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Land Cover Changes in the Central Part of Balkh Province, Afghanistan

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Abstract: *The study area is located in the northern part of Afghanistan (Central Part of Balkh Province) and is characterized by an arid and semi-arid climate. By integrated GIS (Geographic Information System) and RS (Remote Sensing) based methodologies, mapping solution was developed to find the changes in land use and land cover. Land use and Land cover change classification were derived from Landsat 5 image (1998 and 2009) with overall accuracy assessment of 83.53 % and 82.51% in 1998 and 2009 respectively.*

The result of the change was determined for the period 1998 to 2009. It was found that bare land increased up to 6.48% (162.088 square kilometer), while water decreased for 0.196% (4.919 square kilometre). In addition, vegetation is found to be decreased at the rate of 16.202 % (405.216 square kilometre), while built up land was increased for 9.918 % (242.418 square kilometer). According to the analysis, the total changes in the study area equal to 32.805% (820. 447sq.km).

In Conclusion, not suitable class presented to 826. 505503sq.km (33.05%), while moderate class was 1010. 95426sq.km (40.42%). There was also high suitable class resulting in 663. 5403365sq.km (26.531%).

Keywords: *Land Use/Land Cover Changes, Remote Sensing, GIS, Accuracy Assessment, Balkh Province.*

1. INTRODUCTION:

In recent years the increase of population and the food deficit in the world forced growers to cultivate in the existing land more and more efficiently and to bring new areas under cultivation which have never been used before. These new areas mainly located in arid and semi-arid regions. Additionally, activities are going on to save the existing land under cultivation and to stop desertification especially in dry regions.

RS supply cost effective multi spectral and multi-temporal data, and transport them into information critical for consideration and monitoring land patterns and processes for building land cover datasets which then be useful to make land use datasets by inferring land use from land cover. On the other hand, GIS technology was known to have the capability in handling, merging, and linking spatial data (in the form of maps) which will be useful and also provides data for change detection and database development. The usege of Satellite-based remote sensor data has been widely used to provide a cost-effective means to develop Land Cover map at local and regional scale. This study also finds a way to identify land cover types by using Landsat TM values of each land cover; and to apply the integration of RS and GIS to produce a land cover maps at two different epochs; and to quantitatively assess the change of land cover from 1998 to 2009.

Remote Sensing can be a reading process by using different sensors for collecting data and analyzed to acquiring information about the object, area or occurrence being investigated(Lillesand and kiefer 1994).

Remote sensing is defined as the science and technology by which the characteristics of objects of interest can identify, measured or analyzed the characteristics without direct contact. Remote sensing is classified to three types with respect to the wavelength region 1.Visible and Reflective infrared 2.Thermal Infrared 3. Microwave Platform is a vehicle to carry sensor. It can be such as satellites aircraft balloon etc. (Japan Association on Remote sensing, 1999)

A sensor is a detector method for receiving a signal or stimulus such as pressure, temperature, motion and light also it responds a distinctive manner. There are two kinds of sensor in the remote sensing passive sensor and active sensor; the most popular sensors that use in remote sensing are camera and the solid state scanner like the CCD (charge coupled device) images. (Japan Association on Remote sensing, 1999)

Sensor is a equipment to use for detecting the electromagnetic radiation reflected form an object, such as cameras or scanner. Platform is a vehicle is used to carry sensor, balloon, aircraft and satellite can be used like platform. At the first time Remote Sensing was used in the United States in 1960 and encompassed photogrammetry, photo-interpretation, photo-geology etc. In 1978 the first earth observation satellite was launched. Nowadays Remote Sensing has usage for different fields.

The objectives of the study is to create land use and land cover change map of central part of Balkh province for two different epochs (1998 and 2009)

Land use systems comprise two elements: land and land use. Land refers to the compounded properties of climate, soil, terrain, flora and fauna (including crops, weeds, diseases, livestock, wildlife and pets land use (notably infrastructure).

Meyer (1995), Land use and land cover are different yet closely linked characteristics of the Earth's surface. The use to which we put land could be crop, agriculture, urban development, logging, and mining among many others. While land cover categories could be cropland, forest, wetland, roads, urban areas among others. The term land cover formerly referred to the category and state of vegetation, such as forest or grass cover but it has broadened in subsequent usage to include other things such as human constitutions, biodiversity, soil type, surface and ground water.

Land use affects land cover and changes in land cover affect land use. A change in either however is not necessarily the product of the other. Changes in land cover by land use do not necessarily involve degradation of the land. Nevertheless, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects water and radiation budgets, biodiversity, trace gas emissions and other course of actions that come together to affect climate and biosphere (Riebsame, Mayer, and Turner, 1994)

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Change detection is a significant process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest. (Singh, 1989)

Fei Yuan 1, Kali E. Sawaya, Brian C. Loeffelholz, Marvin E. Bauer (2005), monitored land cover change and developed a methodology to map by using multi temporal Landsat Thematic Mapper (TM) in the seven portion Twin Cities Metropolitan Area of Minnesota for four years (1986,1991, 1998 and 2002). The average of accuracy assessment for four years is 94% as a result seven-class classification. The change detection map showed that between 1986 and 2002 the amount of urban class increased from 23.7% to 32.8% of the total area, by using post- classification change detection method and; therefore wetland and forest decreased from 69.6 % to 60.5 %. For reducing the errors of classification post- classification process were applied and maximum likelihood classification was used for classifier training. (Fei, Y. et al, 2005).

2. STUDY AREA:

Geographic location

The study was carried out in the central part of Balkh province which is one of the famous provinces of Afghanistan with elevation 376M and coordinates (latitude 36° 42´and longitude 67° 12´).

The study area is located at a distance of 445 Kilometers from Kabul, the capital of Afghanistan and is accessible by road to Kabul that runs from the south to east (Wikipedia, 2006). It covers an area of around 2501.0001 square kilometer.

Boundary and administration

Mazar-i-Sharif City and central part of Balkh province is the most significant region in Afghanistan. the City has been the most aesthetic place of the country there are a lot of sight sing, therefore; yearly a lot of tourists come there.

Boundaries of study area include: North with Shortepa, Dawlat abad and Kaldar distrects , South by Sholgara and Chahar kint distrects, East with Khulm distrect and westh by chimtal and charhar bolak.

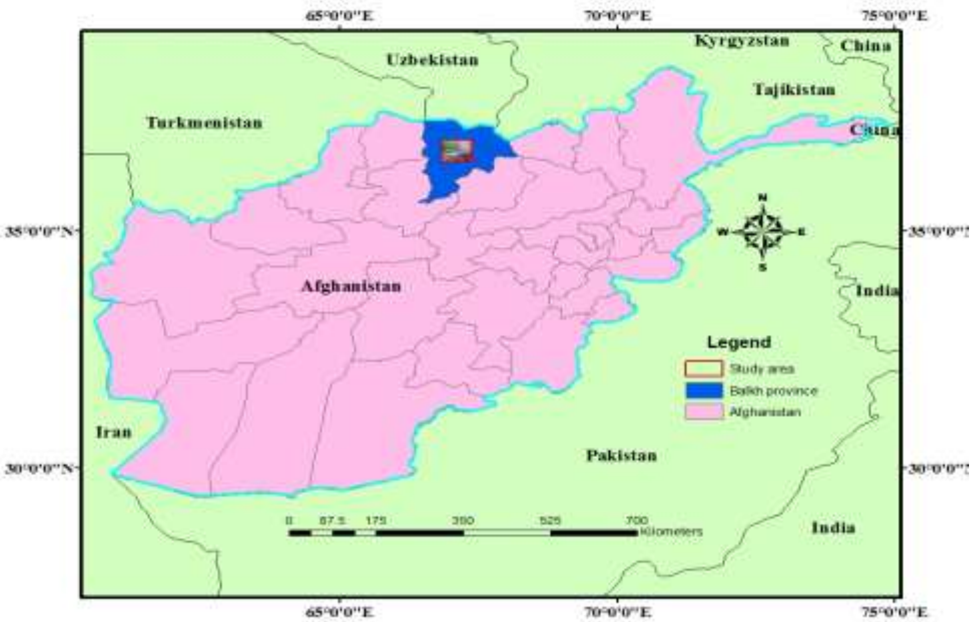

Figure 1. Map showing the study area located in the north of Afghanistan

Climate

Since Afghanistan is a mountainous country it has a continental climate with many local variations. It is arid in the south and southwest and semiarid in most other parts of the country. The high mountain ranges of Hindu Kush and Pamir where covered by permanent snow and glaciers at altitudes above 5,000m are moderate humid. (ADB, 2009).

