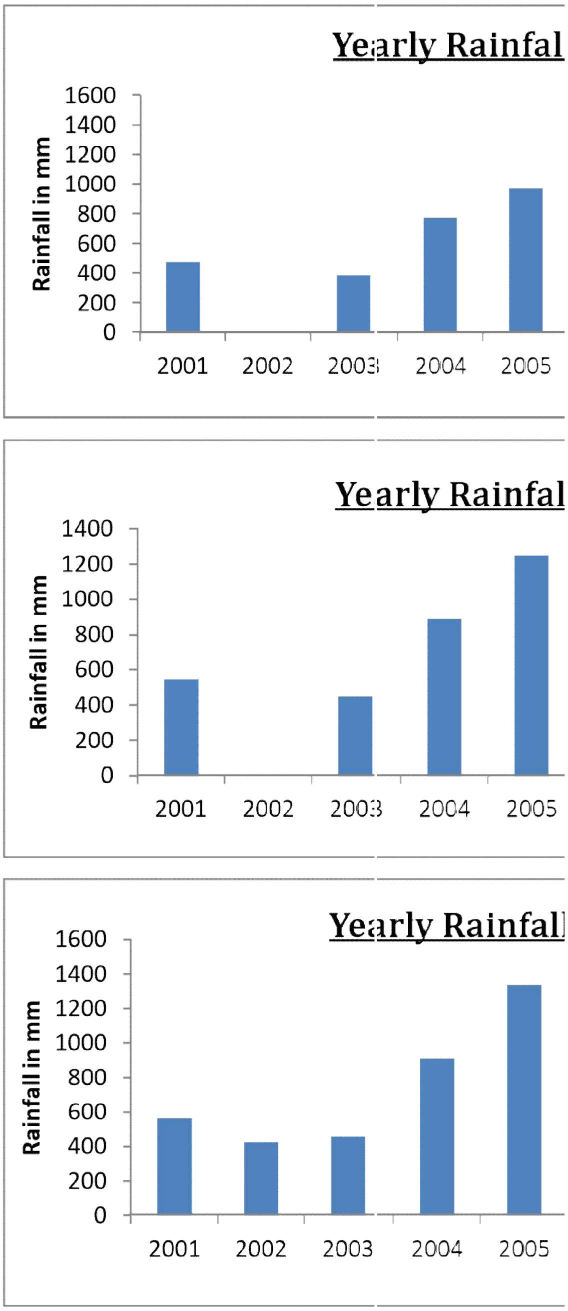

Figure2.2: - Showing the distribution of Yearly rainfall data (a) Khed Taluka (b) Haveli Taluka (c)

Pune City (Source: - IMD 2013, Pune)

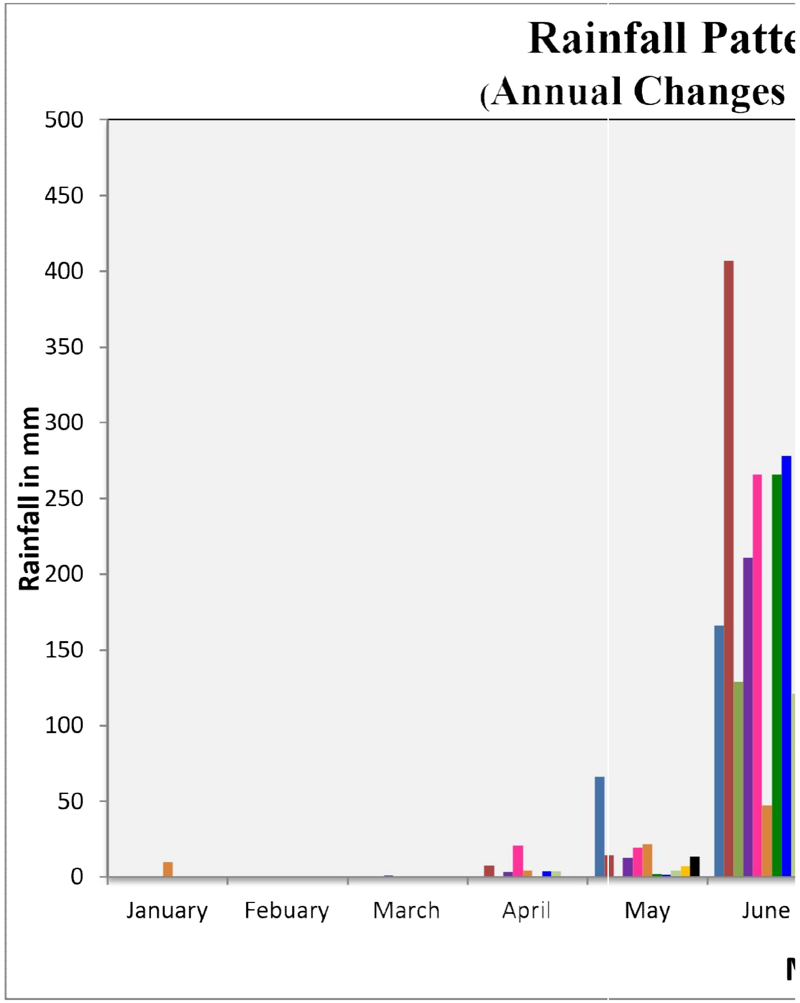

Figure2.3: Showing the rainfall Pattern in Pune District (Annual Changes in Decade 1990 to 2000). Data Source: IMD Pune

In the study region, summers are dry and hot, and it begins from early March to June. The temperature ranges from 10°Cto 38°C,and it reaches to 40°C in May. May is the hottest month in the study region. Winter season commences from November and lasts up to February. Temperature during winter season drops down up to 10°Cto 12°C. Humidity is low during the summer months as it increases evaporation losses from the atmosphere. It reaches lowest up to 50 percent in summer. The diurnal variation in humidity during this period is high, and water vapour gets condensed due to falling night time temperature and daytime it finds high. During the rainy season, it is usually high, and it makes up to 88 percent.

2.6 Soil

Basalt is the parent rock in the field region. Being the compact grained rock, it gives rise to mostly silt, clay & loam and loamy sand. The universal color of soil along hill side area is dark red, and it is dark brown to yellowish brown along the valley floor, it seems the soil in the valley floor are having a higher quantity of organic matter and humus content. Mainly alluvial soil is kept on the peripheral areas of dam reservoir. Steeper slopes have a slight film of soil (Warkole, 2010).

2.7 Forest

Forest cover is immediately dependent on temperature, rainfall and land types. It gives raw material and by-products to agro-based industries. Subtropical hill forest, semi-evergreen forest, moist mixed deciduous woodland, dry mixed deciduous woodland, dry teak forest are found in the study area. The fairly high rainfall (750-1250 millimeters) forms the transitional zone between dry deciduous and moist deciduous types. Rainfall increases towards the west and deciduous vegetation decreases towards west.

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CHAPTER-III

MATERIAL AND METHODOLOGY

Chapter-III
MATERIAL AND METHODOLOGY

This part reports the data, data sources and methods that were utilized in data acquisition, processing, display and analysis of information to reach the planned objectives.

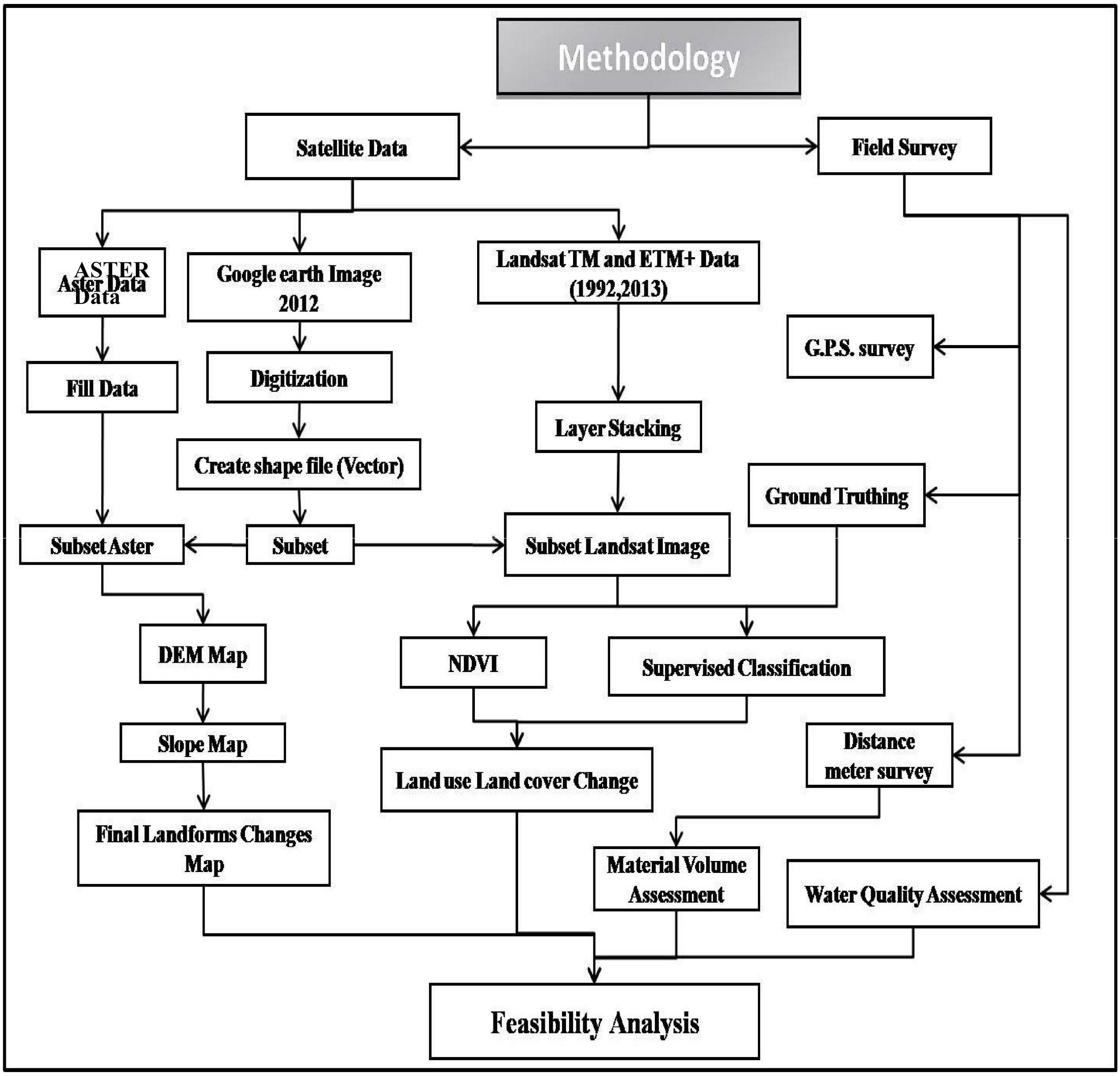

Figure3.1: Flow Chart of Methodology

3.1 Material

The present work is mainly directed to find out changes took place due to human action.To recognize the conditions existed in recent past remote sensing data is the sole authentic source of data. The material used for this study is in the form of remote sensing data. Besides the remote sensing data, field data is also collected for and verification.

3.1.1 Software used

The software employed in the study are Google Earth (it provides historical images), Google Earth Pro (for digitisation), Global Mapper 8, Erdas 9.2 and ArcGIS 9.3 (for Data preparation and analysis).

3.1.2 Data and Data Sources

ASTER image (figure: 3.2), Landsat TM+ image (figure: 3.3) of, December 4th, 1992 and Landsat ETM+ January 12th, 2013 of the study area is obtained from the web site- http://glovis.usgs.gov.This is the official USGS distribution website for Landsat 4+5 and 7, as well as for ASTER.

ASTER Image

The Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) is an advanced multispectral imagey that was launched on board NASA’s Terra spacecraft in December 1999. ASTER covers a broad spectral region with 14 bands from the visible to the thermal infrared with high spatial, spectral and radiometric resolution. An additional backwards looking near-infrared band provides stereo coverage. The spatial resolution varies with wavelength: 15 m in the visible and near-infrared (VNIR), 30 m in the short wave infrared (SWIR), and 90 m in the thermal infrared (TIR). Each ASTER scene covers an area of 60 x 60 km (http://www.asterweb.jpl.nasa.gov.com).

Table3.1: Characteristics of the 3 ASTER Sensor Systems

Subsystem	Band No.	Spectral Range (microns)	Spatial Resolution in m	Quantization Level
VNIR	1	0.52-0.60	15	8 bits
	2	0.63-0.69		
	3N	0.78-0.86		
	3B	0.78-0.86		
SWIR	4	1.60-1.70	30	8 bits
	5	2.145-2.185		
	6	2.185-2.225		
	7	2.235-2.285		
	8	2.295-2.365		
	9	2.360-2.430		
TIR	10	8.125-8.475	90	12 bits
	11	8.475-8.825		
	12	8.925-9.275		
	13	10.25-10.95		
	14	10.95-11.65		

(Source:- http://geo.arc.nasa.gov.).

LANDSAT 7 (ETM+)

The Enhanced Thematic Mapper Plus (ETM+) instrument is a fixed "whisk broom", eight-band, multispectral scanning radiometer capable of providing high-resolution imaging data of the Earth's surface. It detects spectrally-filtered radiation in VNIR, SWIR, LWIR and panchromatic bands from the sunlit Earth in an 183 km wide swath when orbiting at an elevation of 705 kilometer.

The primary new features on Landsat 7 are a panchromatic band with 15 m spatial resolution, an onboard full aperture solar calibrator, 5% absolute radiometric calibration and a thermal IR channel with a four-fold improvement in spatial resolution over TM.

LANDSAT 7 (TM+)

The Thematic Mapper (TM) is an advanced, multispectral scanning, Earth resources sensor designed to achieve higher image resolution, sharper spectral separation, improved geometric fidelity and greater radiometric accurateness and resolve than the MSS sensor. TM data are sensed in seven spectral bands simultaneously. Band 6 senses thermal (heat) infrared radiation. Landsat can only obtain night scenes in band 6. A TM scene has an Instantaneous Field Of View (IFOV) of 30m x 30m in bands 1-5 and 7 while band 6 has an IFOV of 120m x 120m on the ground. (http://www.asterweb.jpl.nasa.gov.com).

Table3.2:-TM Technical Specifications

Sensor type	**Opto-mechanical**
Spatial Resolution	**30 m (120 m - thermal)**
Spectral Range	**0.45 - 12.5 µm**
Number of Bands	**7**
Temporal Resolution	**16 days**
Image Size	**185 km X 172 km**
Swath	**185 km**
Programmable	**yes**

Source:-(http://geo.arc.nasa.gov.).

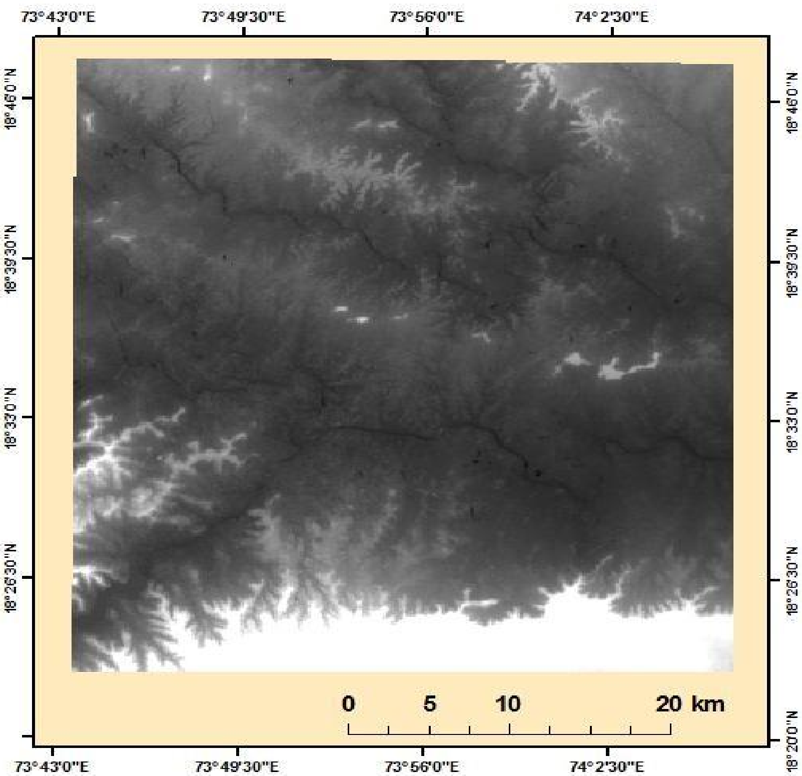

Figure 3.2: ASTER image of study area

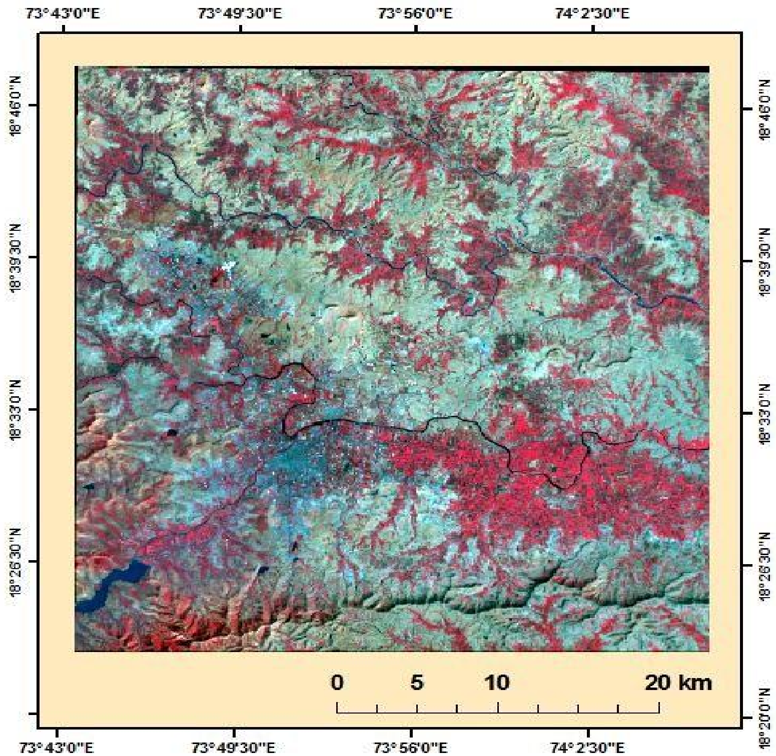

Figure 3.3: Landsat 7 TM+ image of study area (1992)

Landsat 7 collects data in agreement with the World Wide Reference System 2, which has assembled the world's land mass into 57,784 scenes, each 183 km wide by 170 km long. The ETM+ produces about 3.8 Gigabits of data for each scene. An ETM+ scene has an Instantaneous Field Of View (IFOV) of 30 meters x 30 meters in bands 1-5 and 7 while band 6 has an IFOV of 60 meters x 60 meters on the ground and the band 8 and IFOV of 15 meters. Please visit the L7 Science Data Operators Handbook for a detailed description of ETM+ spatialcharacteristics.