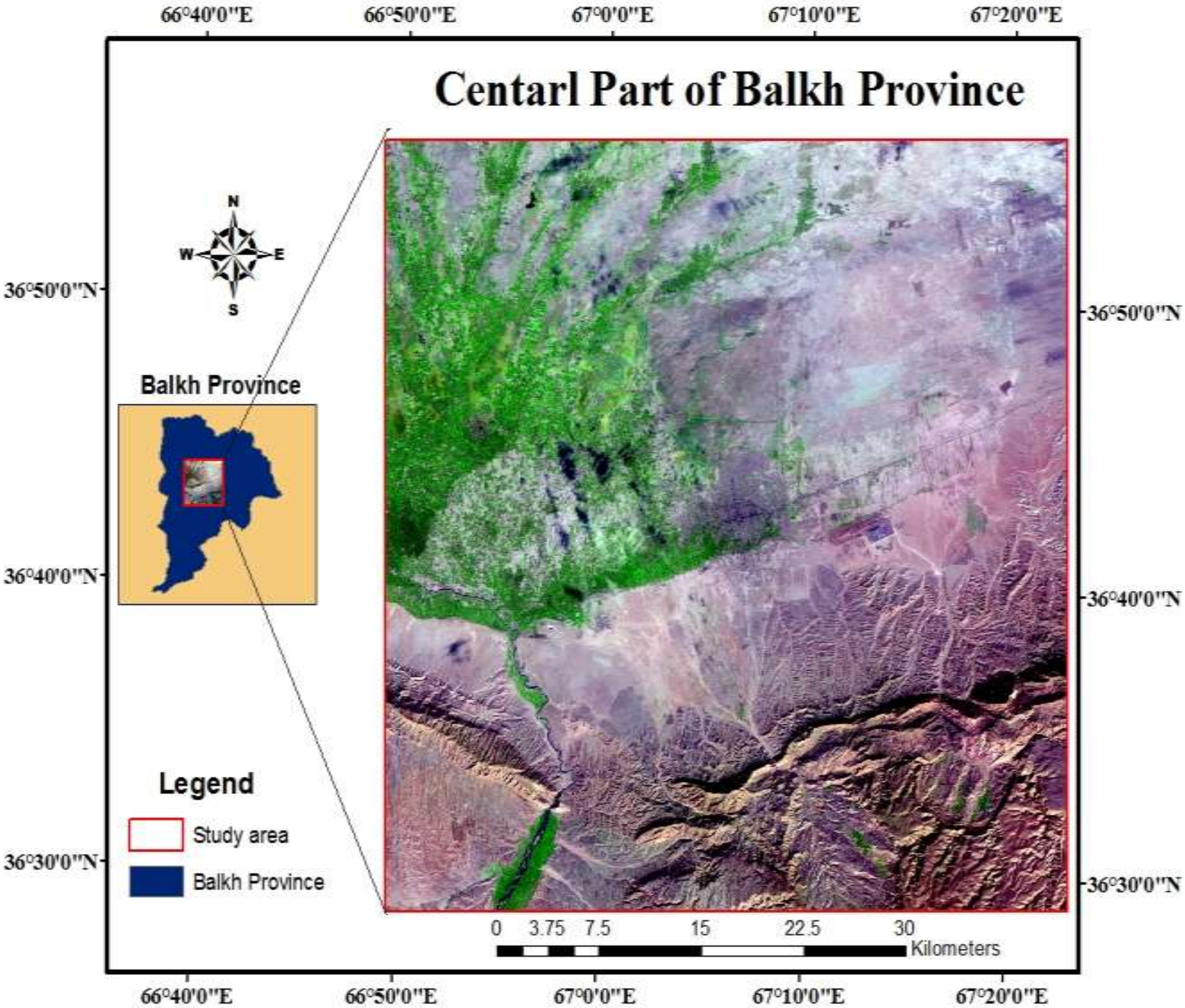

Figure 2. Map of study area

Central part of Balkh province experiences four seasons throughout the year: rainy, hot, hotter and cool. From January to March Mazar i Sharif City and central part of Balkh province has cool weather the temperature range is 10 to 28°C. However, temperature can sometimes dip down to freezing point at night. It is during April to Jun that temperature of study area increase from 28 to 38°C. On July the study area has the highest temperature include 40 sometimes 45° after that the temperature decrease from 38 to 35° during August to September. The study area has mild sunny weather with decreasing temperature ringing between 30 to 10 from October to December. The histogram of the below shows the temperature for four seasons in the year.

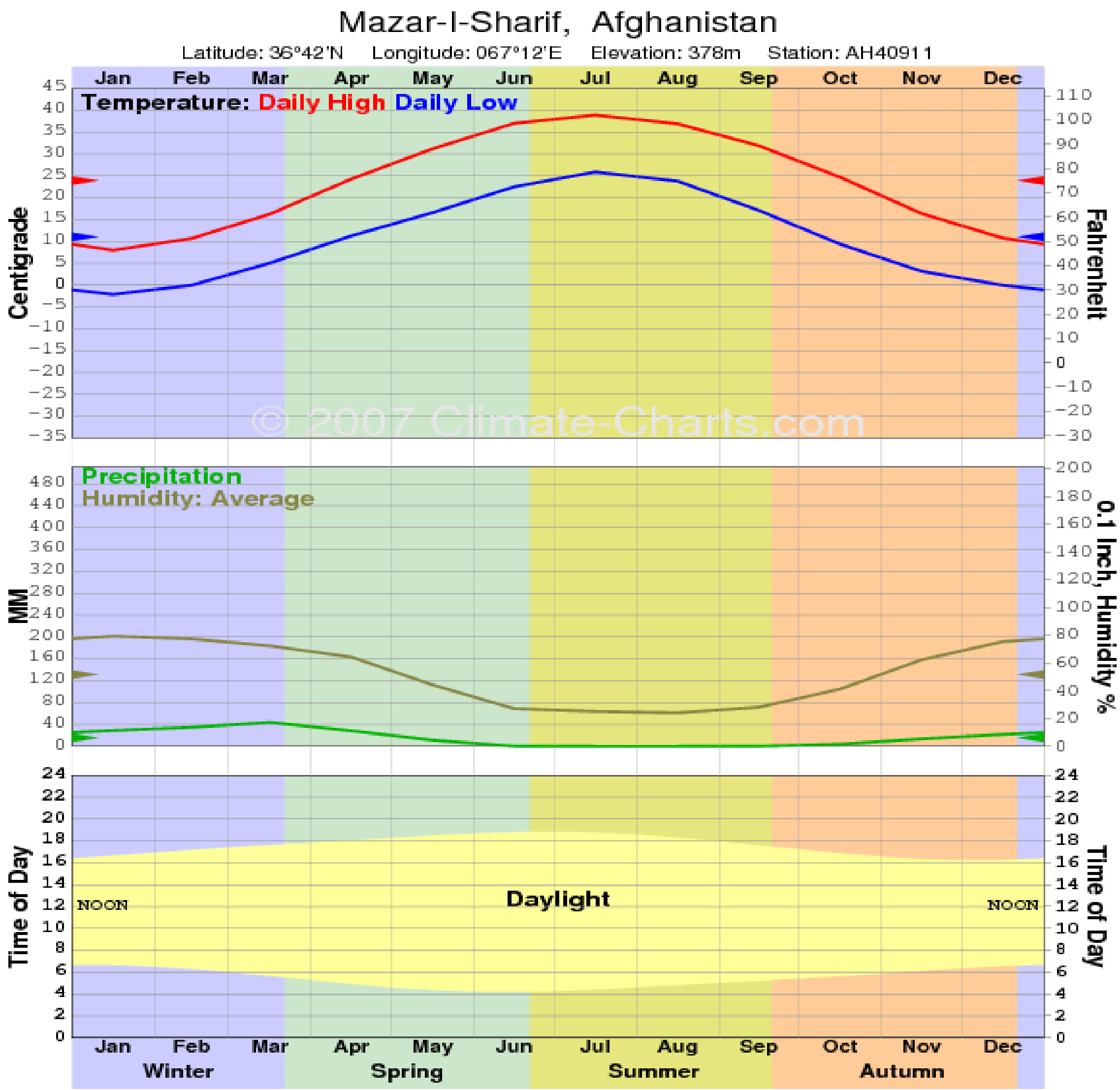

Figure 3. Climate of central part of Balkh province on 2007

Available on: http://www.climate-charts.com/Locations/a/AH40911.php

3. Materials and Methods:

Data used in this study

The first step of this study is to map the latest land use and land cover by classification of Landsat imagery with 30 m resolution, followed by accuracy assessment. Map projection was (UTM) projection, zone 42 datum WGS-84. Five factors are considered in each analysis.

Primary and secondary information

Information of the satellite data and Thematic Maps are given in the tables below.

Table 1. Description of satellite data and Thematic Maps

Satellite Data / GIS Data	Data and Time	Source
Landsat 5	31 July1998: 05:44:25 (UTC) 1 October2009: 05:56:02 (UTC)	http://glovis.usgs.gov
Aster		http://www.gdem.aster.ersdac.or.jp
Administrative map of study area		Afghanistan International Management Service (AIMS)

Software and equipment

- ERDAS 9.3
- ARCGIS 9.3

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Equipment

- Digital camera
- GPS

General Explanation of Methodology

The objective of study was to observed the land cover change. The image preprocessing, image enhancement was preformed after which the study area was divided into subsets. The geometric correction and radiometric rectification has been tested. The overall methodology of the study is given in the flowchart.

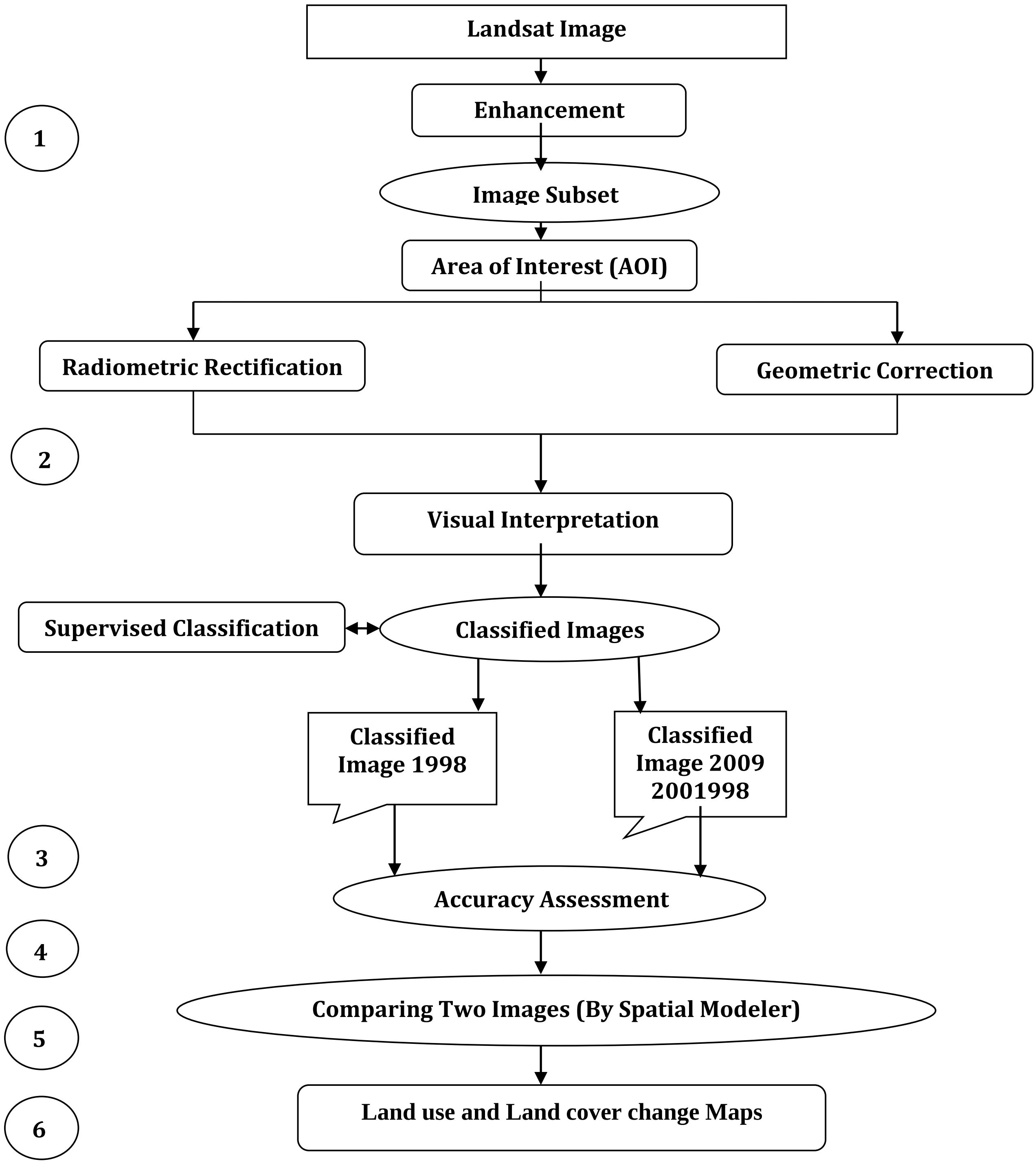

Figure 4. Framework of methodology (land use and land cover change)

Processing

This research was focused to use Remote Sensing data processing (classification land use and land cover change detection.

Remote sensing data processing

For the study, Landsat satellite images of Mazar I Sharif city and central part of Blakh Province were used which were acquired in 1998 and 2009 respectively. Ground truth points for image classification and accuracy assessment were collected from the four land cover types (bare land, water, vegetation and building) using GPS. Image classification was done using pixel based supervised image classification with Maximum Likelihood Classification algorithm. Accuracy assessment was carried out using error matrix and kappa statistics. The error matrix is a strong tool in that it indicates the nature of the classification error.

Image processing

Image processing and analysis were done in six stages namely, 1) Image enhancement, 2) pre- processing, 3) classification of Landsat images (supervised Classification), 4) post processing, 5) comparing classified images (1998 and 2009) to identify changes in land use and land cover and 6) Data Format Conversion. Satellite image was processed and analyzed in ERDAS (Earth Resource Data Analysis System) IMAGINE versions 9.3 for classifying land cover of the area. The methodology of image processing is shown in figure 4.

Image Subset

The original images of Central Part of Balkh Province (1998 and 2009) were taken from Landsat 5 satellite, the first satellite image did not consist the whole study area. Two Landsat images were integrated to produce a mosaic by using ERDAS IMAGINE 9.3 software The mosaic covers larger area than the study area; therefore, to extract the area of study, subset method in ARC GIS 9.3 was used.

Ground Truth

In order to link satellite data and the real feature on the ground, ground truth verification is very important in remote sensing. It also allows the standardization of remotely data for interpretation and analysis. Ground truths include ground checking and survey, stage surface explanation also dimensions of various properties of the feature of the ground resolution cells, that contained with the remote sensing digital data. In addition, ground truth needs to be collected to compare with ground resolution cells, it has been done by using geographic position system technology and evaluating those with the coordinates of the pixel being to understand and analyze the location errors and how it may have an effect on a particular study.

Supervised classification needs ground truth verification in the initial stage of classification of an image. However, the characteristics and position of land use and land cover types are known through a blend of field work, maps and personal experience.

Training Area Selection

Area of interest (AOI) in ERDAS IMAGINE software was selected according to ground truth, so the four land cover classes type from the sampling area were conducted as follows: bare land, water, vegetation and building.

Supervised Classification

Supervised classification uses information derived from a few known areas to classify the image. Several methods are provided in the ERDAS IMAGINE system for supervised classification by each specific algorithm technique. The classification result is shown in groups of different meaning on feature types. The training area is necessary for this type of classification because these classifications are classified according to the homogeneous characteristic of the training area selected. The ERDAS IMAGINE system provides training area selection by using Area of Interest (AOI) menu.

Change Detection Method

Change or alteration in the surface components (land cover) of a landscape can be said to have occurred when it can be demonstrated that a land surface has a different appearance when viewed on at least two successive occasions. In related to remotely sensed data, a measure of the change that has occurred can be obtained by comparing the brightness values for each pixel location in a scene with that corresponding value acquired for the same area but on a different.

A review of the remote sensing and GIS literature reveals that there are many and varied approaches to change detection analysis. For change detection using remote sensor satellite data, change detection method should be based on a sensor system that:

- Has a systematic period between over flights.

- Records imagery of the same geographic area at the same time of a day to minimize diurnal sun angle effects.
- Maintains the same scale and look-angle geometry.
- Reduces relief displacement as much as possible.
- Records reflected radiant flux in consistent and useful spectral regions.