Table3.3: Landsat 7 ETM+ Characteristics

Band Number	Spectral Range (microns)	Ground Resolution (m)
1	0.45-0.515	30
2	0.525-0.605	30
3	0.63-0.690	30
4	0.75-0.90	30
5	1.55-1.75	30
6	10.40-12.5	60
7	2.09-2.35	30
Pan	0.52-0.90	15

(Source:- http://geo.arc.nasa.gov.)

3.2 Methodology

The purposes of the present study are contented using following methodology. The stages involved in the methodology are given in detail in following sections.

3.2.1 Digitization

Digitization in GIS is the procedure of ―tracing, in a geographically accurate way, information from images/maps. This data after adaptation is in the binary format, which is directly decipherable by computer (http://www.s4.brown.edu.)

Digitization of the study area, roads, settlement and agriculture grounds have been done in Google Earth Pro (with aspatial resolution of 1.65m in GeoEye1) these digitised files are saved in .kml (Keyhole Markup Language) is a file format.

3.2.2 Creation of Vector file

Vector file stores non-topological geometry and attribute information for the spatial features in a data set. The geometry for a feature is kept as a shape comprising a set of vector coordinates. The digitised files (.kml files) are exported as a shape file (figure: 3.6) in the Global Mapper 8 to get area and to create subset area of interest.

3.2.3 Image Processing

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an improved image or to extract some useful information from it. It is a type of signal dispensation in which input is an image, like video frame or photograph and output, may be image or physiognomies related with that image.

Image classification refers to the computer-assisted interpretation of images—an operation that is vital to GIS. Finally, image transformation refers to the derivation of new imagery as a result of some mathematical treatment of the raw image bands (Lillesand and Kiefer, 1994).

Image processing basically includes the following three steps.

- Importing the image with an optical scanner.
- Analyzing and manipulating the image which includes data compression and image improvement and spotting patterns that are not to human eyes like satellite photographs.
- The output is the last stage in which result can be an altered image or report that is based on image analysis.

3.2.4 Filling of the data gaps

ASTER imageries contain “no-data” holes where water or heavy shadow prevented the quantification of altitude. These are generally small holes, which nevertheless render the data less useful. Therefore, these images are further processed to fill in these no-data voids. This involved the production of vector contours and points and the re-interpolation of these derived contours back into a raster DEM. These interpolated DEM values are then used to fill in the original no-data gaps within the ASTER data. These processes are applied using ArcGIS. (http://www.wwu.edu/huxley/spatial/tut/merge_mosaic.htm).

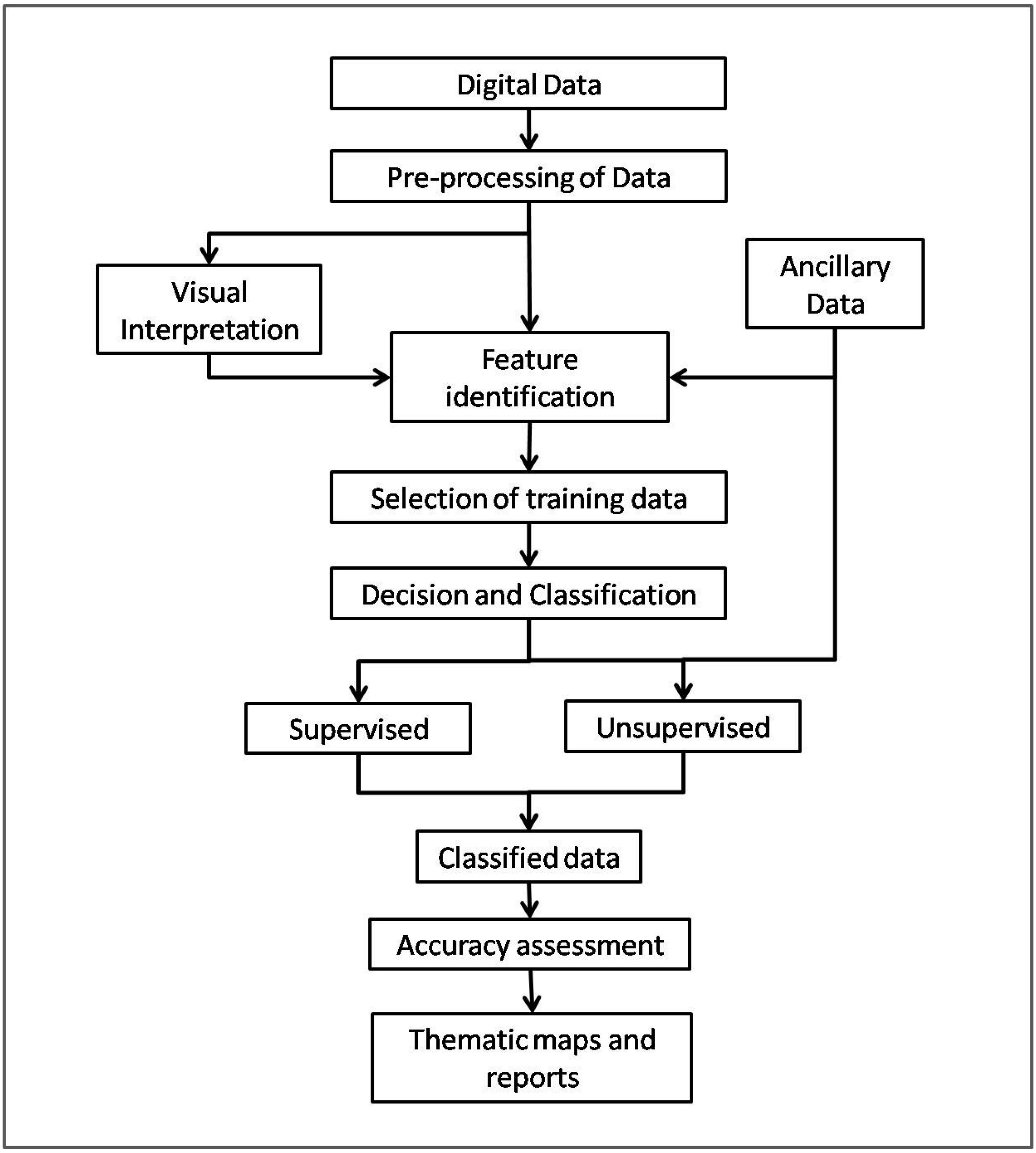

Figure3.4: Flow Chart of Digital Image Processing

3.2.5 Geometric and Radiometric Corrections

All Landsat standard data products are processed using the Level 1 Product Generation System (LPGS) with the following parameters applied:

- Large output format of the image Geo-TIFF
- Resampling method Cubic Convolution (CC)
- Pixel size (reflective bands) 30-meter (TM, ETM+) and 60-meter (MSS)
- Map projection: Universal Transverse Mercator (UTM) & Polar Stereographic projection for Antarctica.
- World Geodetic System (WGS) 84 datum
- MAP (North-up) image orientation

A very minoraggregate of LANDSAT TM scenes is processed using the National Land Archive Production System (NLAPS). Systematic Correction (Level 1G) Gap-filled (Scan Line Corrector off only) *includes radiometric correction, geometric correction, and replacement of all missing image pixels*within the SLC-off (primary) scene with assessed values based on histogram-matched data from one or more user-defined "fill" scenes acquired on a separate date. Therefore, LANDSAT images have been occupied directly for analysis (http://landsat.usgs.gov).

3.2.6 Layer stacking

Layer Stacking is used to build a new multiband file from geo-referenced images of various pixel sizes, extents, and projections. The input bands will be resampled and re-projected to a common user-selected output projection and pixel size. The output file will have a geographic extent that either covers all of the input file extents or comprises only the data extent where all of the files overlap (Leica Geosystem, 2006).

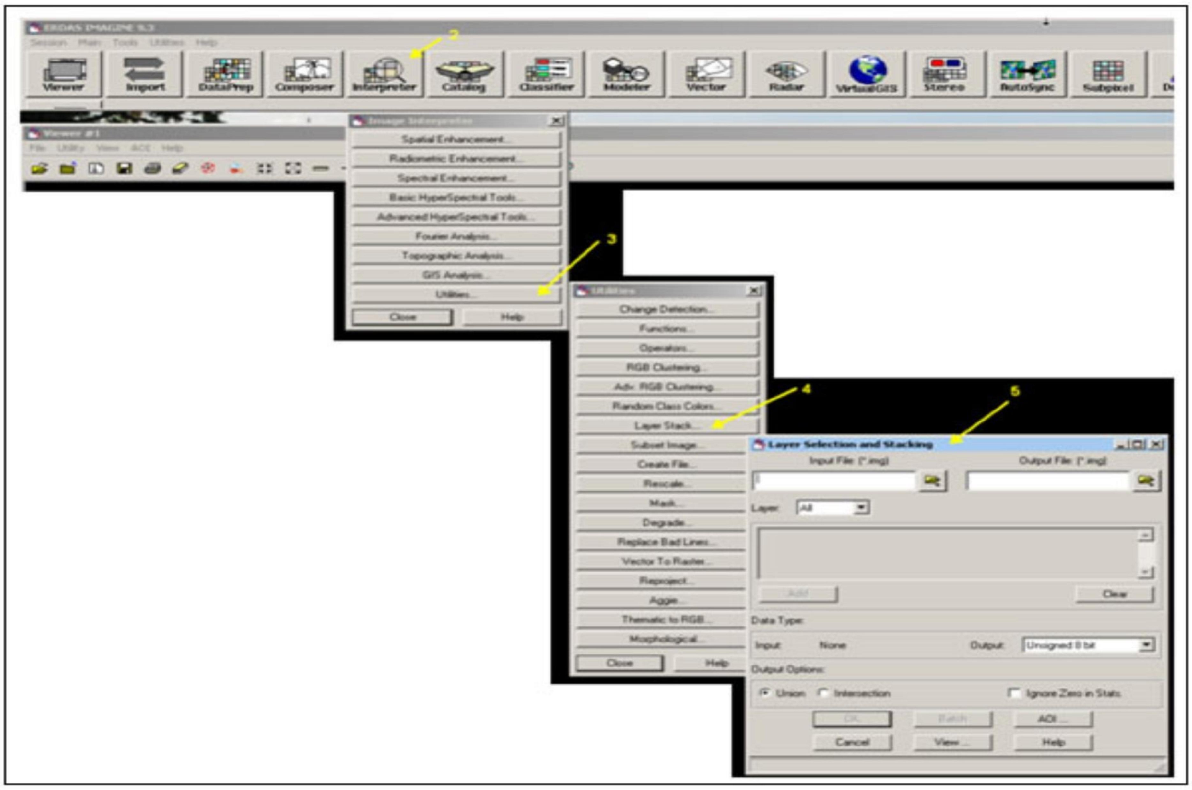

Figure3.5: Layer Stack in Erdas software

3.2.7 Combining appropriate Band

The band combination used in image classification is 4, 3, 2 standard false color composite (FCC) and 3 and 4 i.e. visible red and near infrared for NDVI ratio. Vegetation seems in shades of red, urban settlement areas are seen as cyan blue, and soils vary from dark to light browns. Ice, snow and clouds are white or light cyan. This is a very general band combination and is useful for vegetation studies, monitoring drainage and soil patterns and various stages of crop growth. Usually, deep red hues indicate broad leaf and/or healthier vegetation while lighter reds signify grasslands or sparsely vegetated areas. These visual color combinations are used in visual interpretation of the satellite images. Densely populated urban areas are shown in light blue. This TM band combination gives results similar to traditional color infrared aerial photography.

Selecting the appropriate bands to use in the color image on the other hand does have a huge impact on which features can be seen in a particular image. The list below explains some of the features of the seven Landsat Thematic Mapper bands and how they are tailored for detecting different features.

Band 1 (0.45-0.52 µm, blue-green): Since this short wavelength of light penetrates better than the other bands it is often the band of choice for aquatic ecosystems. It is used to monitor sediment in water, mapping coral reefs, and water deepness. Tactlessly, this is the noisiest of the Landsat bands since short wavelength blue light is scattered more than the other bands. For this reason, it is rarely used for "pretty picture" type images.

Band 2 (0.52-0.60 µm, green): This has analogous qualities to band 1 but not as extreme. The band was selected because it matches the wavelength for the green we see when looking at Vegetation. **Band 3** (0.63-0.69 µm, red): Since vegetation absorbs nearly all red light (it is sometimes called the chlorophyll absorption band) this band can be useful for distinguishing between vegetation and soil and in monitoring vegetation health.

Band 4 (0.76-0.90 µm, near infrared): Since water absorbs nearly all light at this wavelength water bodies appear very dark. This contrasts with bright reflectance for soil and vegetation so it is a good band for defining the water/land interface.

Band 5 (1.55-1.75 µm, mid-infrared): This band is very sensitive to moisture and is therefore used to monitor vegetation and soil moisture. It is also good at distinguishing between clouds and snow.

Band 6 (10.40-12.50 µm, thermal infrared): This is a thermal band, which means it can be used to measure surface temperature. This is primarily used for geological applications but it is sometime used to measure plant heat stress. This is also used to differentiate clouds from bright soils since clouds tend to be very cold. One other difference between this band and the other multispectral ETM bands is that the resolution is half of the other bands (60 m instead of 30 m).

Band 7 (2.08-2.35 µm mid-infrared): This band is also used for vegetation wetness although Generally band 5 is favored for that application, as well as for soil and geology mapping.
(http://web.pdx.edu).

3.2.8 Performing Subset

A distinctive LANDSAT scene covers an extent of about 185 km by 185 km. Therefore, it is desirable to cut out a subset of this larger image to simplify the analysis and focus on the portion of the scene that is of primary interest. For this determination, vector file of the study area and ERDAS Imagine 9.2 have been used to subset the area of interest.

3.2.9 Image classification

The intent of the classification process is to categorize all pixels in a digital image into one of several land cover classes, or themes. This categorized data may then be used to produce thematic maps of the land cover present in an image. Normally, multispectral data are used to perform the classification and, indeed, the spectral pattern present within the data for each pixel is used as the numerical basis for categorization.

Two main classification methods are Supervised Classification and Unsupervised Classification. In a supervised classification, the analyst identifies in the imagery homogeneous representative samples of the different surface cover types (information classes) of interest through previous knowledge. These samples are referred to as training areas which are then used to regulate the spectral classes which represent them (Lillesand and Kiefer, 1994).

Ground Truthing

It confirms that feature classes resulting from image data precisely represent real world features. Ground truth data can be derived from a diversity of sources- field visits, topographical map, aerial photography, maps, written reports and other sources of measurements and, ideally, should be collected at the same time as the remotely sensed data. In this study ground truthing has been completed through field visits and with the help of Google earth.

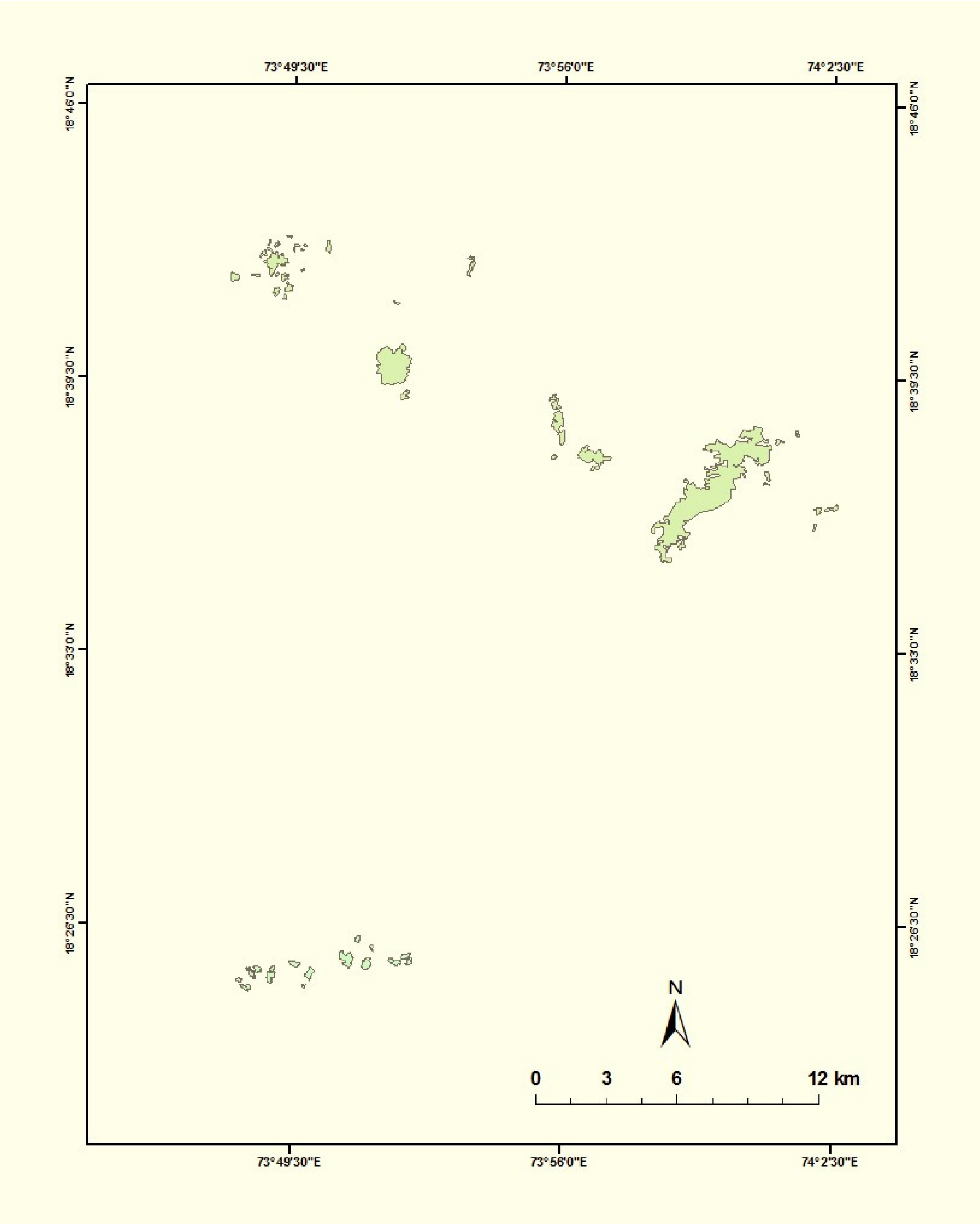

Figure 3.6:- Stone Quarries in the Study Area

In this study classification has been done by using supervised classification method in ERDAS IMAGINE 9.2. It involves three basic steps (Lillesand and Kiefer, 1994):

1. Training stage

2. Classification stage

3. Output stage

1.) Training stage

The analyst identifies representative training areas and develops a numerical description of the spectral attributes of each land cover type of interest in scene. The selection of appropriate training areas is based on the analyst's familiarity with the study area and their knowledge of the actual surface cover types present in the image. 10 to 20 training sites have been taken for each class to categorize the study area. The computer uses a special program or algorithm to regulate the numerical signatures for each training class. Once the computer has determined the signatures for each class, each pixel in the image is compared to these signatures and labeled as the class it most closely resembles digitally.

2.) Classification stage

Throughout this stage the spectral patterns in the image data set are assessed in the computer using predefined decision rule to determine the identity of each pixel. Various supervised classification algorithms may be used to allocate an unknown pixel to one of a number of classes. The choice of a particular classifier or decision rule hinge on the nature of the input data and the desired output. Parametric classification algorithms assume that the observed measurement vectors for each class in each spectral band during the training phase of the supervised classification are Gaussian in nature; that is, they are normally distributed. Nonparametric classification algorithms make no such assumption. Among the most frequently used classification algorithms are the parallelepiped, minimum distance, and maximum likelihood decision rules.

The ERDAS IMAGINE classification software treats the non-parametric and parametric approaches as complimentary. Depending on the properties of the data and the classification scheme, some classes may best be defined as objects in feature space and should be classified using a non-parametric decision rule. Other classes can be legitimately described with statistics and can best be distinguished using a parametric rule. The parametric and non- parametric technique used in the study are maximum likelihood decision rules and parallelepiped respectively.

3.) **Output stage**

After the entire data set has been categorized, the results are presented in the output stage. A virtually unlimited selection of output products may be generated. The output products used in the study are graphic product and table of area statistics.

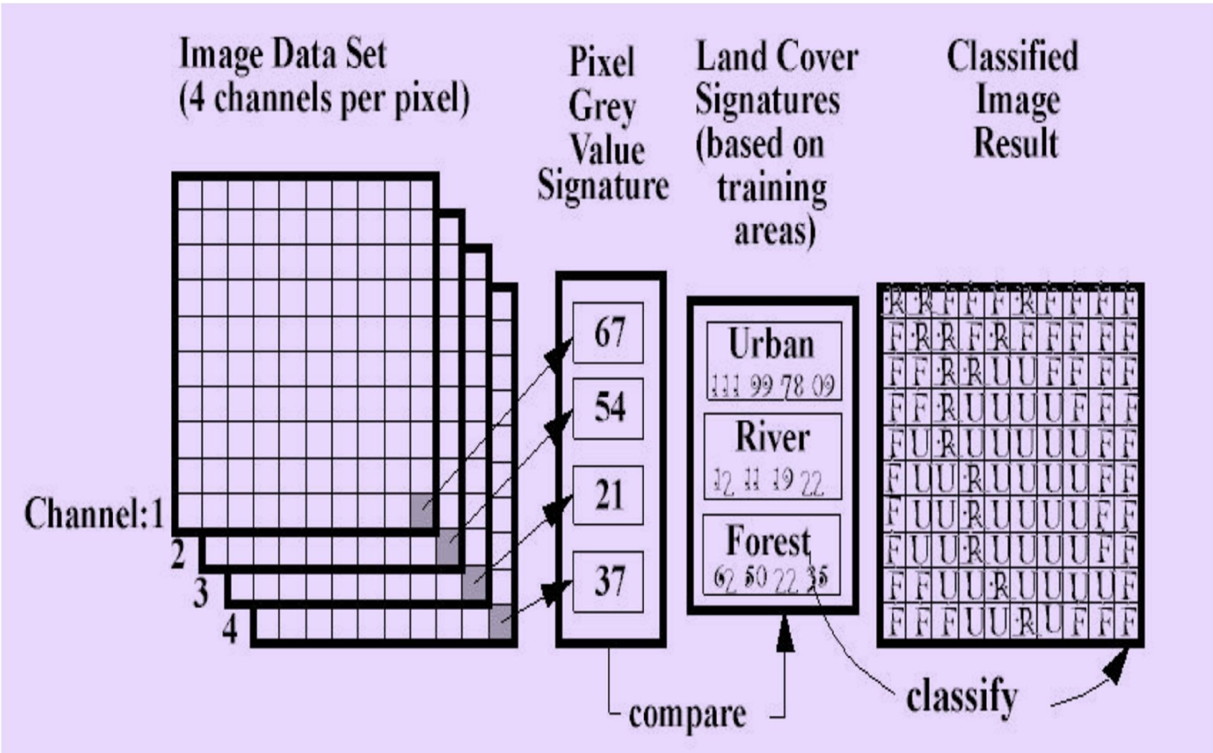

Figure3.7:- Major stages in Supervised classification (source: Lillesand and Kiefer, 1994)

3.2.10 Digital Elevation Model (DEM)

The accessibility of digital elevation models (DEMs) is acute for performing geometric and radiometric alterations for terrain on remotely sensed imagery, and permits the generation of contour lines and terrain models, thus providing another source of information for analysis. Present mapping programs are rarely instigated with only planimetric considerations. The demand for digital elevation models (Fig4.3:) is growing with increasing use of GIS and with increasing evidence of improvement in information extracted using elevation data (for example, in discriminating wetlands, flood mapping, and forest management). The incorporation of elevation and terrain data is vital to many applications, particularly if radar data is being utilized, to compensate for foreshortening and layover effects and slope induced radiometric effects. Elevation data is used in the production of prevalent topographic maps.

Elevation data, integrated with imagery is also used for generating perspective views, useful for tourism, route planning, to optimize views for developments, to lessen visibility of forest clear cuts from major transportation routes, and even golf course planning and development. Elevation models are combined into the programming of cruise missiles, to guide them over the topography.

3.2.11 Slope Map

Information regarding the slope steepness alone is of considerable importance in land management, for it can deliver the critical restricting factor for some uses. Croft (1973) has suggested that appropriate slope class boundaries for practical purposes are 2.5, 5, 10, & 20%. Thus, if a morphological map is shaded using these class intervals it can be used directly to ascertain some critical practical limits to its direct uses by man (Hart, 1985). Slope map (Fig:) in the present study has been prepared by using slope option in 3D Analyst tool in ArcGIS and is classified into four categories (0.1-5, 5-10, 10-20, >20%) on the basis of Croft‘s critical slope criteria.

3.2.12 NORMALIZED DIFFRENCE VEGETATION INDEX (NDVI)

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is recognized to analyze remote sensing measurements and assess whether the target being observed comprises live green vegetation or not.

NDVI has found a wide application in vegetative studies as it has been used to estimate crop yields, pasture performance, and rangeland carrying capacities among others. It is often unswervingly related to other ground influences such as percent of ground cover, photosynthetic activity of the plant, surface water, leaf area index and the amount of biomass. NDVI was first used by Rouse et al. (1973) from the Remote Sensing Centre of Texas A&M University.

Usually, healthy vegetation will captivate most of the visible light that falls on it, and reflects a great portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible band of light and less near-infrared light. Bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum (Holme *et al* 1987).

The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands.

NDVI= (NIR-RED) / (NIR+RED)

This formulation permits us to manage with the fact that two identical patches of vegetation could have diverse values if one were, for example in bright sunshine, and another under a cloudy sky. The bright pixels would all have larger values, and consequently a larger absolute difference between the bands. This is avoided by dividing by the sum of the reflectance. Theoretically, NDVI values are characterized as a ratio ranging in value from -1 to 1 but in practice extreme negative values characterize water, values around zero exemplify bare soil and values over 6 represent dense green vegetation.

3.2.13 WATER QUALITY PARAMETERS & INDICATORS

Water quality regulates the ‘goodness’ of water for particular purposes. Water quality tests will give information about the health of the waterway. By testing water over a period of time the variations in the quality of the water can be seen. Parameters that may be tested comprise Temperature, pH, Salinity, TDS (Total Dissolved Solids), Conductivity. An assessment of the aquatic macro invertebrates can also provide an indication of water quality.

Water Temperature

Many of the physical, chemical and biological characteristics of Stone quarries are directly affected by water temperature. It is a very important parameter in terms of stream health and it is simple to measure. Unfortunately, the interpretation of water temperature results is not so simple because temperature effects many different properties of water. Several things influence the rise and fall of water temperature in a stream but the most important being, the season, time of day and the weather. A wide range of temperatures can occur along the length of a stream especially in the summer months due to factors such as: water depth, water colour, amount of shading vegetation and flows**.**

pH

The pH of Stone quarries is a measure of how acidic or alkaline (basic) the water is on a scale of 0 to 14. Pure distilled water is neutral with a pH of 7. pH measurements below 7 specify that the solution is acidic containing more H^+ ions than OH^- ions. Measurements above 7 indicate that the reverse situation occurs, making the water alkaline. It is important to reminisce that for every one unit change on the pH scale, there is approximately a ten-fold in how acidic or alkaline the sample is.

TDS (Total Dissolved Solids)

Solids are found in Stone quarries in two forms, suspended and dissolved. Suspended solids comprise silt, Stirred-up bottom sediment, decaying plant matter, or sewage-treatment effluent. Suspended solids will not pass through a filter, while dissolved solids will. Dissolved solids in freshwater Samples contain soluble salts that yield ions such as sodium (Na^+), calcium (Ca_2^+), magnesium (Mg_2^+), bicarbonate (HCO_3^-), sulfate (SO_4^-), or chloride (Cl^-). Total dissolved solids, or TDS, can be determined by evaporating a pre-filtered sample to dryness, and then finding the mass of the dry residue per liter of sample. The conductivity is then transformed to TDS. Either of these methods yields a TDS value in units of mg/L.

Conductivity

Conductivity is the ability to conduct electricity. Water conducts electricity because it contains dissolved solids that transmit electrical charges. For example, chloride, nitrate, and sulfate carry negative charges, while sodium, magnesium, and calcium carry positive charges. These dissolved solids affect the water's ability to conduct electricity. Therefore, measuring the conductivity of the water indirectly indicates the amount of Total Dissolved Solids (TDS) in the water.

Salinity

Salinity is a measure of the dissolved salts in the water. Salinity is typically highest during periods of low flows and increases as water levels decrease. Salinity is measured as either TDS (Total Dissolved Solids), which measures the expanse of dissolved salts in the water, or as EC (Electrical Conductivity), which is the property of a constituent which enables it to serve as a channel or medium for electricity. Salty water conducts electricity more readily than purer water. A sample's EC can be converted to TDS and vice versa.

Table No3.4:- Water Quality Parameters, Definitions and Standard range:-

Parameters	Standard Range (Illinois Water Quality Report 2004)	Reason for the analysis
Temperature	16-22°C	Temperature can exert great control over aquatic communities. If the overall water body temperature of a system is altered, an aquatic community shift can be expected. In water above 30°C, a suppression of all benthic organisms can be expected. Also, different plankton groups will flourish under different temperatures. For example, diatoms dominate at 20 -25 degrees C, green algae dominate at 30-35 degrees C, and cyan-bacteria dominate above 35
		degrees C.
pH value	6.5 to 8.5	pH is an indicator of the existence of biological life as most of them thrive in a quite narrow and critical pH range.
Total Dissolved Solids, (TDS)	500mg/l	The total dissolved solids (TDS) in water consist of inorganic salts and dissolved materials. In natural waters, salts are chemical compounds comprised of anions such as carbonates, chlorides, sulphates, and nitrates (primarily in ground water), and cations such as potassium (K), magnesium (Mg), calcium (Ca), and sodium (Na). In ambient conditions, these compounds are present in proportions that create a balanced solution. If there are additional inputs of dissolved solids to the system, the balance is altered and detrimental effects may be seen. Inputs include both natural and anthropogenic source.
Conductivity	300mmho/cm	Conductivity indicates the presence of ions within the water, usually due to in majority, saline water and in part, leaching. It can also indicate industrial discharges. The removal of vegetation and conversion into monoculture may cause run-off to flow out immediate thus decrease recharge during drier period. Hence, saline intrusion may go upstream and this can be indicated by higher conductivity.
Salinity	>100 ppm	High salinity may interfere with the growth of aquatic vegetation. Salt may decrease the osmotic pressure, causing water to flow out of the plant to achieve equilibrium. Less water can be absorbed by the plant, causing stunted growth and reduced yields. High salt concentrations may cause leaf tip and marginal leaf burn, bleaching, or defoliation. As per Conductivity, salinity (NaCl content, g/kg) can be used to check for possible saline intrusion in future.

Source:(http://www.epa.state.il.us/water/water-quality/305b/305b-2004.pdf)

CHAPTER IV

RESULTS AND DISCUSSION

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Introduction

Due to huge migration of the people to Pune City from surrounding villages and other cities around the country, the demand is increasing in all the aspects. Therefore, to fulfill the increasing demands of increasing population the city is expanding in all directions. Due to thegrowth of the city, different types of constrictions are going on in many areas (Gogai, 2005). Change in land use can be perceived in the southern part of Pune city. Katraj area which is having Pune-Bengaluru and Pune-Mumbai highways has also witnessed rapid development near it. The areas around Sinhagad Road have been developing at a rapid pace. In the western part, Kothrud area is developing rapidly. Bavdhan, which was earlier a small village, has now industrialized into a posh locality. Similar scenario is observed for the Pashan and Sus villages which have urbanized because of their improved connectivity with the main city (Dhorde et al. 2012).

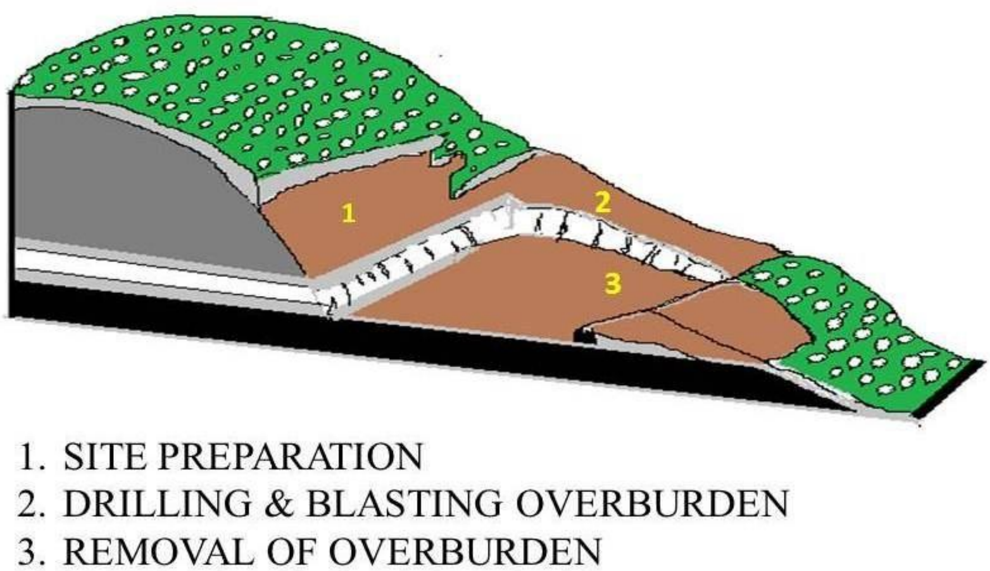


Figure4.1:. Three-dimensional view of contour mining (Grim and Hill, 1974).

4.1 Overview

This chapter presents the finding of the Anthropogenic Landforms evolution and morphometric assessment and also finding land use and land cover (LULC) change across the Study area over the period of 1992 to 2013. The results of the remote sensing image includes the LULC classification, assessment of the accuracy of the classified images, vegetation density classification based on NDVI (Normalized Difference Vegetation Index) ratio, slope category map based on Croft's Methods. The combination of qualitative and quantitative results confirms that LULC has changed significantly over the last twenty-one years across the Pune urban & suburban area.

4.2 Findings

4.2.1 Anthropogenic Landforms

From the field visit the study area we can find out how urbanization in Pune City has affected on the natural landscape. Man as an active geomorphic agent, perform different kind of activities on the natural landscape and which lead to change in the face of the original look of the landscape elements. When the people performs the different activities it leads to affect the different processes like quarries, hill cutting, artificial dam, building construction etc. In urban area these processes are critically affected. If the rate of those processes either increases or decrease due to any reason it leads to change in the landscape.

Table 4.1: Different Kind of geomorphic activity & processes in study area:-

SL No.	**Location**	**Activities**	**Geomorphic Processes**
1.	Wagholi	Major activity is Hill slope cutting, Stone quarries, clearance of vegetation.	Alteration of fluvial process, erosion due to confined outlet through manmade pipes, removal of weathered man tale soil and exposed bedrock.
2.	Alandi	Quarries, development of buildings and construction in the valley, clearance of	Alteration of fluvial processes, slope alteration, removal of weathered man tale soil and

		vegetation cover.	exposed bedrock.
3.	Jambhulwadi	Excavation, construction, dumping and modification of slope, channel modification, remove the surface vegetation cover.	Alteration in slope processes, fluvial processes, removal of weathered man tale soil and exposed bedrock

4.2.1.1 Study of Quarrying

Stones Quarrying and others constructional material is not a new economic activity; but the rate of quarrying has increased rapidly. During 19th& 20th century there was a sharp increase in the housing and building activity, which was principally because of industrial revolution and related to the growth in technology, the population also had increase and demand for space was more as technology improved the expense shot up. Now it was less time consuming to blast a mountain and get stone, the labour included was skilled labour and the finest quality of stones could be grown (Figure:-4.1). Dynamic and other blasting materials were uses to blast the stones Transportation facilities increased and this in turn demand good roads. Road construction for efficient transportation and network has increased. This all lead to rapid urbanization.