If these conditions are satisfied, it may be possible to analyze the spatial, spectral, and temporal characteristics of the remote sensor data to obtain land use change statistics and produce a land use change map. For change detection method in the integration of remote sensing and GIS, techniques of the integration of land cover information with supplement data and automation of the detection process employing and expert-system approach has been studied by Wieslaw Z. Michalak (1993)

Producing Land Cover Change Map

Only the supervised images were used here in producing land cover change map. For straight forward area calculation, the pixel count (in the raster attributes) for each category of classified image (bare land, water, vegetation and building) was multiplied by the cell size (30m x 30m). However, to calculate the area of different land covers whether changed or not changed, both images have to be overlaid. First image (1998) was multiplied by 10 and then added to the second image (2009). This process gives 2 – digit value to the resulting image. The first (ones) digit represents the land cover types in year 1998 while second digit (tens) represents the land cover types in year 2009. The graphical model of this process and the script are shown in figures 5 and 6 respectively.

Comparing Two Landsat 5 Images

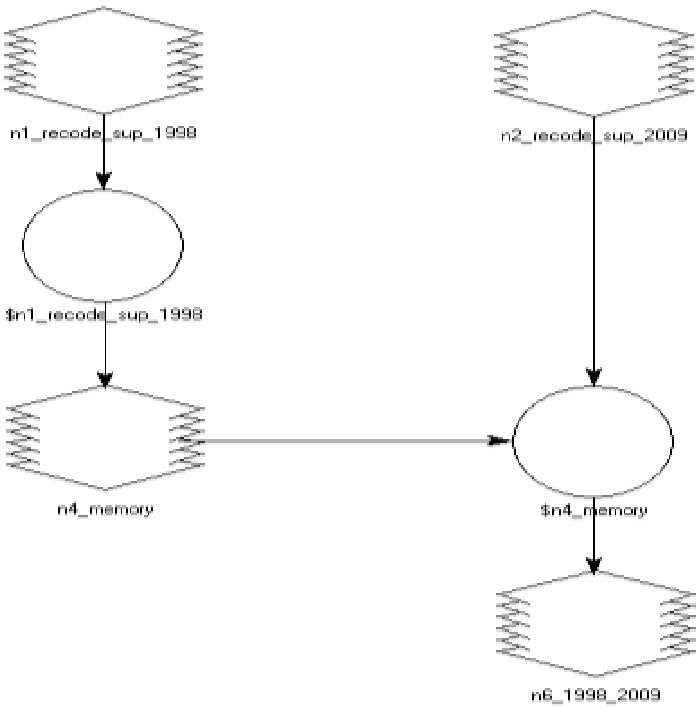

Figure 5. Comparing two Landsat 5 images (1998 and 2009)

From the land cover changed map pixel information 16 distinct values were found and according to those values the changes from one class to other classes were listed. These changes found in the study area were given (Table 3). The second digits of the result image values indicating the land cover changes in 2009 compared to 1998.

Table 2. Land cover types of change map

New Pixel Value	New observed changes in classes
11	Water (no change)
12	Water to vegetation
13	Water to bare land
14	Water to building

21	Vegetation to water
22	Vegetation (no change)
23	Vegetation to bare land
24	Vegetation to building
31	Bare land to water
32	Bare land to vegetation
33	Bare land (no change)
34	Bare land to building
41	Building to water
42	Building to vegetation
43	Building to bare land
44	Building (no change)

4. RESULTS AND DISCUSSION:

The appropriate analysis and the results of the first and the second objectives stated in the methodology are presented and discussed in this chapter.

Land cover classification using supervised method

The Landsat image of the study area was classified into four (4) land cover classes/types covers by using supervised classification method by maximum likelihood classifier. These classes are:

- Water
- Vegetation
- Bare land
- Building

Accuracy assessment

The images shown in figures 6 and are the outputs of supervised classification of two Landsat images of 1998 and 2009, respectively. Eighty-five points were randomly selected to check the accuracy of its classification, then the results show that the overall accuracy was 83.53% and 82.51% in 1998 and 2009 respectively. Also the points have been used for accuracy assessment it has shown with yellow color in figure 6.

Table3. Accuracy assessment 1998 and 2009

Image Year	Overall Accuracy (%)
1998	83.53
2009	82.51

Year 1998 Year 2009

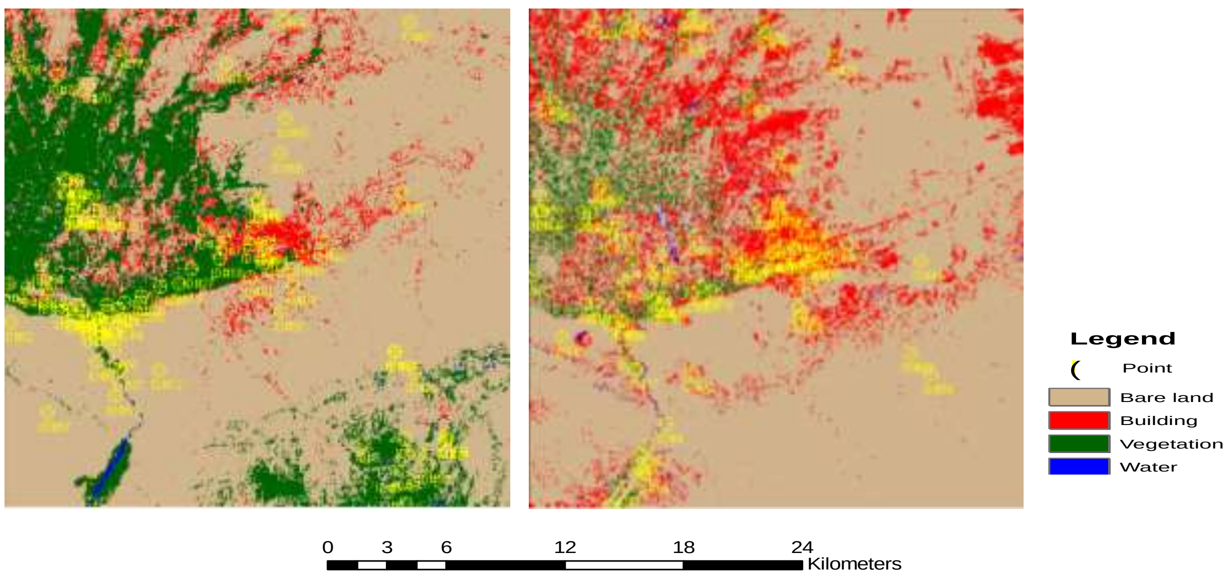

Figure 6. Points used in accuracy assessment

Land cover map

Land cover maps for 1998 and 2009 were produced in Arc GIS 9.3. The following tables (table 5 and 6) show the land cover classes and their corresponding area in square kilometer and hectares. As shown in table 5.2, most of the areas in the Central part of Balkh province are bare land that constitutes of 72.0141% (1801. 0737sq.km) of the total area, water being 0.6535% (16.3458 sq.km), vegetation 20.8639% (521.8074 sq.km) and building covered 6.4683% (161.7732 sq.km)

Table 4. Land cover types 1998 (supervised classification)

No	Land Cover Types	Area/Hectare	Area (Sq.Km)	Percentage Total Area
11	Water	1634.58	16.3458	0.653570546
22	Vegetation	52180.74	521.8074	20.86394959
33	Bare land	180107.37	1801.0737	72.01413946
44	Building	16177.32	161.7732	6.468340405
Total		**250100.01**	**2501.0001**	**100**