The area Wagholi, Alandi and Jambhulwadi has been quarried for basalt which was used for road, construction, etc. The quarries stretch in a N-S pattern in the study area. The total area under quarries is 13.67 sq. km. The detail of quarries in the study area is given in Table4.2. Most of the quarries are active in Wagholi site and some of the quarries are idle and useless in Jambhulwadi site. Moreover, they collect stagnant water and eventually breed mosquito larvae. These quarries could cause point-source pollution like the one near the Jambhulwadi Bridge. Fieldwork around some of these quarries indicates that they are excavated in massive basalt and are abandoned when the vesicular basalt is encountered at the base. Therefore, these quarries can be used to artificially recharge rainwater. It is contemplated that, because of favorable hydrogeological conditions and the need to conserve and harvest water, such quarries can be used either for water storage or for artificial recharge.

Table4.2: Total disturbed area for all three sites:

SL No.	Study Area	Water Quarry	Without Water Quarry	Total No. of Quarry	Area in sq. km	Nature of Quarry
1.	Wagholi	67	113	180	9.16	HQ
2.	Alandi	31	27	58	3.24	HQ
3.	Jambhulwadi	33	45	78	1.27	Medium to HQ

(Data source:- Filed Study; Note:- "HQ" Hard Quarry)

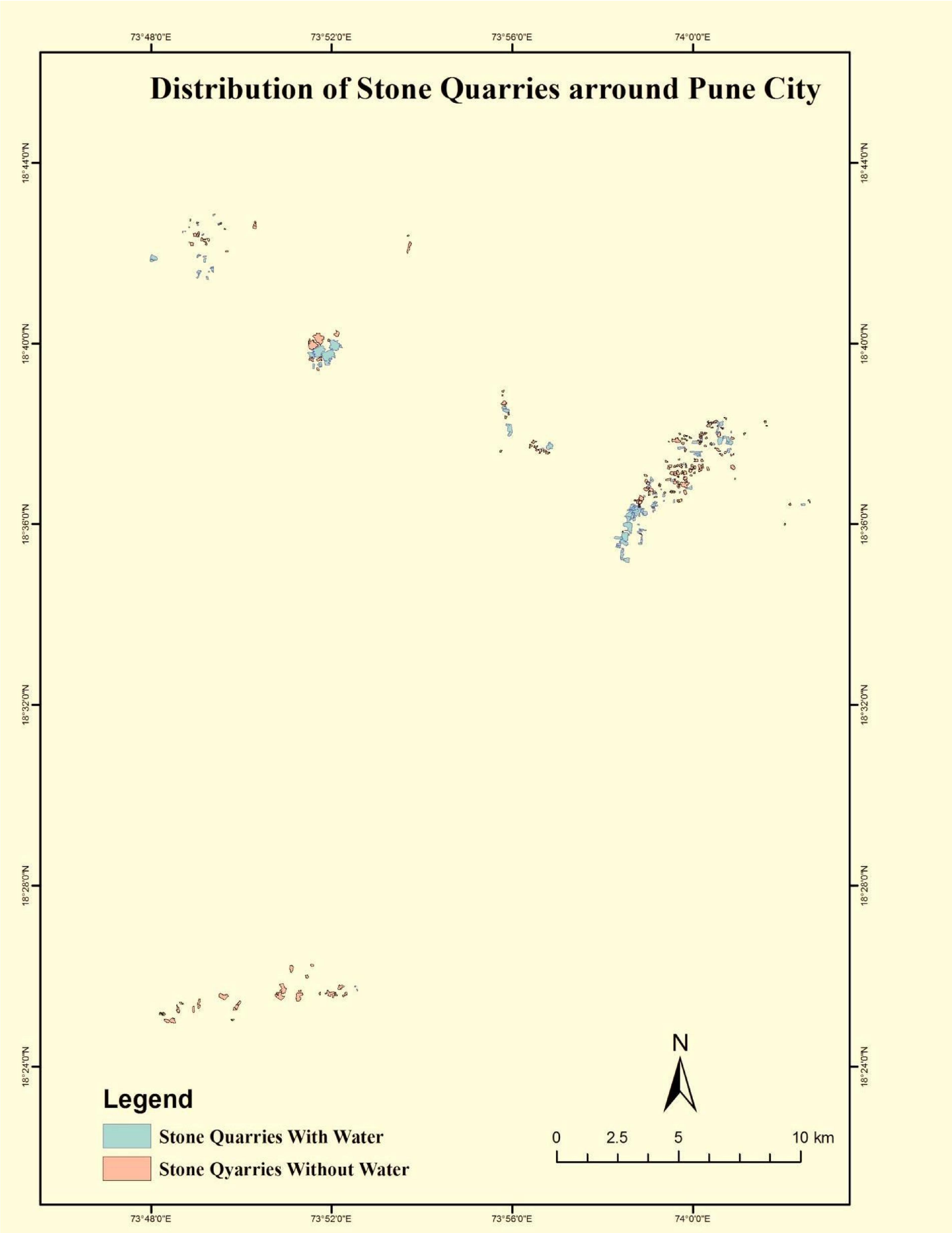


Figure4.2:- Map shows the distribution of stone quarry around the Pune city

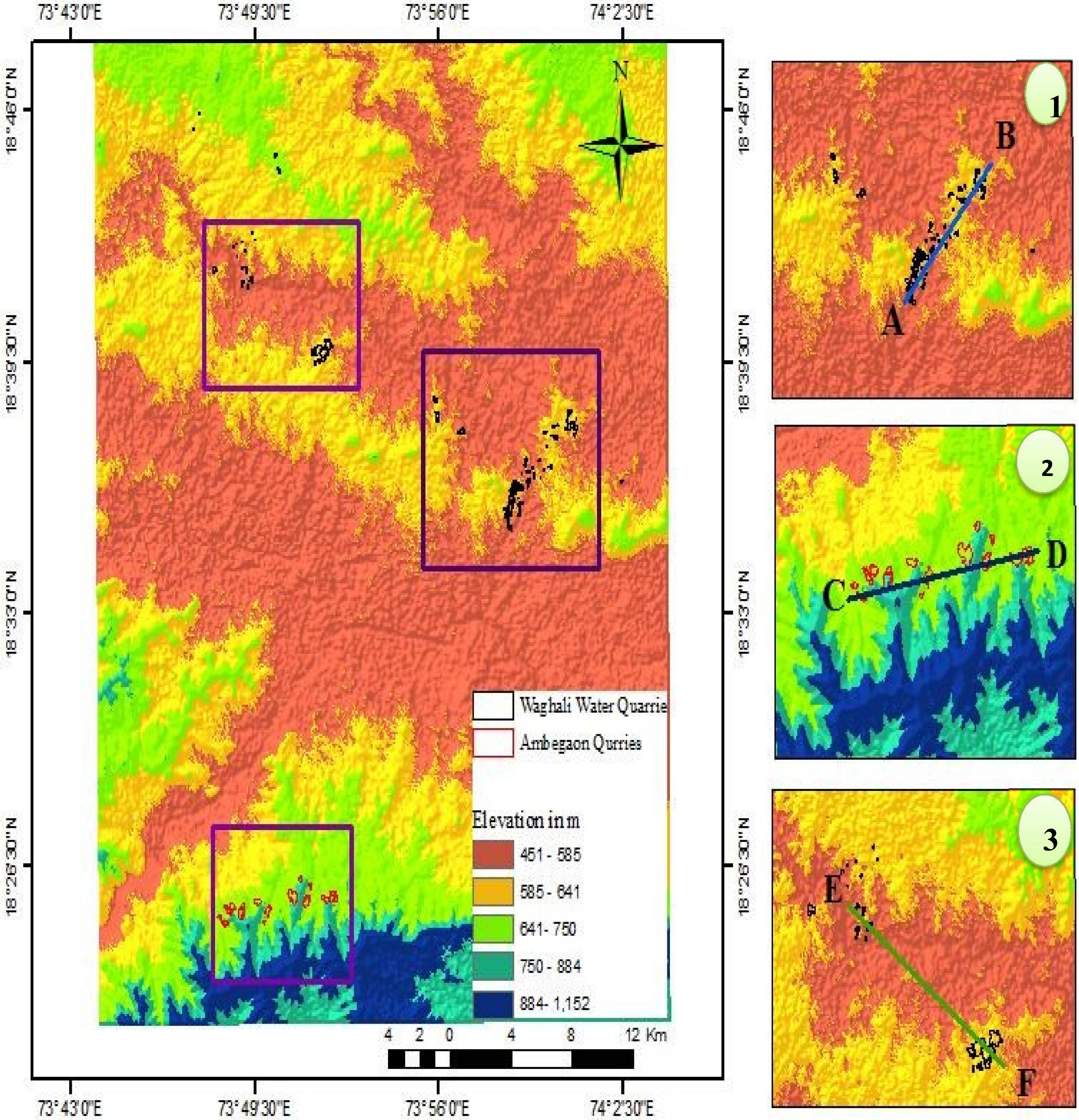
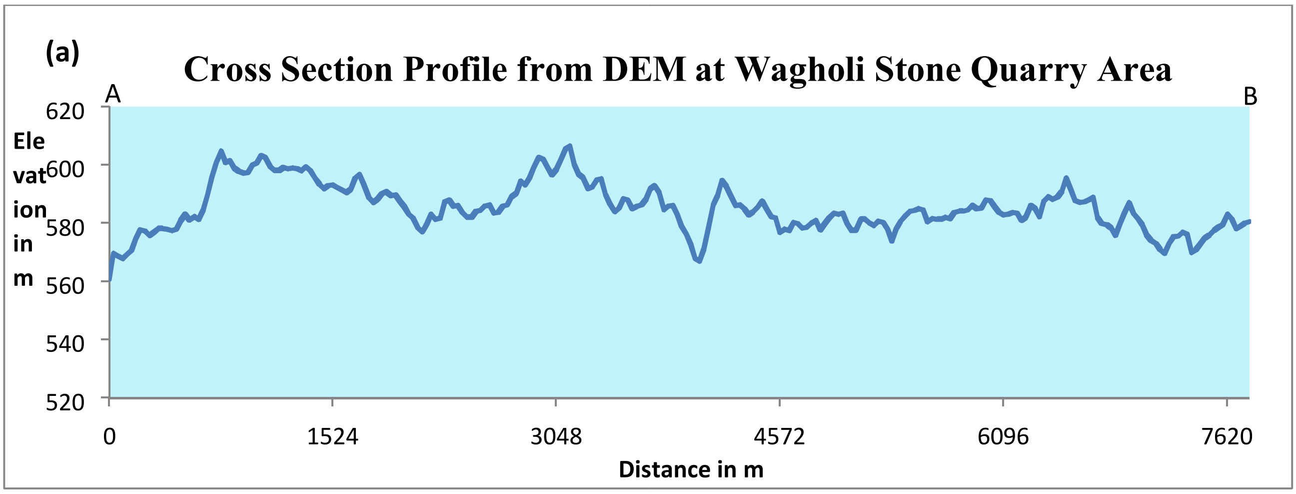
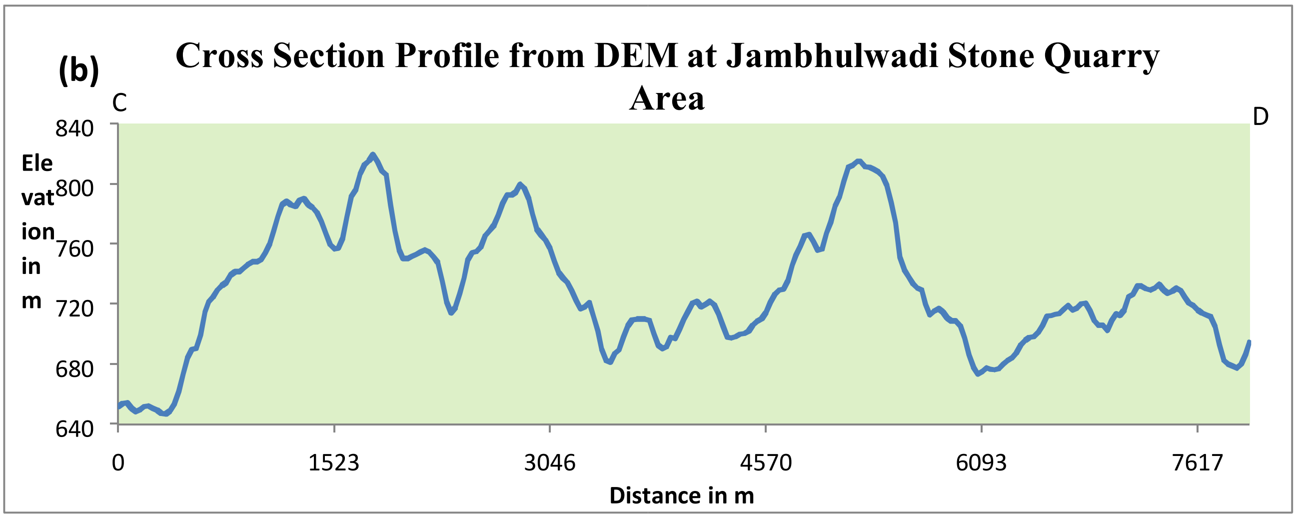


Figure4.3:-Classified colour-coded elevation image of the Study Area. The image was generated from ASTER-DEM data. The image shows the Location of Stone quarries area at site around Pune city. 1 = Transverse profile across the Stone quarries at Wagholi site; 2 = Transverse profile across the Stone quarries at Jambhulwadi site; 3= Transverse profile across the Stone quarries at Alandi site.(Stone quarries surface derived from ASTER data in ArcGIS 10).


(a)
Cross Section Profile from DEM at Wagholi Stone Quarry Area
A
B
Elevation in m
620
600
580
560
540
520
0
1524
3048
4572
6096
7620
Distance in m


(b)
Cross Section Profile from DEM at Jambhulwadi Stone Quarry Area
C
D
Elevation in m
840
800
760
720
680
640
0
1523
3046
4570
6093
7617
Distance in m

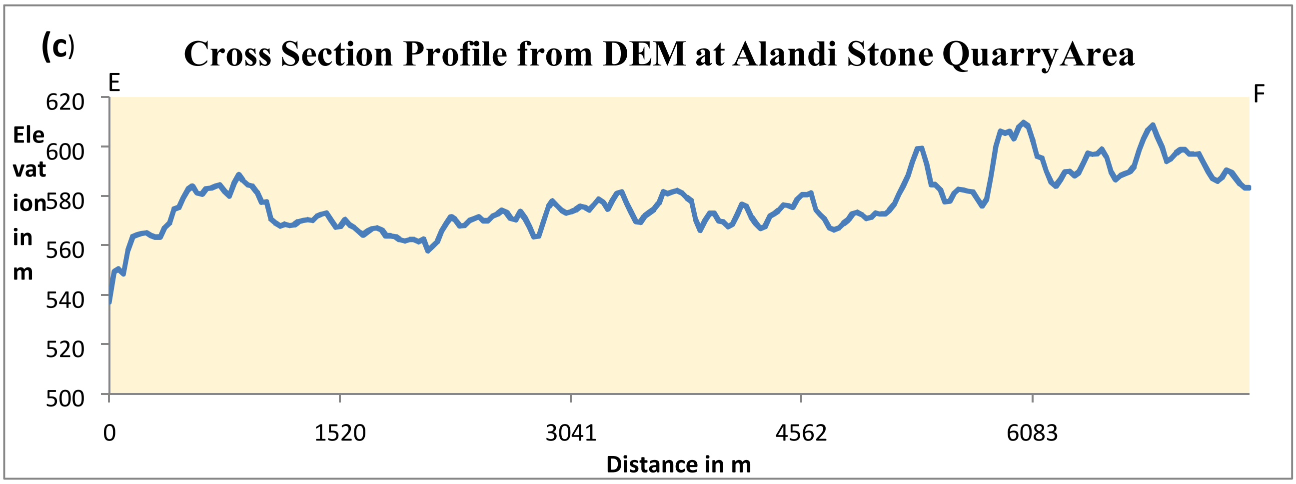
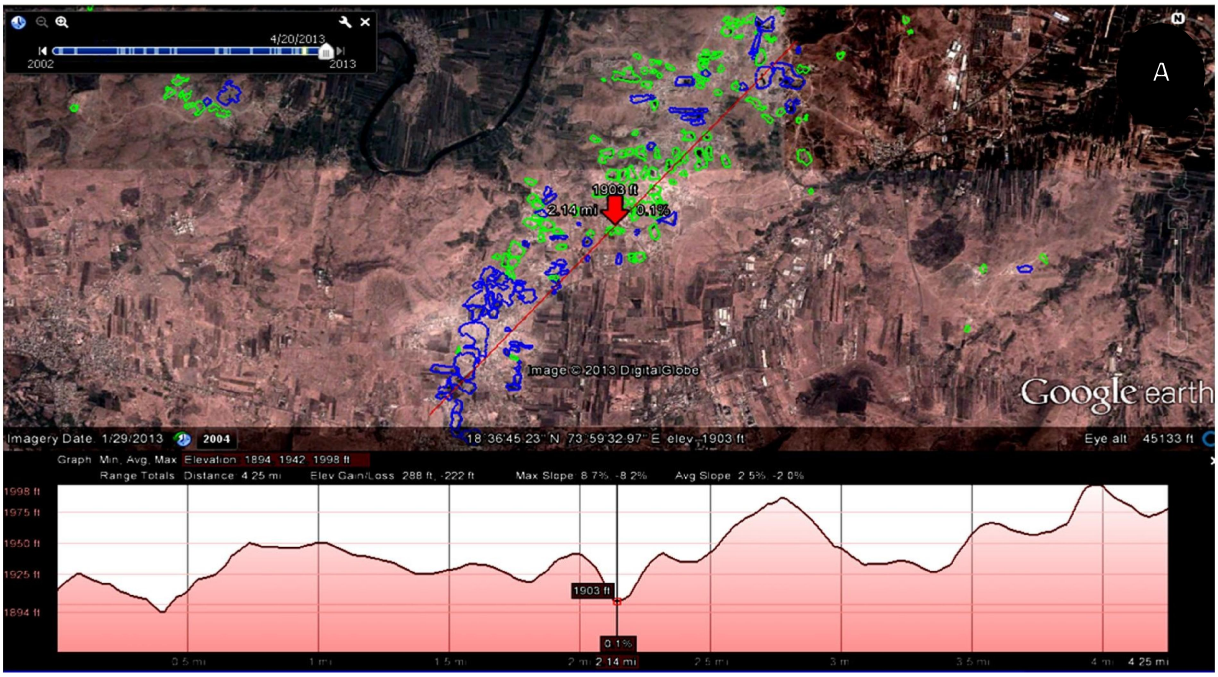