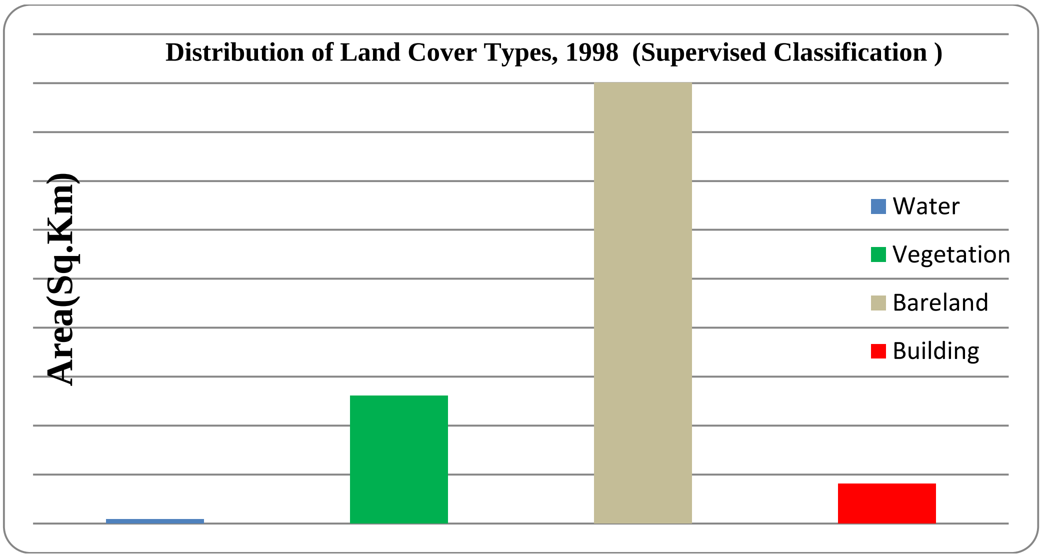

Figure 7. Distribution of land cover types, 1998 (supervised classification)

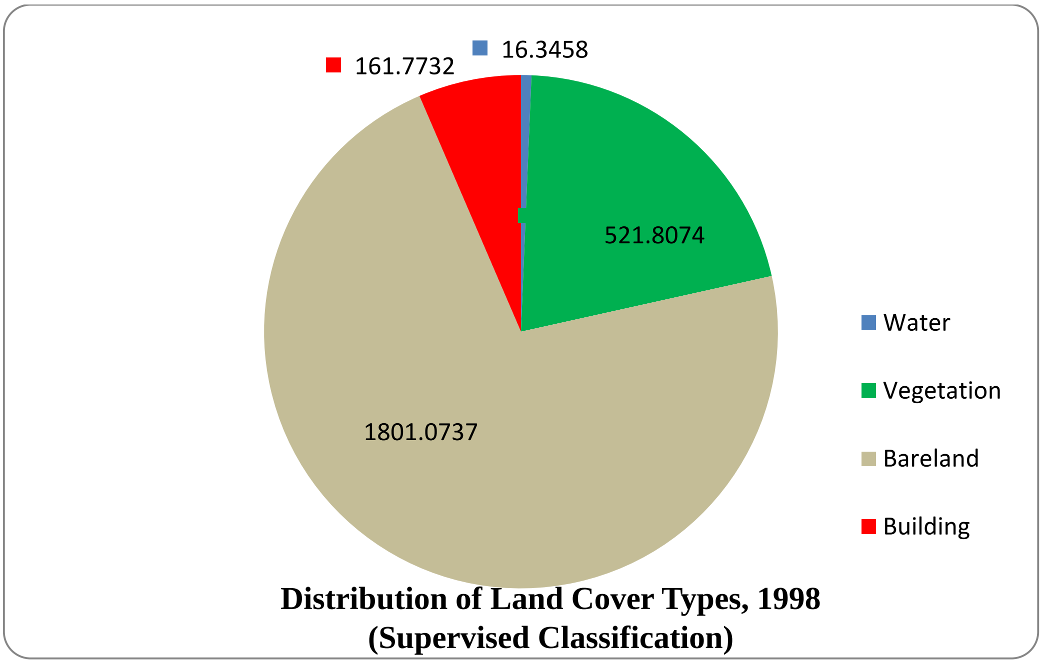

Figure 8. Distribution of land cover types, 1998

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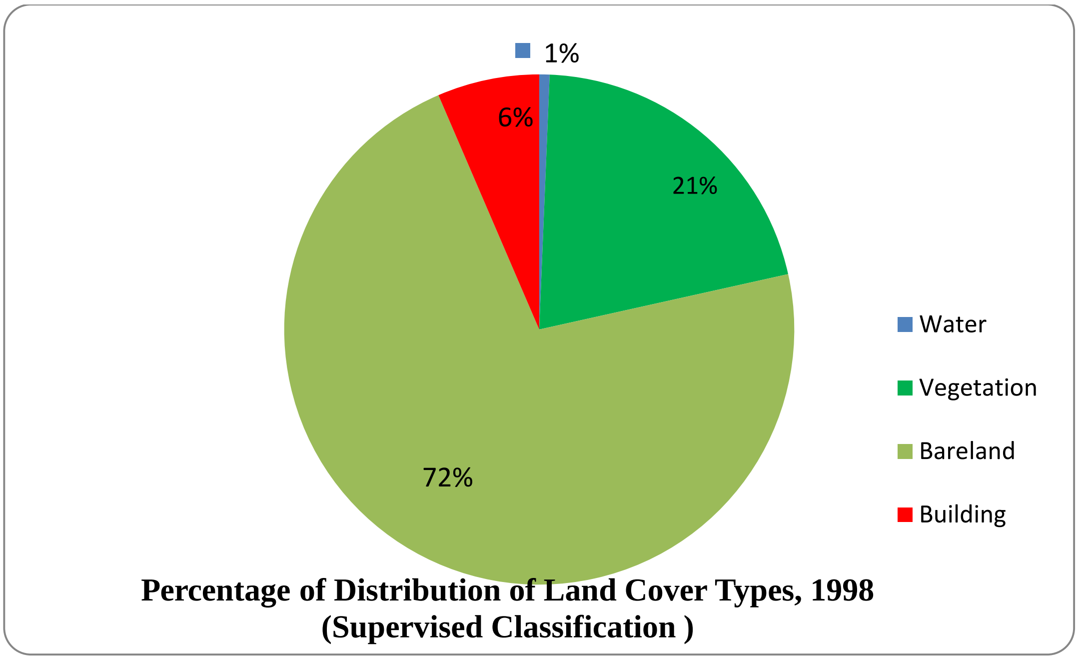

Figure 9. Percentage of distribution of land cover types, 1998 (supervised classification)

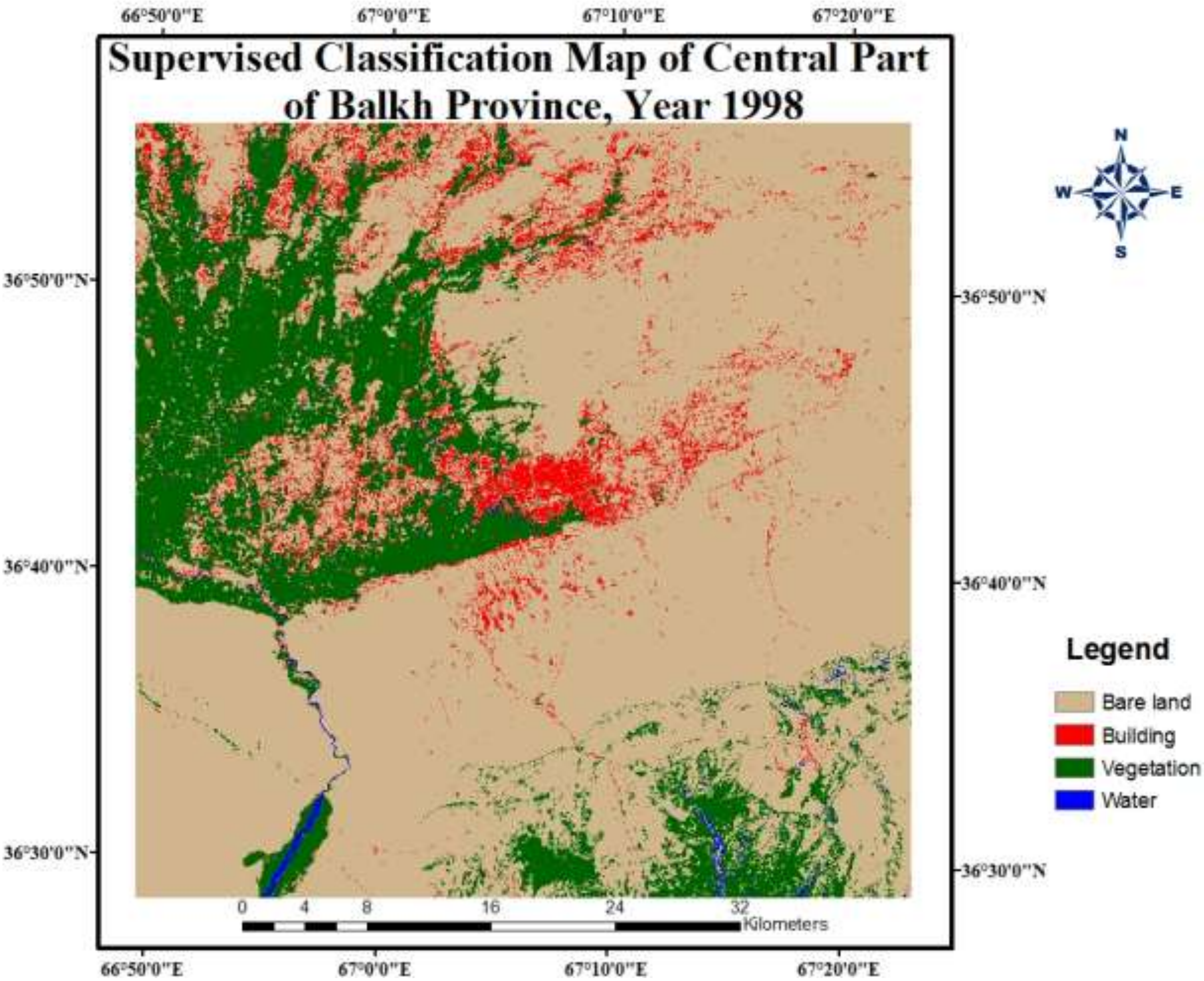

Figure 10. Land cover map of central Part of Balkh province, year 1998

On the other hand, the area of bare land in 2009 was increased to 6.481%, versus water reduced to 0.197% and vegetation also decreased by around 16.202 % and most of this area was converted to building, thus, building increased by around 9.918%. Land cover map during1998 and 2009 produced by supervised classification.

Table 5. Land cover types 2009 (supervised classification)

n	Land Cover Types	Area/Hectare	Area (Sq.Km)	Percentage Total Area
1	Water	1142.64	11.4264	0.456873232
2	Vegetation	11659.23	116.5923	4.661827083
3	Bare land	196316.1	1963.161	78.49503884
4	Building	40982.04	409.8204	16.38626084
Total		**250100.01**	**2501.0001**	**100**

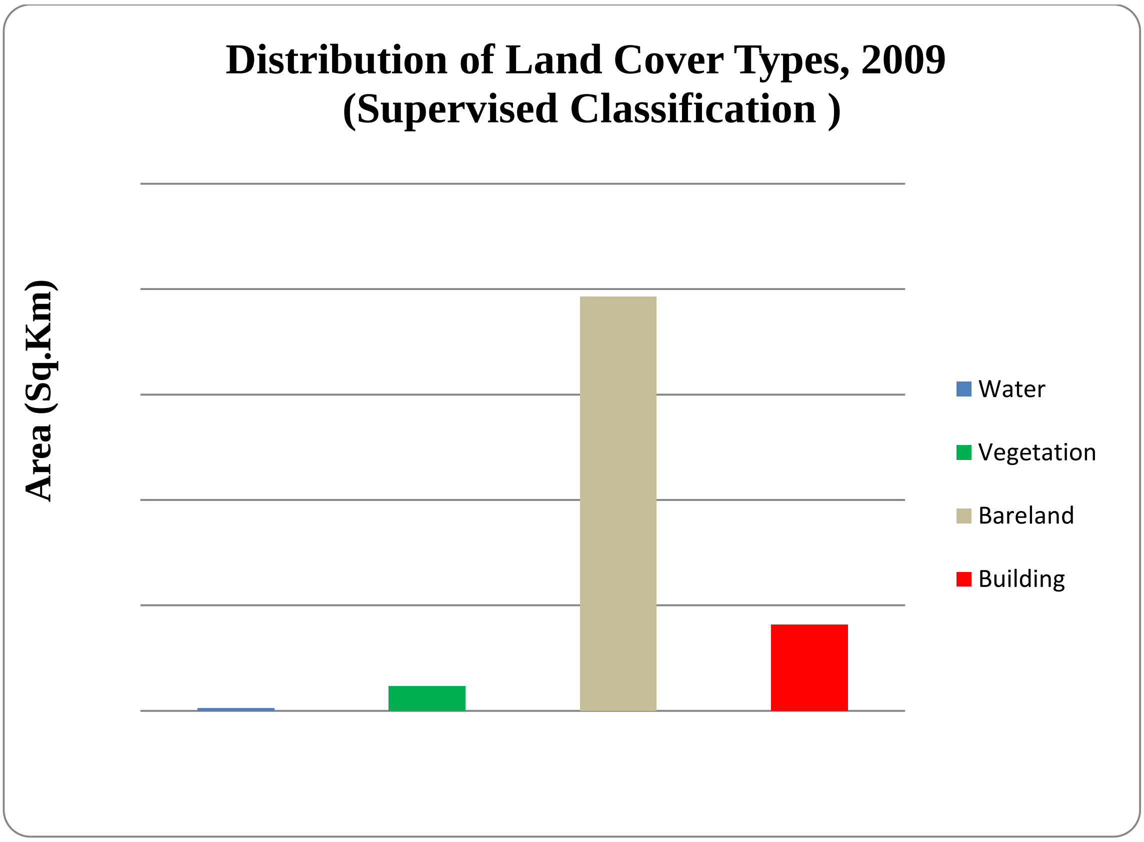

Figure 11. Distribution of land cover types, 2009 (supervised classification)