(c)
Cross Section Profile from DEM at Alandi Stone QuarryArea
E
F
Elevation in m
620
600
580
560
540
520
500
0
1520
3041
4562
6083
Distance in m

Figure 4.4:- Graph showing the cross profile at stone quarries (a) Wagholi (b) Jambhulwadi (c) Alandi



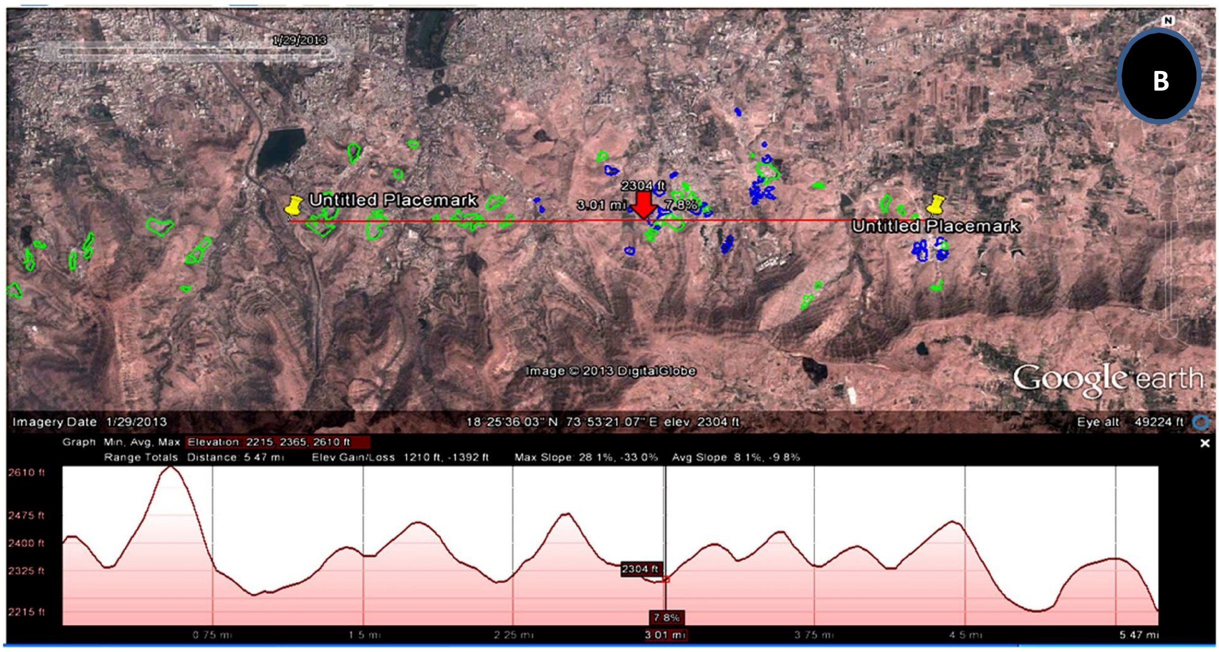


Figure4.5:-Google earth images of different stone quarries **(A)** Google earth image of the Wagholi Stone quarry and showing the location of the transect lines. (B) Google earth image of

the Stone quarry in Jambhulwadi & surrounding area and showing the location of transect line. The color polygon represents approximately the location and extent of the man-made quarry.

3D View

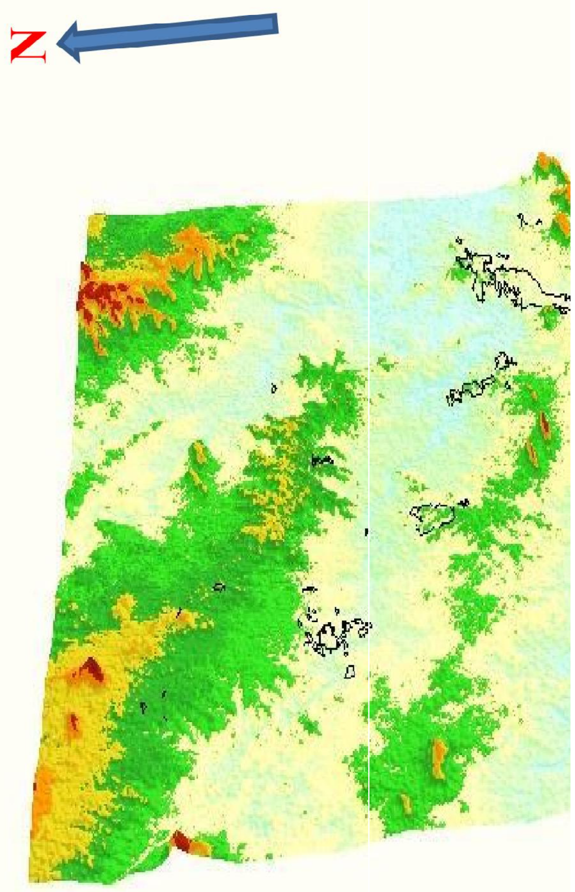


Figure4.6

4.2.1.2 Modified channel or Valley morphology

In Jambhulwadi and Alandi site main stream, river is totally altered even other small streams are also totally modified due to construction of new building and roads the flows of streams are diverted. Channelization and diverting streams infiltration and the recharge and the recharge of ground water, the amount of surface water increases and it leads to increase in the wash processes.

4.2.2 Scarping & cutting of Hill Slope

The major man-made or anthropogenic landforms that are commonly found around Pune city. Scarping and cutting the hill-slope because of rapid growth of urbanization, and construction of building and expansion of road network increase the number of the man-made landforms or anthropogenic changes. Consequently, there is a decrease in the size and outline of mountains. In around Pune city spurs and mountain barriers have been cut and increasing number of artificial landform.

The scrapping and cutting of hills can be put forth clearly by the study

1. Cutting of hills for the purpose of construction of roads.
2. Scarping of hills for the construction of houses.

4.2.2.1 Cutting of hills for the purpose of construction of roads

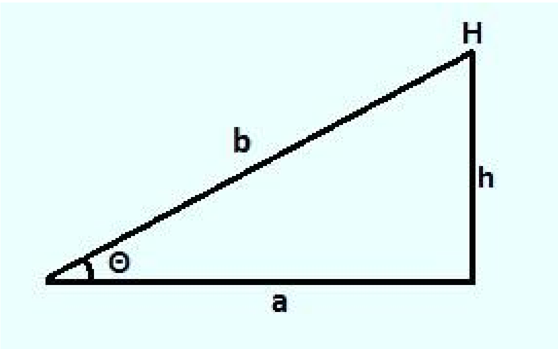
Roads for transportation and communication are inevitable parts of urbanization construction of highway are exclusive examples of man-made landforms since highways need to be as straight as possible and with little differences in relief character the other roads within the city may follow the natural relief and may have ups and downs. Urban suburban roads have remained in place for a cut the land is made even and building of housing complexes have taken place here. This was mainly because of the lack of availability of space. Many urban roads have remained in place for a period of time and have a long history but highways are planned sufficiently and have a high budget to use all possible technologies of road construction including tunneling and cutting of road. In case of Mumbai-Bangalore highway road is cuts through spur and the extracted materials still lay near beside the road. This could lead to problems of waterlogging and sheet wash in the rainy season.

Sr. No	GPS Points	Location (Jambhulwadi Area)	Reading (m)		Length between two GPS points (m)	Total Distance (m)	Slope (degree)	Height (m)	Area (Sq. m)	Area Average (Sq. m)	Volume (cu.m)	Average Volume (cu. m)
			Top	Bottom								
1	GP_1	1st Site	50.8	43.21	0	130.00	31°43′50″	26.72	1154.44	1023.27	150076.89	133024.63
2	GP 2		50.27	45.8	32.07		24°20′51″	20.72	948.93		123361.49	
3	GP_3		50.54	43.13	73.07		31°26′6	26.36	1136.78		147780.75	
4	GP_4		45.81	40.75	25.53		27°10′59″	20.93	852.92		110879.40	
5	GP_5	2nd Site (Left)	41.98	36.45	0	223.00	29°44′30″	20.83	759.25	907.57	169313.53	202387.06
6	GP_6		50.7	37.1	21.43		42°57′57″	34.56	1282.18		285925.25	
7	GP_7		45.7	42.33	50.66		22°08′10″	17.22	728.87		162538.22	
8	GP_8		42.61	34.62	150.91		35°39′25″	24.84	859.96		191771.26	
9	GP_9	2nd Site (Right)	43.43	39.05	0	186.00	25°58′27″	19.02	742.64	818.63	138130.28	152264.49
10	GP_10		48.62	41.61	50.37		31°8′42″	25.15	1046.49		194647.42	
11	GP_11		40.85	30.83	60.49		40°59′53″	26.79	825.94		153624.04	
12	GP_12		37.47	31.4	74.51		33°03′28″	21	659.44		122656.21	
14	GP_13	3rd Site (Near Jambhulwadi Lake)	41.53	33.84	0	528.00	35°25′10″	24.07	814.63	1068.33	430122.04	564078.1
13	GP_14		48.92	37.33	104.56		40°16′01″	31.67	1182.27		624240.02	
15	GP_15		54.69	38.06	105.95		45°53′29″	39.16	1490.55		787008.86	
16	GP_16		47.4	45.82	83.77		14°51′32″	12.16	557.16		294179.97	
17	GP_17		50.6	39.49	98.05		38°41′33″	31.63	1249.07		659508.27	

18	GP_18		48.69	39.8	123.07		35º10′ 14″	28.05	1116.31		589409.49	
19	GP_19	4th Site New Katraj Tunnel(Left)	43.94	28.5	0	815.00	49º33′ 39″	33.44	953.04	978.05	776727.60	797109.7
20	GP_20		53.01	29.68	178.78		55°56′ 59″	36.07	1070.56		872504.44	
21	GP_21		49.6	30.59	69.3		51º55′ 54″	39.05	1194.34		973390.56	
22	GP_22		44.98	30.56	191.51		47°12′ 42″	33.01	1008.65		822052.65	
23	GP_23		36.61	27.61	375.41		41°03′ 30″	24.04	663.65		540873.32	
24	GP_24	4th Site New Katraj Tunnel(Right)	31.44	27.17	0	214.00	30º13′ 34″	15.83	430.07	516.91	92034.86	110617.99
25	GP_25		33.13	24.3	73.85		42º49′ 03″	22.52	547.19		117098.87	
26	GP_26		33.87	24.26	120.19		44º15′ 44″	23.64	573.46		122720.25	

(Data collected from field survey)

Height and Volume Calculation for hill slope cutting



Where,
a = Base distance. b = Top distance.
h = Perpendicular to the base distance.
H = Height of the object.

Here, $\cos\theta = a/b$
Therefore $\theta = \cos^{-}(a/b)$

And $h^2 = a^2+b^2-2ab.\cos\theta$
Therefore $h = \sqrt{(a^2+b^2-2ab.\cos\theta)}$

Calculation for Area (A) = ½ * Base distance (a) * Height of the object (H) sq unit
Calculation for Volume (V) = Area (A) * Total Length (TL) cubic unit

4.2.2 Scrapping of hills for the construction of building

Construction of temples and forts on hilltops is an old practice. The plains were always considered ideal and appropriate for settlement. But as per the population growth and their demand for space settlements started shifting towards the mountains slopes or pediment zones. The slope area are complex is like an escarpment. Hill top houses are growing a craze in the Pune city; people are ignoring the environment point of view and are continuing to stay in such houses. This may be because they might like the proximity to nature and away from the city traffic, but they are unaware of the environmental damage done to the mountains and hill slopes (Fig.).

4.3 Variations in NDVI (1992-2013)

NDVI is a good indicator of the vegetation cover and its density in an area. NDVI calculation was done in ERDAS imagine by running the indices option. NDVI uses the combination of band 3 (0.63-0.69 µm) *i.e.* Red band and band 4 (0.76-0.90 µm) *i.e.* Near Infrared band for Landsat TM image. NDVI is representative of plant assimilation condition and its photosynthetic apparatus capacity and biomass concentration (Groten, 1993).

Wagholi Site

The NDVI Image of 1992 (Fig. 4.7) shows NDVI values range (-0.6 to 0.8) over the Wagholi and some fringe areas near it and areas near the river banks and the North western part of the wagholi site show higher values (0.2 to 0.8). This is because of comparatively dense vegetation in these areas. In these zones, the appearance of buildings, roads and other infra-structural facilities explains the occurrence of low NDVI Value (-0.5-0.6) in 2013 Image. The NDVI values tend to decrease as one goes towards south east or quarry areas, it indicates that due to quarry activity, road construction, urbanization, vegetation cover has been decreased.

Alandi Site

NDVI value is -0.63 to 0.81 in the year of 1992 and this value has decreased and the NDVI range in 2013 is -0.59 to 0.6. These kinds of vicissitudes are found in around the quarry site.

The NDVI range has decreased towards the northern part of Alandi site.

Jambhulwadi Site

Out of above three site change in vegetation is higher in Jambhulwadi site which can be attributed to several reasons like, road construction, building construction, different kind of mining activity. All those things are happened randomly day to day by through human interferences.

A striking change in the negative direction can be pointed out by observing the change detection output. The positive change is very less all over the image. The most significant negative change in the NDVI values (-0.5 to -0.8) is found mostly in and around Pune city.

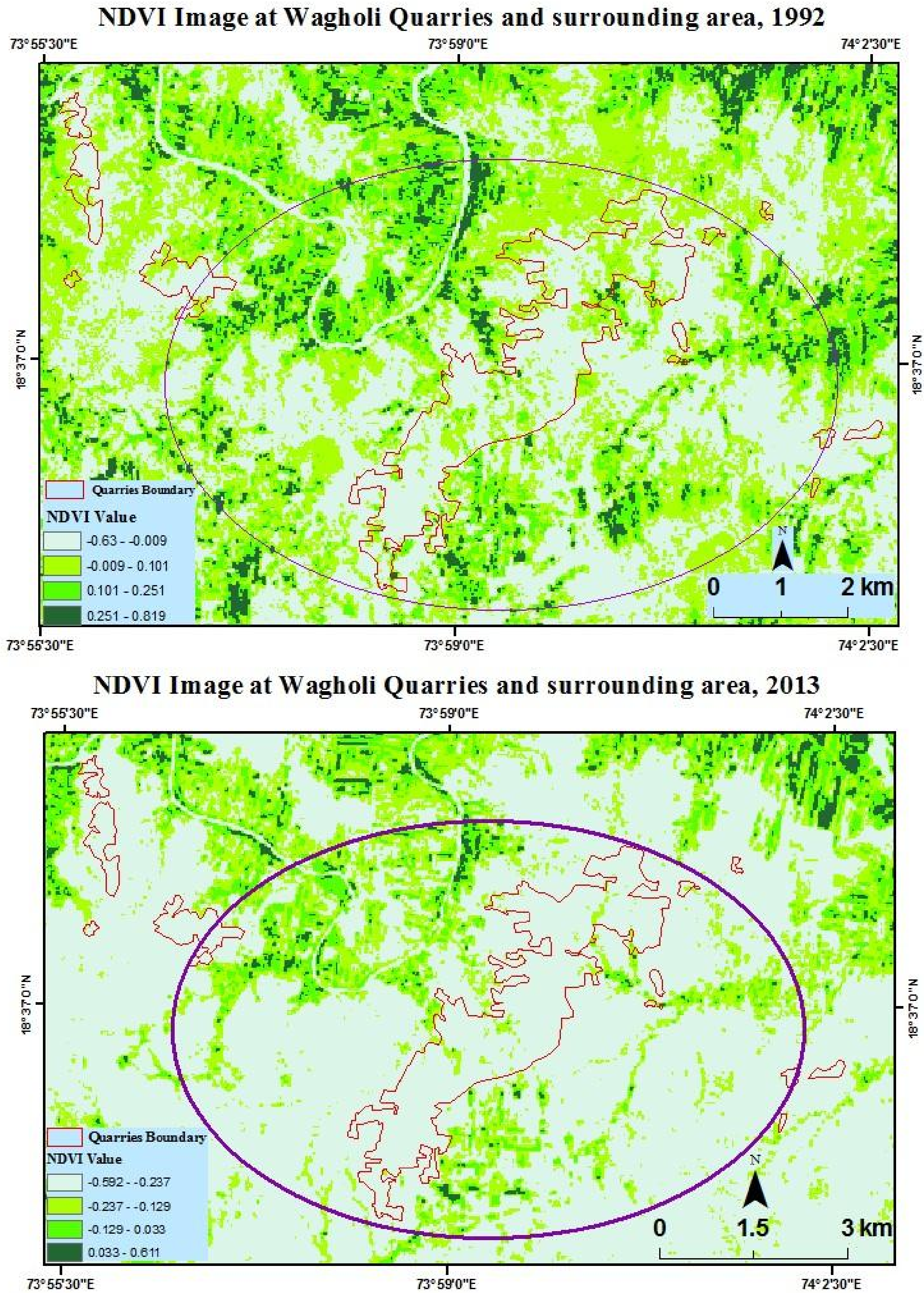


Figure 4.7 NDVI Maps of Wagholi Stone Quarries and Surrounding Area (1992 and 2013)