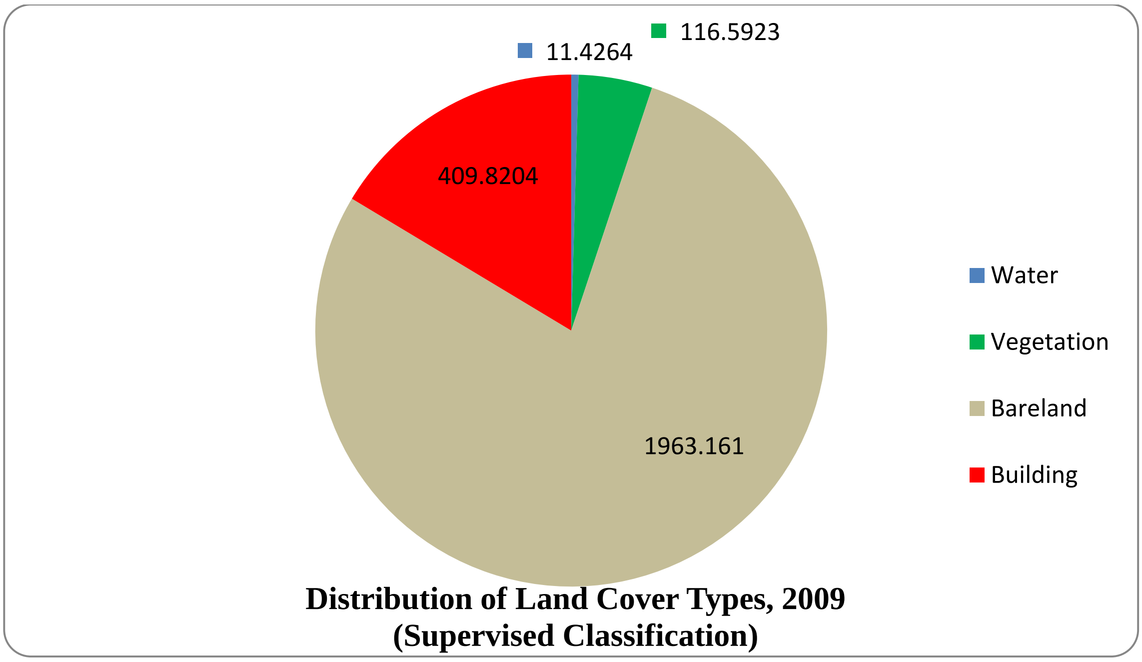

Figure 12. Distribution of land cover types, 2009

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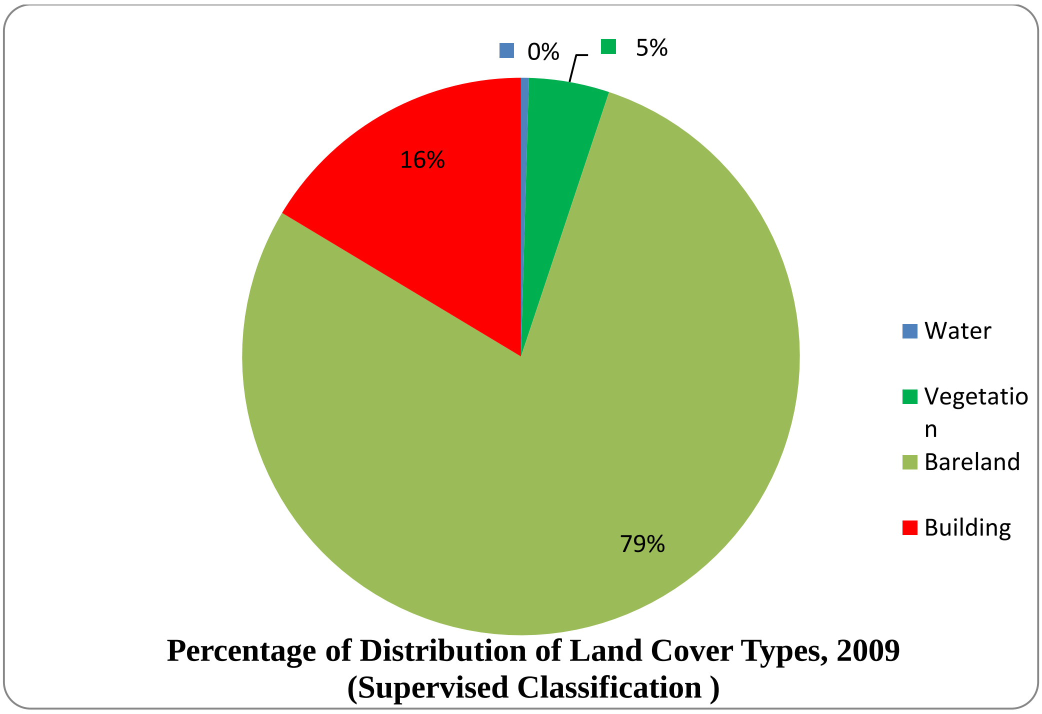

Figure 13. Percentage of distribution of land cover types, 2009 (supervised classification)

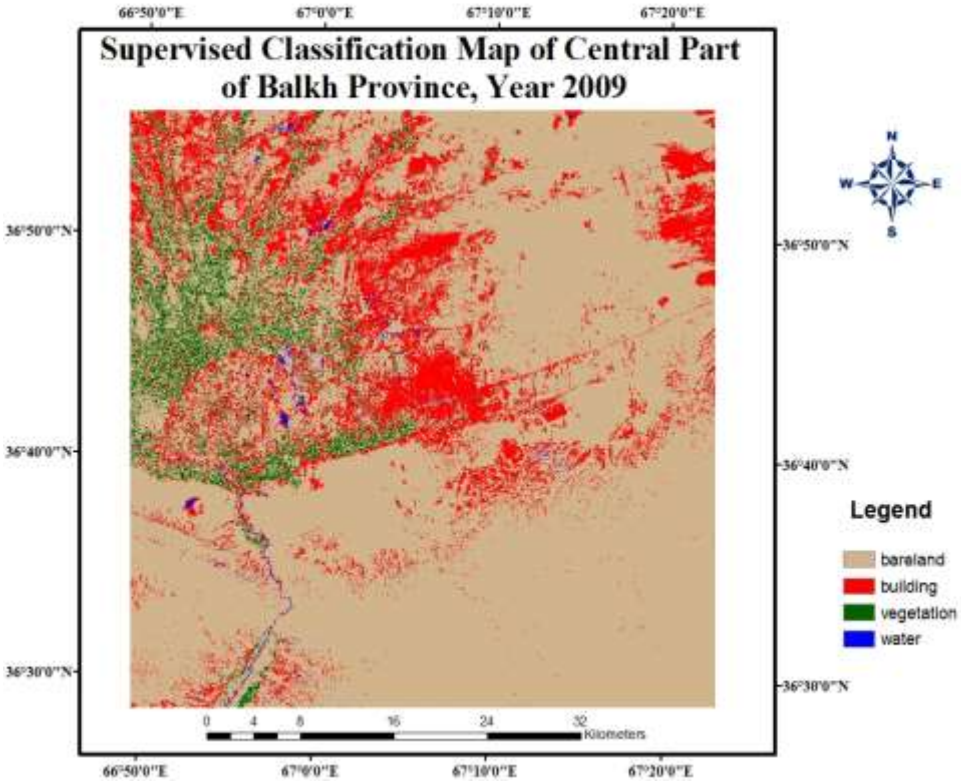

Figure 14. Land cover map of central part of Balkh province, year 2009

Table 6. Land cover types (sq.km total area) 1998 and 2009 (supervised classification)

No	Type	Area_ Sq.Km 1998	Area_ Sq.Km 2009
1	Water	16.3458	11.4264
2	Vegetation	521.8074	116.5923
3	Bare land	1801.0737	1963.161
4	Building	161.7732	409.8204
Total		**2501.0001**	**2501.0001**

Table 7. Land cover types (percentage total area) 1998 and 2009 (supervised classification)

No	Type	Percentage Total Area 1998	Percentage Total Area 2009
1	Water	0.654	0.457
2	Vegetation	20.864	4.662
3	Bare land	72.014	78.495
4	Building	6.468	16.386
Total		100	100

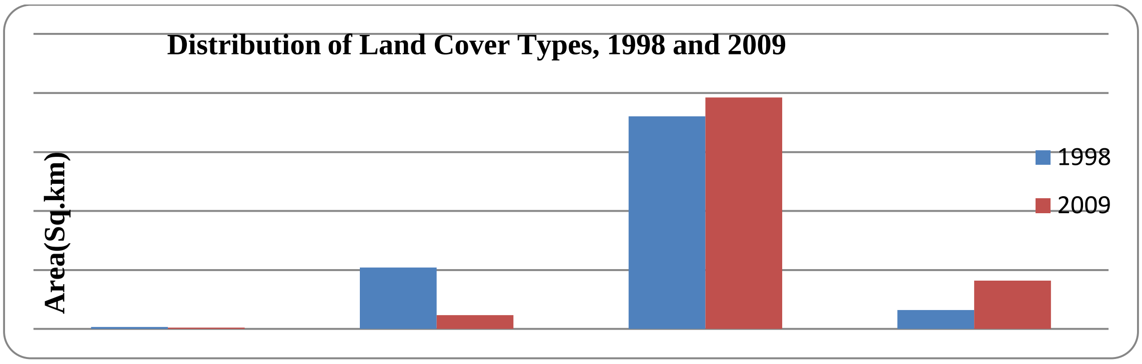

Figure15. Distributions of land cover types, 1998 and 2009 (supervised classification)

Land Cover change detection and statistics

Quantitative change was determined only by using the map produced by supervised classification in this study. For straightforward calculation and as stated in methodology, land cover map in 1998 was multiplied by 10 and then added by the land cover map in 2009; therefore, showing the changes of each individual class to the other classes. The area of each class was then calculated, and the results are shown in table 9. As shown, around 0.568% (14.1957sq.km) of the bare land had changed to vegetation; while only 13.354% (333.985sq.km) of vegetation had changed to bare land cover. There were 0.408% (10.2123sq.km) that had changed from water to bare land, and only 0.268% was changed from bare land to water. Around 10.307% (257.767sq.km) of the bare land changed to building just 3.861% (96.565sq.km) of building had changed to bare land.