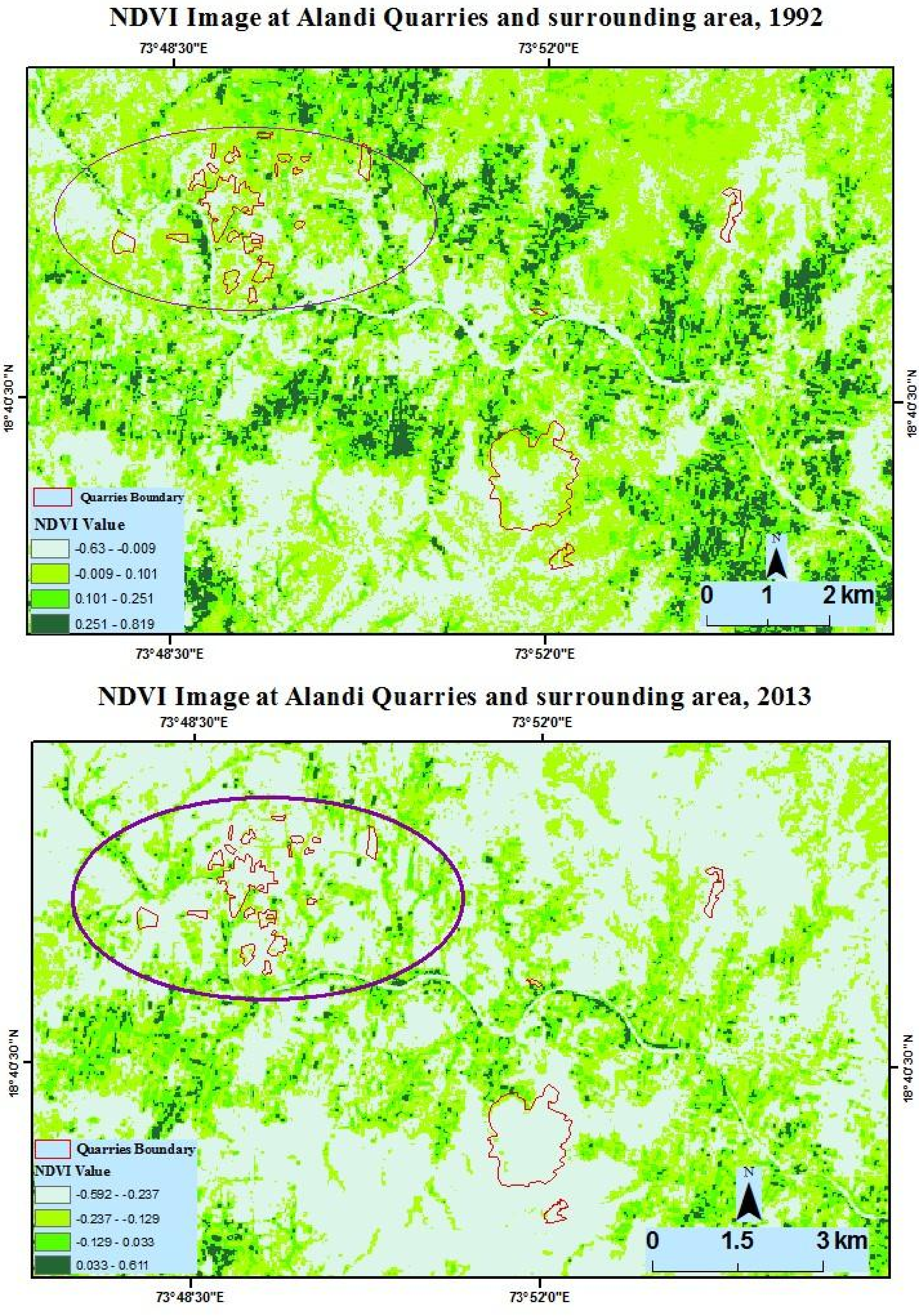


Figure 4.8 NDVI Maps of Alandi Stone Quarries and Surrounding Area (1992 and 2013)

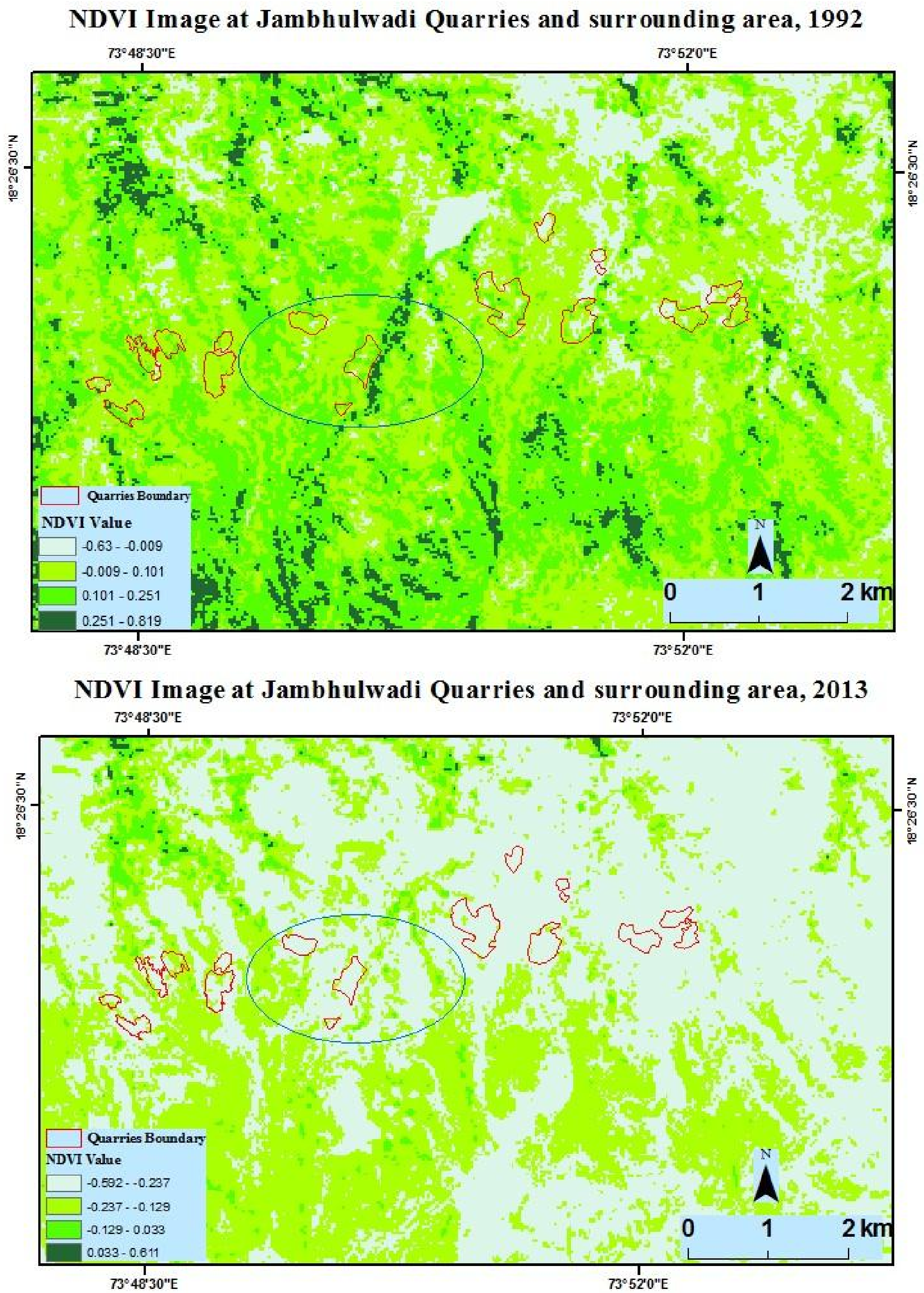


Figure 4.9 NDVI Maps of Jambhulwadi Stone Quarries and Surrounding Area (1992 and 2013)

4.4 Land use and land cover change

The land cover classification images for the year 1992 and 2013 have been prepared and the accuracy assessment is carried out. The calculated overall Classification Accuracy and overall Kappa Statistics is 84.00% and 0.7807 for the year 1992 and 84% and 0.7727 for the year 2013 respectively. The area under each category of classification has been calculated and the results are summarized in the table: 4.4, 4.5, 4.6 and figure: 4.13, 4.14, and 4.15. The most important built-up unit is Pune city. It occupies the central position in the watershed at the confluence of Mula and Mutha rivers. Away from the city, except Pimpri-Chinchwad, no significant suburban area can be pointed out. The built up areas which are away from the city comprise mainly of rural settlements (Dhorde et al, 2012).

Wagholi Site

From 1992 to 2013 the area under agricultural land has declines by 16.06% (20.13 km2) and exposed and Settlements has increased by 5.84% (7.32 km2). The area of water body has gone down by 0.16% (0.21 km2). Therefore, we can say that these changes in land use and land cover may be due to construction of building and roads. Likewise, the decrease in the area under water body is more or less equal to the increased in exposed and built-up area; it clearly illustrates the decrease the volume of water in the lakes. This fluctuation may be due to change in the amount of rainfall received and needs further investigation.

Alandi Site

In Alandi area from 1992 to 2013 the area under agricultural land has reduced by 21.09% (20.03 km2) and exposed and Settlements has increased by 8.74% (9.21 km2). The area of water body has gone down by 0.28% (0.29 km2) (Figure: 4.14 & Table: 4.5).

Jambhulwadi Site

At the Jambhulwadi area the change detection is showing in Table. (Figure: 4.15). From 1992 to 2013 the area under agricultural land has decreased by 40.51% (16.06 km2) and exposed and Settlements area has increased by 3.11% (1.23 km2). The area of water body has gone down by 0.56% (0.22 km2)

Comparison of 1989 and 2008 land use maps reveals that urban growth has occurred mostly in the eastern of Alandi, southern site of Wagholi and south-western directions of Jambhulwadi location around Pune city.

Table No 4.4:- Area under different land use / land cover at Wagholi Site (1992, 2013)

Land Use Pattern	Area (sq. km) 1992 Year	Area (sq. km) 2013 Year	1992 Area in %	2013 Area in %	Net Change (sq Km)
Settlement	1.85	9.17	1.475	7.315	7.32
Agriculture	37.26	17.13	29.727	13.665	-20.13
Water Body	2.92	2.71	2.329	2.161	-0.21
Others	83.31	96.34	66.467	76.85	13.03
Total	125.34	125.34	100	100	40.69

*Total change irrespective of negative or positive change (Source: based on calculations done)

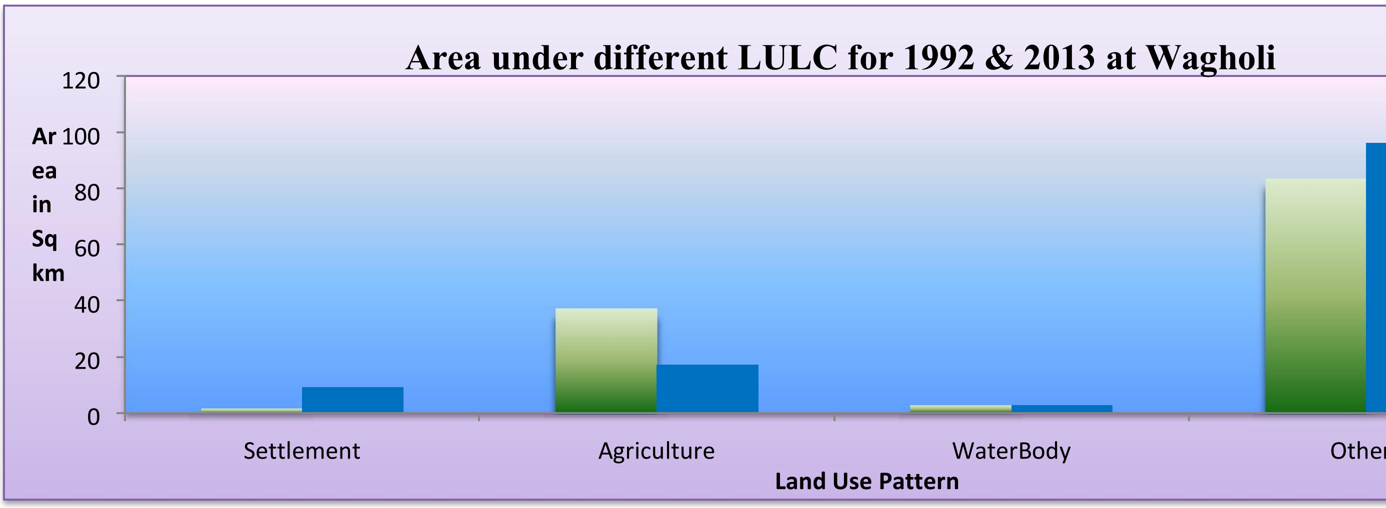


Figure 4.10:- Comparison of areas under different land Use and land cover at wagholi

Table No 4.5:- Area under different land use / land cover at Alandi Site (1992, 2013)

Land Use Pattern	Area (sq. km) 1992	Area (sq. km) 2013	1992_Area in %	2013_Area in %	Net Change (sq. km)
Settlement	4.72	13.93	4.482	13.226	9.21
Agriculture	38.69	17.6	36.739	16.71	-21.09
Waterbody	2.93	2.64	2.782	2.506	-0.29
Others	58.97	71.15	55.996	67.556	12.18
Total	105.31	105.31	100	100	42.77

*Total change irrespective of negative or positive change (Source: based on calculations done)

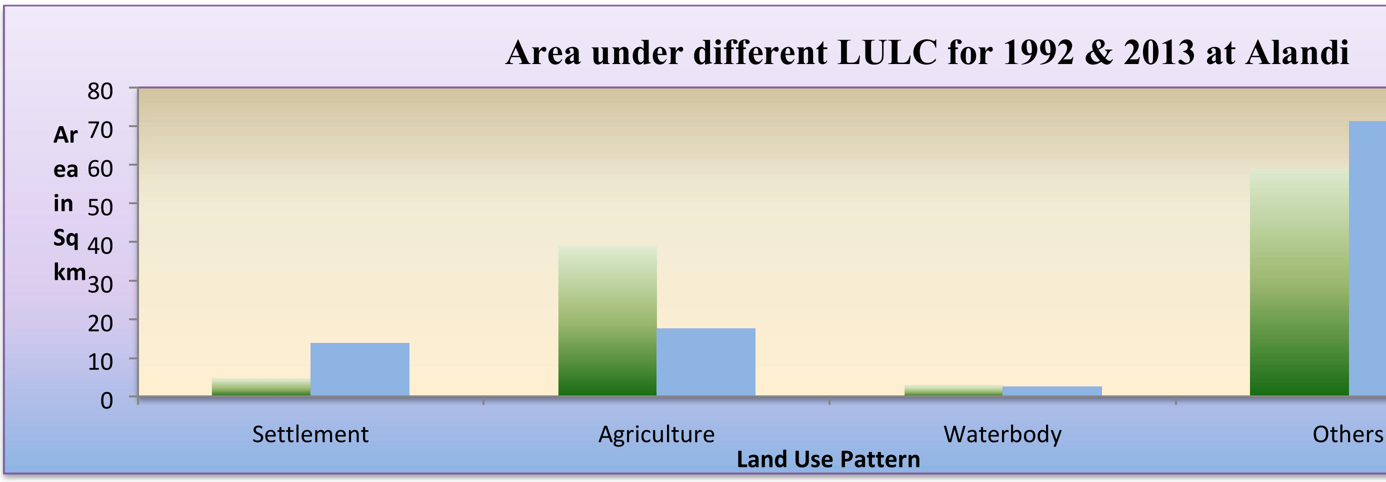


Figure 4.11:- Comparison of areas under different land Use and land cover at Alandi

Table No 4.6:- Area under different land use / land cover at Jambhulwadi Site (1992, 2013)

Land Use Pattern	Area (sq. km)1992	Area (sq. km)2013	1992_Area in %	2013_Area in %	Net Change (sq. km)
Settlement	**2.53**	**3.76**	**6.384**	**9.494**	**1.23**
Agriculture	**21.32**	**5.26**	**53.797**	**13.282**	**-16.06**
Waterbody	**0.27**	**0.05**	**0.681**	**0.126**	**-0.22**
Others	**15.51**	**30.53**	**39.137**	**77.095**	**15.02**
Total	**39.63**	**39.6**	**99.999**	**99.997**	**32.53**

*Total change irrespective of negative or positive change (Source: based on calculations done)

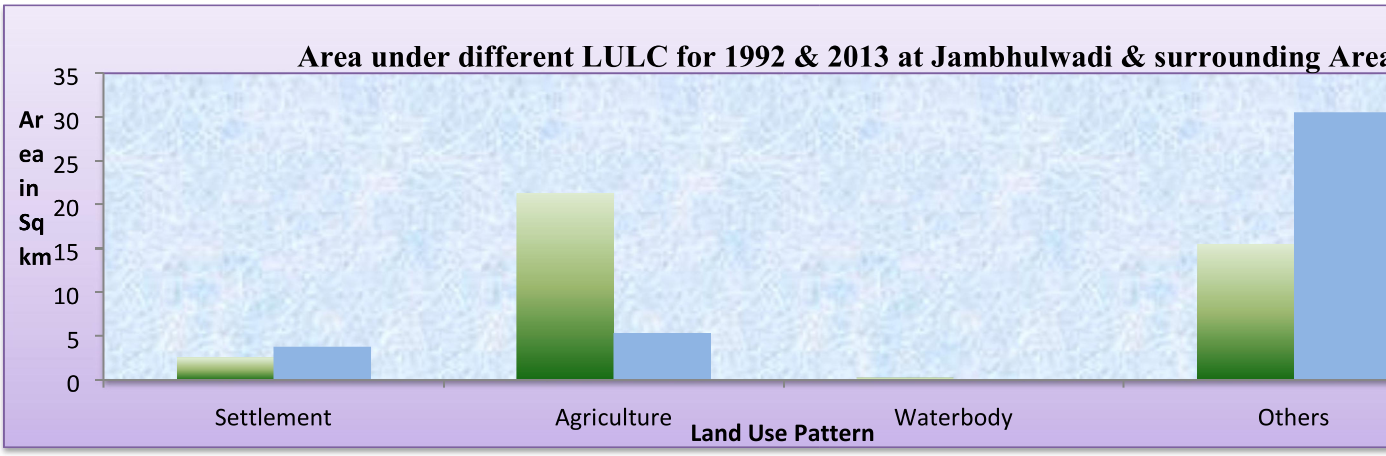


Figure 4.12:- Comparison of areas under different land Use and land Cover at Jambhulwadi

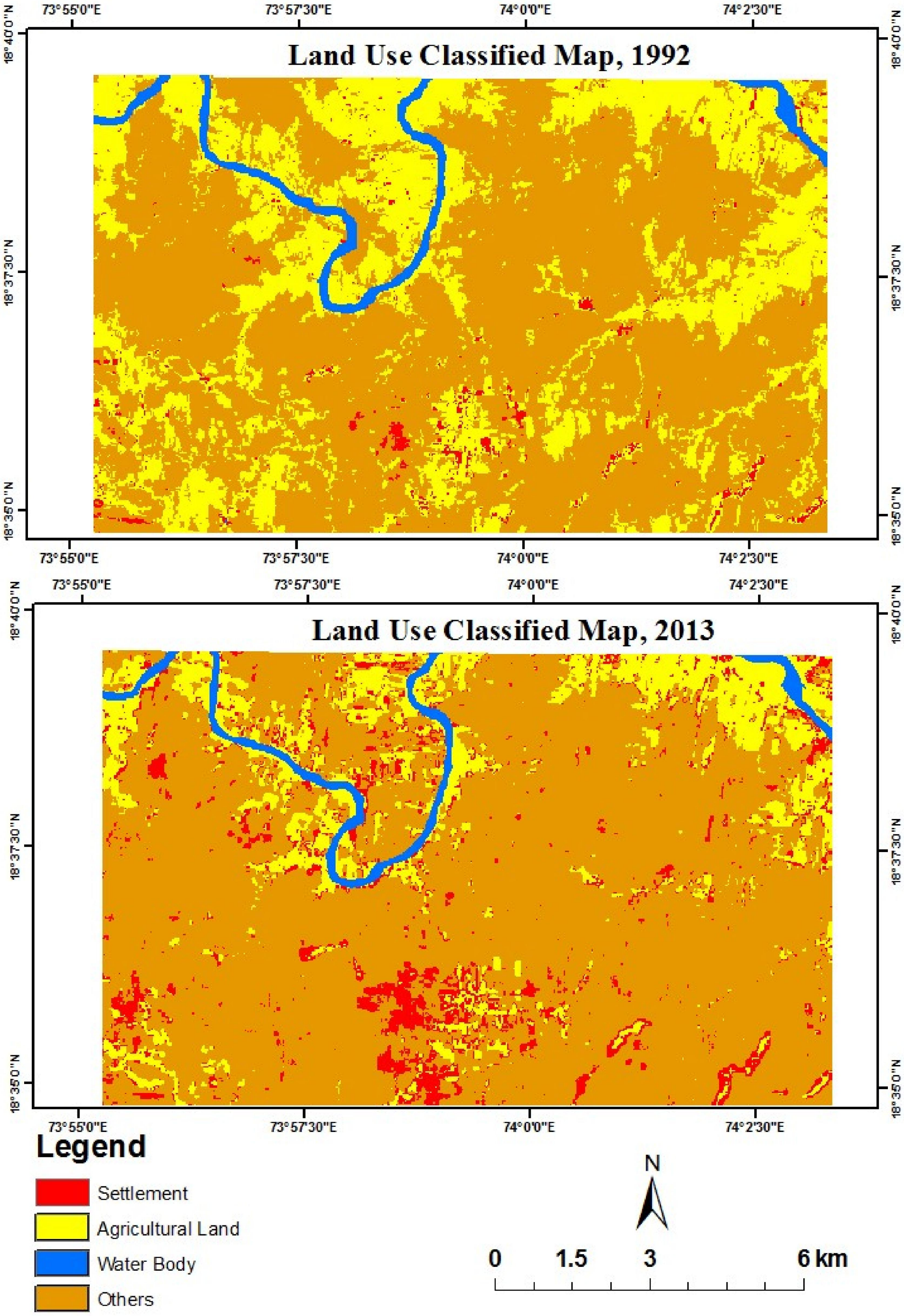


Figure 4.13: LULC map at Wagholi site (1992 and 2013)

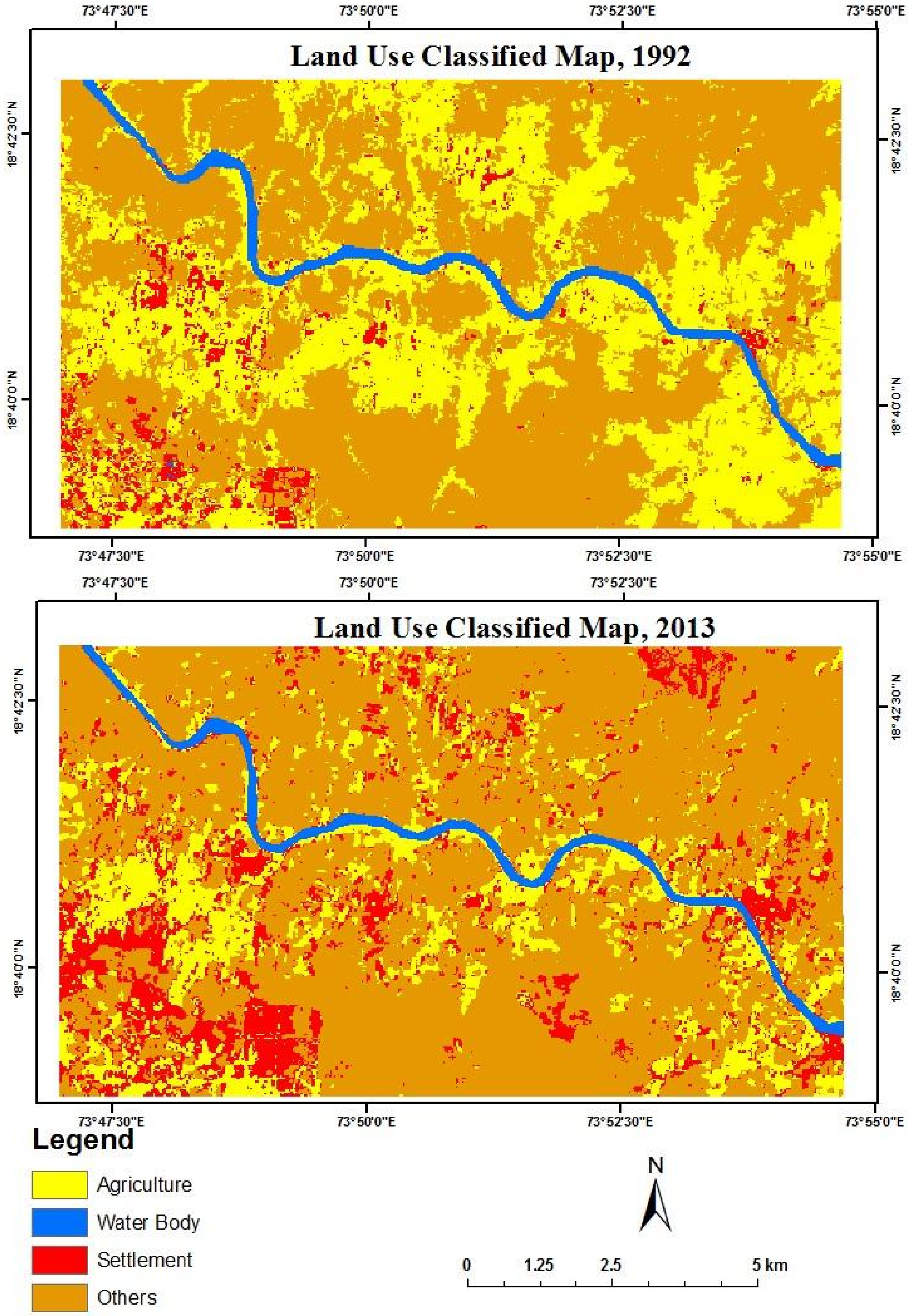


Figure 4.14: LULC map at Alandi site (1992 and 2013)

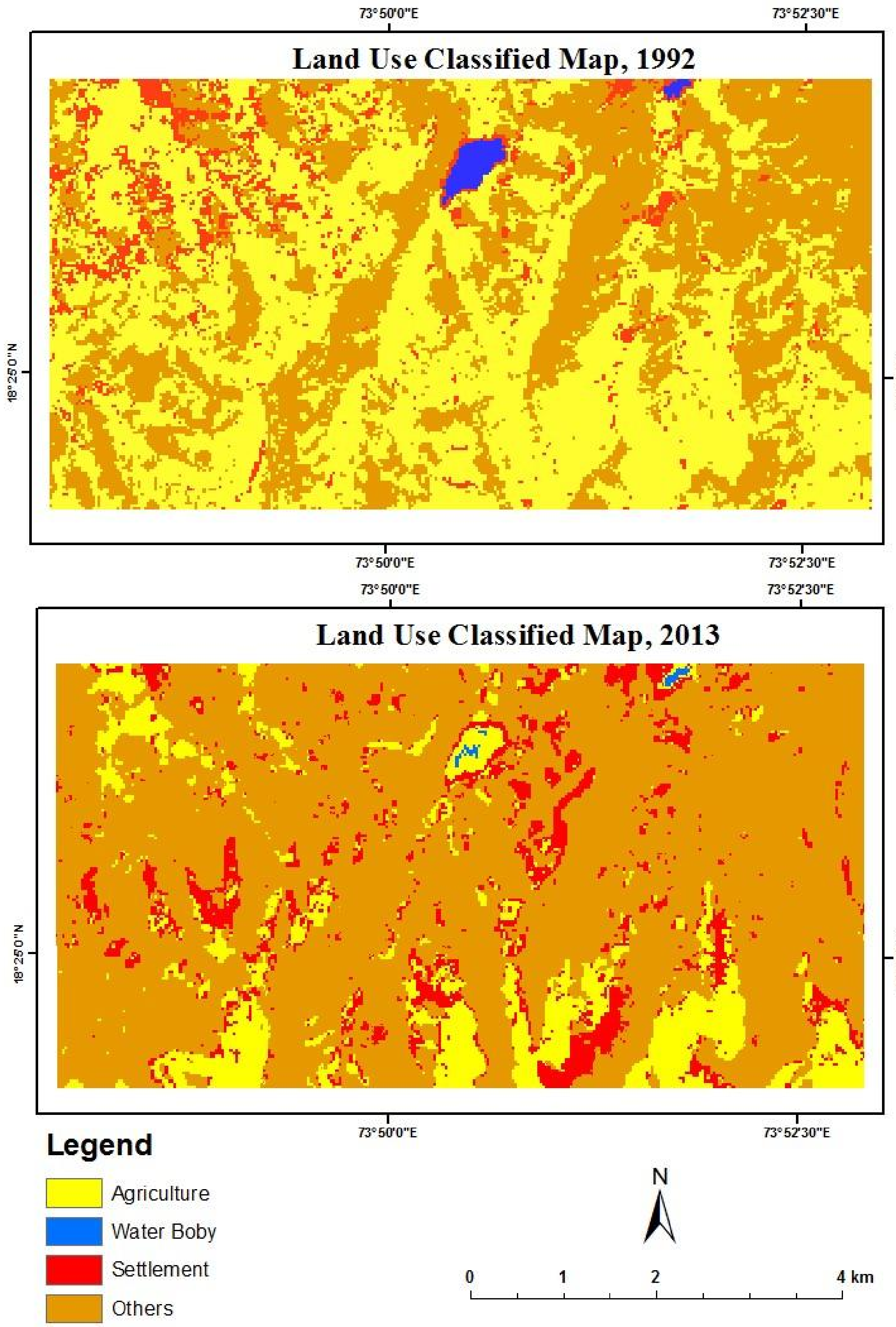


Figure 4.15 LULC map at Jambhulwadi (1992 and 2013)

4.5 Slope Map

The slope is considered as a single most important parameter as far as runoff is considered. The slope was calculated by the relief profile method. The relief map was obtained by creating TIN of the study area with the help of ArcGIS 9.3 Package. From the slope map (Fig.4.16), it can be seen that the study area under four classes of slopes i.e. 0.1 to 5%, 5to 10%, 10 to 20% and >20%. This map is showing that the most of the area is having slope more than 10%. From this map we can find that most of the stone quarries and construction is done over the steep slope category i.e. 10 to 20% and >20%.

4.6 Feasibility Analysis

It is the process of setting up any activity which is preceded by the decision to choose a particular site considering all the related aspect of the site. The aspect must stand the scrutiny from techno-economic, financial and legal perspectives. For feasibility analysis, water quality was taken as one important parameter for aquaculture.

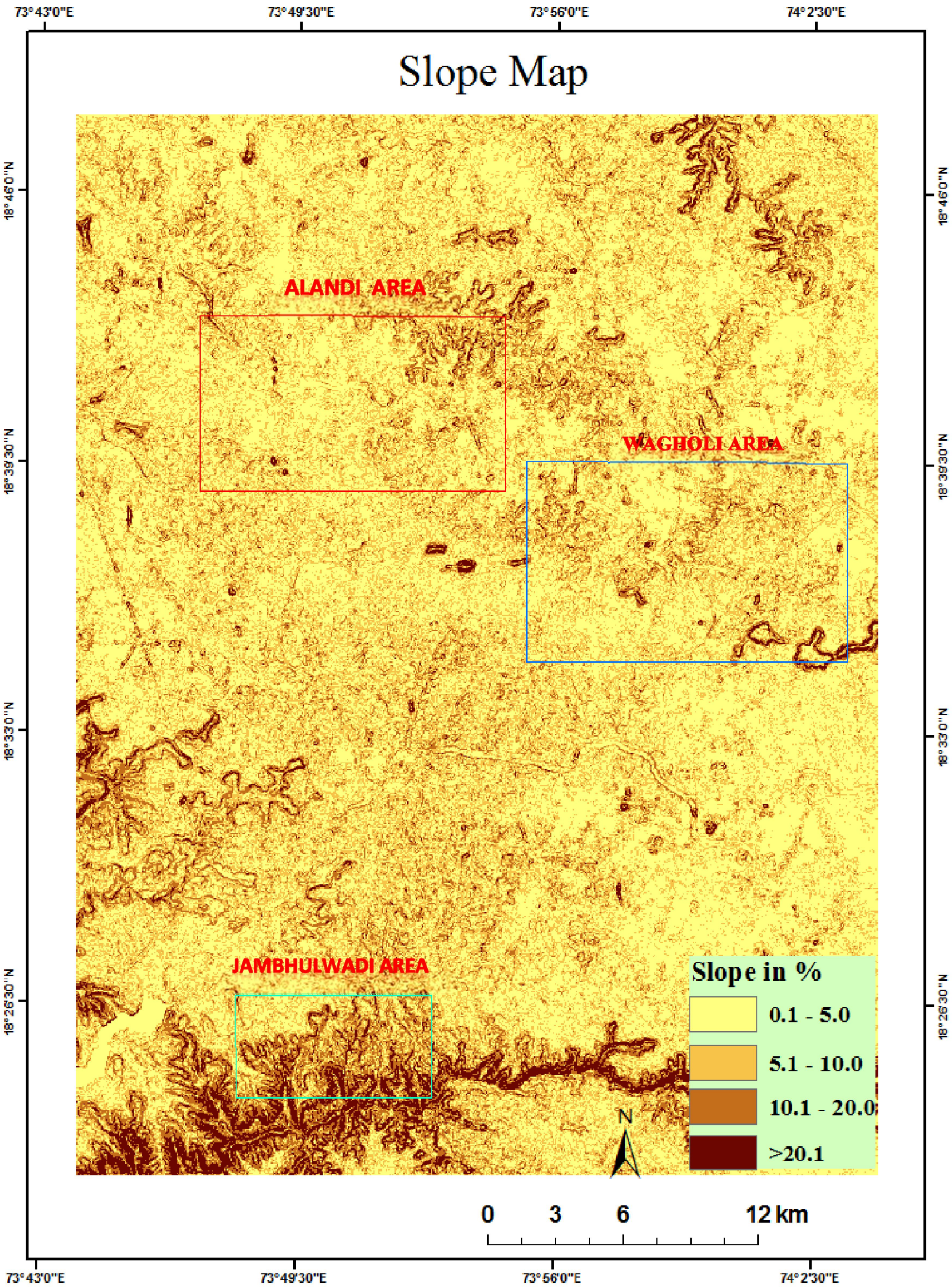


Figure 4.16 : Slope map of study area (based on ASTER image)

4.6.1 Water Quality Assessment

Water is an vital compound that covers approximately 75% of the earth's surface, existing in all the three states as ice, liquid and steam. Water is used in many ways from drinking to industrial and agricultural purposes (Ross, 1972). The impairment of water quality due to the introduction of pollutants is a problem of industrial cities around the world. The uncontrolled releases of waste effluents to large water bodies have negatively affected both water quality and aquatic life (Walters, 2006).

Water quality determines the 'goodness' of water for particular purposes. Water quality tests will give information about the health of the waterway. By testing water over a period of time, the changes in the quality of the water in stone quarry can be seen. Parameters that may be tested include Temperature, pH, Salinity, TDS and Conductivity (Table No.4.7). An assessment of the aquatic macro invertebrates can also provide an indication of water quality for aquaculture.

Table No 4.7:- Analysis of Water Quality of Wagholi, Alandi and Jambhulwadi Stone Quarries:

SL No.	Sample Code	Location	Temperature In °C	pH	TDS in ppt	Conductivity in □S /cm	Salinity in ppt (1 ppt = 1000 mg/L)
1.	GPSP_1	Wagholi	27.8	7.28	0.555	1.108	000.2
2.	GPSP_2		28.2	9.32	0.437	0.893	000.04
3.	GPSP_3		28.3	7.67	0.973	1.928	000.9
4.	GPSP_4		28.3	7.91	1.671	3.31	001.8
5.	GPSP_5		28.5	7.96	0.456	0.919	000.1
6.	GPSP_6	Jambhulwadi	28.2	8.16	0.362	0.729	000.1
7.	GPSP_7		28.3	8.17	0.297	0.595	000.2
8.	GPSP_8		28.2	7.98	0.331	0.611	000.1
9.	GPSP_9	Alandi	28.3	8.11	0.311	0.598	000.05
10.	GPSP_10		28.2	8.15	0.315	0.607	000.1

Total 10 water samples have been collected from Wagholi, Alandi, Jambhulwadi stone quarry area, Pune was analysis. The desirable temperature ranges necessary for potable water. This parameter is essential for the occurring rate of reaction of water. In our study the temperature range was obtain from 27-29°C as the sample code GPSP_1 is minimum and GPSP_5 is maximum value respectively. This temperature is two times higher than the normal temperature.

The desirable pH range necessary from drinking water is from 6.5 to 8.5 (WHO, 2004). In our investigation the pH value of stone quarries water obtains from 7.28 to 9.32, it indicates that the nature of water is from slightly basic nature to strongly basic. The high amount of pH value is observed the sample code GPSP_2 in Wagholi area; The reason may be the local people wash their cloth and other things; this washing powder contain high quantity of OH- and HCO3-

Total dissolved solid (TDS) is a measure of the combined contact of all inorganic and organic contained in a liquid in molecular ionized or micro granular suspended from. The permissible limit of TDS in drinking water is 500 mg/l (WHO, 2004). The observation showing at the stone quarries TDS range from 300-1700mg/l. sample GPSP_4 TDS is high its indicate that the wagholi area amount of dissolved particle is very high than other study area.

The specific conductivity of water sample under study varies between 80-400□mho/cm the maximum permissible limit of this parameter for drinking water is 300□mho/cm, however the average specific conductivity exceed this limit because of its high values during rainy season. In rainy season due to floods and rain water level is well increases which contains more electrolytes.