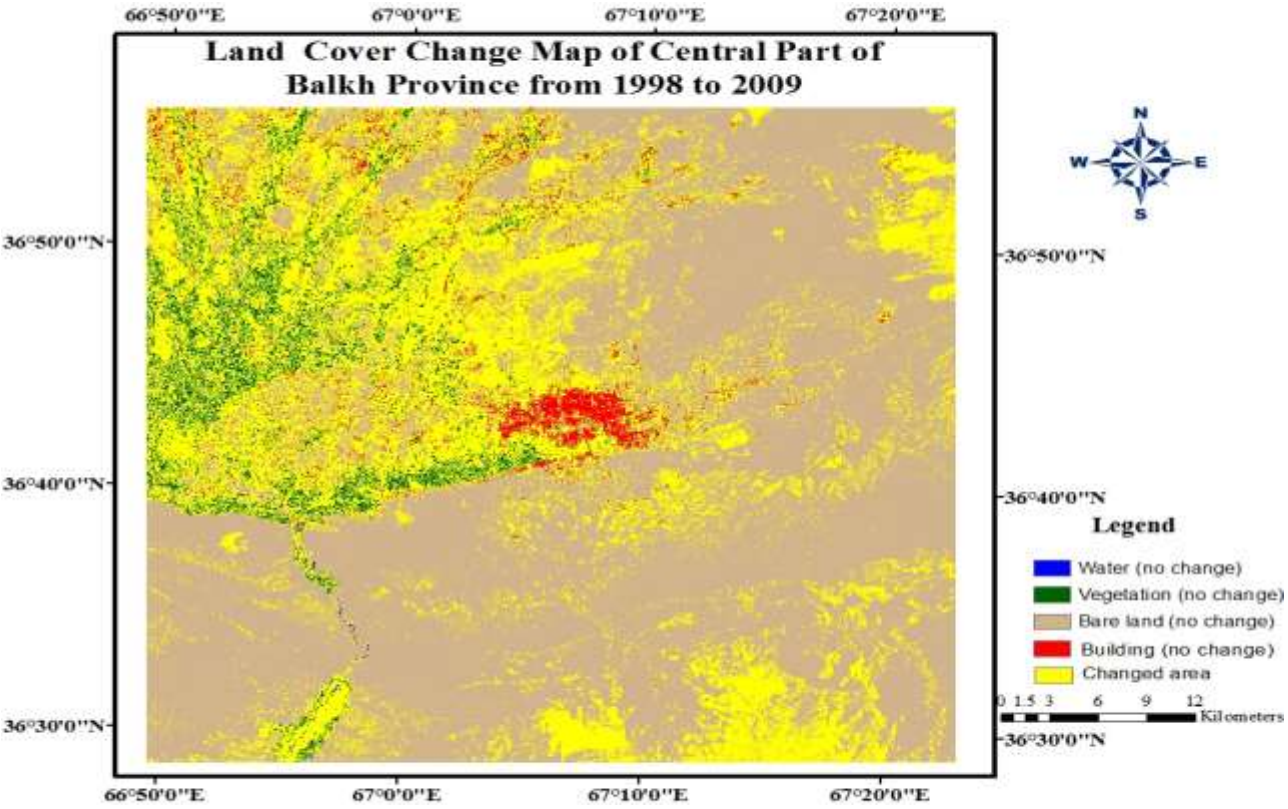

Figure 16. Land cover change map of central part of Balkh province, year 1998 to 2009

Table 8. Quantitative land cover change and no change from year 1998 to 2009

New Classes Pixel Value	Changes From	Changes To	Area Changed/no Changed (Hectare)	Area Changed/no Changed (Sq.km)	Percentage Total Area Changed / no Change
1	Water	Water (no change)	136.98	1.3698	0.054770074
1		Water to vegetation	93.42	0.9342	0.037353047
1		Water to bare land	1021.23	10.2123	0.408328538
1		Water to building	382.95	3.8295	0.153118704
2	Vegetation	Vegetation to water	197.46	1.9746	0.078952394
2		Vegetation (no change)	9720.45	97.2045	3.886624107
2		Vegetation to bare land	33398.5	333.985	13.35405411
2		Vegetation to building	8864.37	88.6437	3.544329134
3	Bare land	Bare land to water	671.13	6.7113	0.268344576
3		Bare land to vegetation	1419.57	14.1957	0.567600778
3		Bare land (no change)	152240	1522.4	60.87163187
3		Bare land to building	25776.7	257.767	10.30655408
4	Building	Building to water	137.07	1.3707	0.05480606
4		Building to vegetation	425.79	4.2579	0.170247846
4		Building to bare land	9656.46	96.5646	3.861038349
4		Building (no change)	5958	59.58	2.382246339
Total			250100.08	2501.0008	100

Table 9. Quantitative land cover change from year 1998 to 2009

New Classes Pixel Value	Changes from	Area Changed/no Changed (Hectare)	Area Changed/no Changed (Sq.km)	Percentage Total Area Changed
1	Water to vegetation	93.42	0.9342	0.037353047
1	Water to bare land	1021.23	10.2123	0.408328538
1	Water to building	382.95	3.8295	0.153118704
2	Vegetation to water	197.46	1.9746	0.078952394
2	Vegetation to bare land	33398.5	333.985	13.35405411
2	Vegetation to building	8864.37	88.6437	3.544329134
3	Bare land to water	671.13	6.7113	0.268344576
3	Bare land to vegetation	1419.57	14.1957	0.567600778
3	Bare land to building	25776.7	257.767	10.30655408
4	Building to water	137.07	1.3707	0.05480606
4	Building to vegetation	425.79	4.2579	0.170247846
4	Building to bare land	9656.46	96.5646	3.861038349
Total		82044.65	820.4465	32.80472761

The area of study that it distribution to four classes include 2501.0001 square kilometer after the classification and estimating the result of the changing classes from 1998 to 2009, Bare land consisting 6.48% (162.088 square kilometer or 16208.79 hectares) increases, water with 0.196% (4.919 square kilometer or 2503.26 hectares) decreases, vegetation with 16.202%(405.216 square kilometer or 40521.55 hectares) decreases and building with 9.918% (242.418 square kilometer or 24804.7 hectares) also increases. According to the analysis above, the total change in the study area equals 32.805% (820.447sq.km or 82044.65 hectares).

5. CONCLUSION:

The process of studying in land use and land cover changes are required. To complete the present objective, Specific method was setup and then implemented in scientific procedure. The Land use and land cover mapping for the period of 1998 and 2009 were prepared based on the Landsat 5 image with 30m resolution. After successful image processing steps, the four important classes were defined; water, vegetation, bare land and building. The overall accuracy assessment was reported at 83.53 % and 82.51% in 1998 and 2009 respectively.

In details, supervised classification had been used in identifying different land cover types. The values and classes of each land cover type were identified, then a conditional classification was also developed in Spatial Modeler. It was found that Landsat presented in high capability to monitor land cover change, because of high spatial resolution and temporal constraints.

The result of the changing was reported in the period of 1998 to 2009. It was found that bare land increased up to 6.48% (162.088 square kilometer), while water decreased for 0.196% (4.919 square kilometer). In addition, vegetation presented in decreased rate of 16.202% (405.216 square kilometer), while building was increased for 9.918% (242.418 square kilometer). According to the analysis, the total changes in the study area equal to 32.805% (820.447sq.km).

In summary, not suitable class presented to 826.505503sq.km (33.05%), while moderate class was 1010.95426sq.km (40.42%). There was also high suitable class resulting in 663.5403365sq.km (26.531%).

REFERENCES:

1. Asian Development Bank, (2003). Environmental Assessment Report. Afghanistan: Preparing the Water Resources Development Project.
2. Fei Yuan, K.E. Saway, B.C. Loeffelholz, M.E.B. (August 2005). Land cover classification and Change analysis of the Twin Cities (Minnesota) Metropolitan Area by multitemporal Landsat remote sensing.
3. Lillesand, T.M and Kiefer, R.W.,(1994). Remote Sensing and image interpretation, John Wiley And Sons, New York.
4. Murai, S. et.al.,(1994). Remote Sensing Note, Japan Association on Remote Sensing.
5. Mayer, W.B,(1995). Past and present Land use and Land cover in the U.S.A Consequence. P.24-p.24-33.
6. Riebsame, W.E., Meyer, W.B., and Turner, B.L.II., (1994). Modeling Land use and Land cover As part of Global Environmental Change. Climate Change. Vol.28.p.45.
7. Singh, A.,(1989). Digital Change Detection Techniques using Remotely Sensed.
8. Wieslaw Z. Michalak. (1993). GIS in land use change analysis integration remotely sensed Data into GIS.
9. Yahaya, S. Ilori, C. Whanda, S.J. and Edicha, J., (2010). Land Fill Site Selection for Municipal Solid Waste Management using Geographic Information System and
10. Multi Criteria Evaluation. American Journal of Scientific Research.

INTERNET SOURCES:

ASTER Global Digital Elevation Model (GDEM)
https://lpdaac.usgs.gov
Analytic Hierarchy Process
http://en.wikipedia.org/wiki/Analytic_Hierarchy_Process#Hierchies_defined
Climate of study area
http://www.climate-charts.com/Locations/a/AH40911.php
Geography of Afghanistan (2005)
http://en.wikipedia.org/wiki/Geography_of_Afghanistan
Land cover
http://en.wikipedia.org/wiki/Land_cover
Landsat Program
http://landsat.gsfc.nasa.gov
Michael Renner, Asian water wrangles (February.08.2010).
http://www.chinadialogue.net/article/show/single/en/3486-Asian-water-wrangles
United State Department of Agriculture, NRCS (Natural Resources Conservation Service)
http://soils.usda.gov/use/worldsoils/mapindex/afghanistan-soil.html .
Water Scarcity, Through 2020,© (1998). United States Filter Corporation.
http://www.sciperio.com/watertech/water-problem.asp