On the other hand Salinity is directly related to the electrical conductivity and TDS. The value depending upon the presence of chlorite and sodium iron. In our case this parameter was measured by the digital analyzer kit the value was obtain in 50-1800mg/l. In our research highest salinity value is observed in GPSP_4 and lowest value in GPSP_1.

4.6.2 Water Quality for Aquaculture Development

Water Quality Guidelines for Aquacultures essentially a user needs specification of the quality of water required for the extensive or intensive production of fresh water fish. It is intended to provide the information required to make judgments as to the fitness of fresh water to be used for fish farming.

Temperature

Temperature tolerances of fish are broadly categorized into cold water, warm water. For each species, there is a minimum and maximum tolerance limit, as well as an optimal temperature range for growth. This optimal temperature range, also known as the standard environmental temperature (SET), may vary with each species, even those within the same temperature tolerance category, and with each development stage of the fish.

Water temperature affects the feeding pattern and growth of fish. Fish generally experience stress and disease breakout when temperature is chronically near their maximum tolerance or fluctuates suddenly. It is therefore important to acclimatize fish gradually when moving them from one location to another. Warm water holds less dissolved oxygen than cool water. This is a point worth noting, since every 10°C increase in temperature doubles the rate of metabolism, chemical reaction and oxygen consumption in general.

Table No 4.8: Solubility of oxygen (ppm) in water at various water temperatures, *(Source: LaDon Swann, http://aquanic.org)*

Variable		Temperature °C (°F)				
		20.0 °C (68.0 °F)	22.0 °C (71.6 °F)	26.0 °C (78.8 °F)	28.0 °C (82.4 °F)	30.0 °C (86.0 °F)
		Oxygen (ppm)				
Salinity (ppm)	0 ppm	9.2 ppm	8.8 ppm	8.2 ppm	7.9 ppm	7.6 ppm
	5,000 ppm	8.7 ppm	8.4 ppm	7.8 ppm	7.5 ppm	7.3 ppm
	10,000 ppm	8.3 ppm	8.0 ppm	7.4 ppm	7.1 ppm	6.9 ppm
Altitude (ft)	0 ft (sea level)	9.2 ppm	8.8 ppm	8.2 ppm	7.9 ppm	7.6 ppm
	1,000 ft	8.8 ppm	8.5 ppm	7.9 ppm	7.6 ppm	7.4 ppm
	2,000 ft	78.5 ppm	8.2 ppm	7.6 ppm	7.3 ppm	7.1 ppm

pH

Measurement of pH is fundamental when assessing a potential water supply for fish, or when evaluating fish health problems as the effect of pH is often manifested through the likelihood or severity of other water quality problems. The most important interaction of pH is that with alkalinity. The normal range of aquaculture is normally 6-8 (U.S Agriculture and cooperative Extension Services of Illinois and Indiana, 1993).

4.7 Geomorphic and Environmental Impacts

Rock quarrying and stone crushing is a global phenomenon, and has been the cause of concern everywhere in the world, including the first world countries. Quarrying activity is a necessity that provides much of the materials used in traditional hard flooring, such as granite, limestone, marble, sandstone, slate and even just clay to make ceramic tiles. However, like many other man-made activities (anthropogenic factors), quarrying activities cause significant impact on the environment (Lubcheco, 1998). In particular, it is often necessary to blast rocks with explosives in order to extract material for processing but this method of extraction gives rise to noise pollution, air pollution, damage to biodiversity and habitat destruction. Dust from quarry sites is a major source of air pollution, although the severity will depend on factors like the local microclimate conditions, the concentration of dust particles in the ambient air, the size of the dust particles and their chemistry, for example limestone quarries produce highly alkaline (and reactive) dusts, whereas coal mines produce acidic dust. The air pollution is not only a nuisance (in terms of deposition on surfaces) and possible effects on health, in particular for those with respiratory problems but dust can also have physical effects on the adjacent plants, such as blocking anddamaging their internal structures and abrasion of leaves and cuticles, as well as chemical effects which may affect long-term survival (Lubcheco, 1998). Air pollution generally and especially dust from quarry sites are known to be responsible for vegetation injury and crop yield loss and thus become a threat to the survival of plants in industrial areas (Iqbal and Shafig, 2001). Such dusts reduce plant cover, height and number of leaves. Apart from the dust emitted, toxic compounds such as fluoride, Magnesium, Lead, Zinc, Copper, Beryllium, Sulphuric acid and Hydrochloric acid are injurious to the vegetation.

Construction of the roads alter the morphology of the hill slope by cutting hills on one hand and through dumping the excavated loose material on down slope on the other hand. Cutting of the hills and quarry activities makes the slope steeper and more prone to erosion and is also a cause of deforestation. The excavated material again becomes a problem for the environment.

On the basis of the maps prepared, it is found that most of the study area falls under the category of steeper slopes. These steep slopes are more vulnerable to erosion processes and loss of material. This will lead to risk of failure of slope in the form of landslide. Such evidences are mentioned through photographs captured from Jambhulwadi area (figure: 5.5). This may further lead to problem of damaging vegetation and structures. Some precautionary measures are already taken by the private developers which are highly local and can minimize the risk only at those sites.

There is another way of operation for indirect human impacts. The activity or the resulting landforms do not induce new processes but only modify the extent and rate of already operating processes together with their consequences. Since no new process occurs here, the impact is not qualitative but quantitative on the natural evolution of an area. A good demonstration is erosion by surface runoff. It is well known that forest clearance usually upsurges runoff and causes floods along rivers. In addition, in the upper section of the catchment valley, incision may accelerate, while increased sediment load of rivers arriving onto the plain enhances the intensity of accumulation there. A change on a more modest scale – although occasionally rather spectacular and rapid – can be, for instance, mine water extracted from depth during mine operation and conducted into surface water-courses. The additional discharge accelerates incision; terraces may take shape overnight, while in other places increased accumulation alters the morphology of the environs of the watercourse, thereby causing a transformation also affecting human society. In addition to the above rapid geomorphological hazards, more gradual geomorphic processes under human impact are also significant in environmental management.

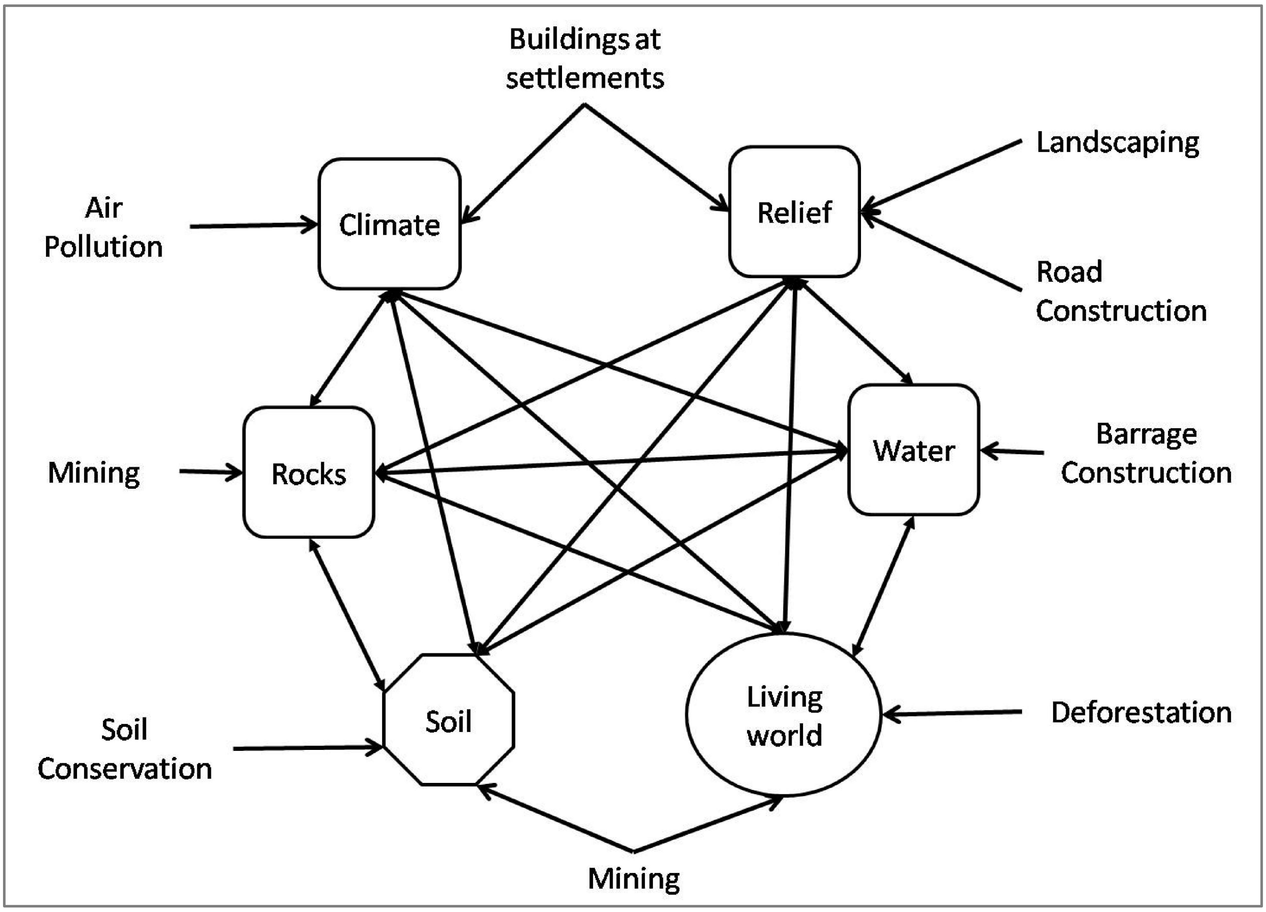


Figure 4.17 Impact points of the geographical system and anthropogenic activities (after. Echeverría 2012)

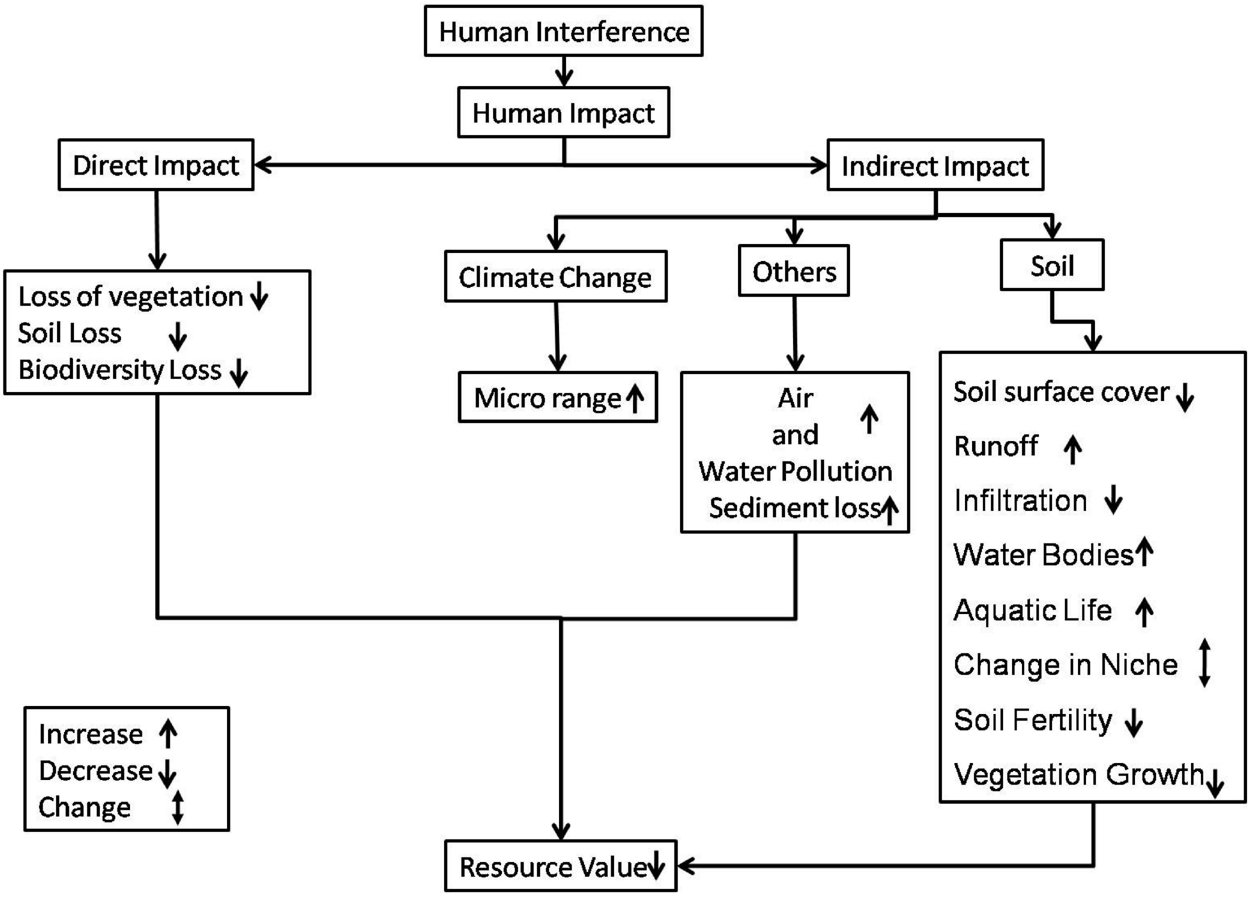


Figure 4.18:- Model of ecological and physical changes by human interference (Modified from Carter, 1988)

CHAPTER V

CONCLUSION AND SUGGESTIONS

Chapter-V

CONCLUSION AND SUGGESTIONS

5.1 Conclusion

Based on the results of this study the following conclusions have been drawn:

- There is a rapid increase in the number of man-made landforms around Pune city.
- The study of these man-made landforms is going to be increasingly important is the resource planning & development.
- Quarries, scraping of hills and cutting of hills are some ideal example of purely manmade landforms these create more destruction than construction in the nature.
- The study undertaken has helped to understand changes in the land use land cover pattern. One of the major change identified that the land use is agriculture land to built up area. If we consider the images of 1992 and 2013 it clearly identified the changes. An advent of new technologies in constructional (engineering) activities, natural features (like hills, rivers, forests, etc.) do not pose any kind of barrier for developmental work.
- It can be inferred from the NDVI images obtained for 1992 and 2013 that there are some clear variations in the amount of area covered by different NDVI value classes. For identifying the areas where the change is observed and the magnitude of the change in the study area is used and it is formed that the altered areas show decrease in the NDVI values that i.e. decrease in vegetation cover.
- If the current scenario of land acquisition and development goes as it is, the study area will soon face many severe environmental problems, such as increases runoff decrease in vegetation etc. (figure 4.18)

5.2 Suggestions

Rapid urbanization in the Pune city, the pace of development and the exponential growth in population have led to increased pressure on the natural resources, such as land, water and air. Pune being an urban area, rooftop rainwater harvesting has been suggested as one of the measure for harvesting rainwater for artificial recharge of groundwater (Duraiswami R, 2009).

Rainwater harvesting is a practice for collecting and storing runoff from precipitation. It can be suggested that, the abandoned quarries can be used for different purpose. Hill slope quarries can be used to develop artificial ponds, for cultivation of algae and fishing, swimming pools and as dumping ground etc. with any damage (Pardeshi & Pardeshi, 2007). Another one good example is the Lakaki lake in the Model Colony area Shivajinagar lying in the heart of the crowded Pune city (Duraiswami R, 2009). Demand for resources such as constructional material will promote the wasteland creation through human activities. Expansion of settlements in such areas will cause burden on natural resources. Therefore it is also suggested to assess the requirement of natural resources and other resources before and after the development of hill stations in this area. This will help to manage water resources, forest cover and also the human resources.

5.2.1 Control on land development

Government should reform the policy to control the current rate of land acquisition by private developers.

Quarrying Activity:

Quarrying activity is frequently observed in the study area. As the building construction is rapidly increasing in the area, construction material is also demanded on large scale. Stone is quarried and used for construction. It is also observed that quarrying leads to removal of vegetation cover and weathered mantle. This causes loss of vegetation and reduction in ground water recharge capacity of the ground water. Exposed bare rock surface causes increase in surface run off. It also causes increase in surface temperature when it is completely bare and rocky. On a micro scale, the large sites of quarry will act as heat islands. Quarrying of land surface leads to loosing aesthetic values of landscape. Quarrying on large scale in such areas is done at alarming rate. Therefore, it is suggested to avoid quarrying activities on vegetative areas. Afforestation around these quarrying sites should be encouraged so that problem of erosion owing to this activity can be curbed to some extent (Dhar 1997).

Tourism:

In this area eco- tourism should be encouraged. Eco-tourism is a form of tourism that involves visiting natural areas- in the remote wilderness or urban environments. According to the definition and principles of ecotourism established by The International Ecotourism Society (TIES) in 1990, ecotourism is Responsible travel to natural areas that conserves the environment and improves the well-being of local people (TIES, 1990). Honey (2008) expands on the TIES definition by describing the seven characteristics of ecotourism, which are:

- Involves travel to natural destinations.
- Minimizes impact on nature.
- Builds environmental awareness.
- Provides direct financial benefits for conservation of nature.
- Provides financial benefits and empowerment for local people.
- Respects local culture.
- Supports human rights and democratic movements.

Being rich in bio-diversity and natural resources, the study area offers potential sites for the development of eco-tourism. The government, NGOs and local communities should come forward to take action plan in this direction. Tourism activities should definitely be encouraged but not at the cost of environment. Therefore, eco-tourism is the best way out.

5.3 Limitations

- Availability of high resolution data for such study is always beneficial. For the present study high resolution data was not available due to economic and time constrains. This was partially fulfilled using Google images with resolution of 1.65 m. (GeoEye1). For this study Landsat 7 images of 1992 and 2013 were used. As the resolution of the image is 30X30, so most of the time roads (on an average have width less than 5 meters) and the isolated houses and resorts are mixed with the nearest class comprising the larger area, most likely with the class of grass cover and open forest.

- ❖ Availability of Landsat data with minimum cloud cover in the study area is also an important issue while selecting the satellite data from the archives of USGS. It was also tried to maintain the same period or season while selecting satellite data from the archives. Images available in the archives with very close variations in the dates and months for different years were selected.

- ❖ In field visits some inaccessible areas could not be visited. Some of the areas were prohibited areas. While collecting GCP it was not possible to reach up to desired sites because of such limitations. Availability of time for such type of work is also a major constrain.

- ❖ The Brightness Values (BV) of grass and open forest class is coinciding with the class of exposed and built-up area.

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