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# Dynamics of human activities and its impact on land use land cover (LULC) " A case study of Shomadi area at Renk County-Upper Nile State"

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## ABSTRACT

Shomadi, the study area is located south/south east of Renk County in Upper Nile State. It lays within the grids 11° 29' 11.76" N - 32° 43' 39.45"E and 11° 43' 40.62" N - 32° 48' 16.59"E with total area of 169,283.79 ha. The rich vegetation cover of Shomadi area is seriously deterioration due to increasing irrational anthropogenic activities. All attempts to manage this resource in sustainable manner failed due to lack of information. Therefore it became necessary to carry out this study with the objective to identify the dominant and the endangered species; distribution and density so that to determine the trend, main drivers to understand the dynamics of vegetation cover during the period 1972-2005 and produce thematic maps. To achieve these objectives, geospatial technology supplemented with ancillary ground truth is used. The results of ERDAS imagine version 9.1 and statistical analysis showed a remarkable decrease in forest lands from 33.20 % to 20.50%, barren lands from 02.58% to 0.76%, water bodies from 0.75% to 0.50%, and built up from 0.09% to 0.07% respectively during the period 1972-2005. While data of agricultural land reflected an increase from 25.70 % to 43.79%, and the range lands from 18.84% to 34.38 % respectively for the same period. The frequency distribution of the dominant species showed great variability, where Acacia mellifera reflected the highest frequency distribution (96%), followed by Cadaba rotundifolia (59%) and Acacia nubica (44%), meanwhile the Albizzia sericocephala showed the lowest value of frequency (1%). Moreover, the result showed tree density in the study area ranges between 28-1639 trees/ ha. according to the human activities. As conclusion, irrational land use/land cover resulted in decrease of vegetation lands, losses of wildlife and habitats, negative impact on hydrological cycle, socio-economic and environmental settings.

**KEYWORD:** Enhanced Thematic Mapper Plus (ETM+), Anthropogenic, Ancillary, Ground truth. Thematic Map (TM), Muti.Sensor Scanner (MSS).

## INTRODUCTION

Studying the changes in land cover, like forest lands, agricultural lands, rangelands, settlements and forest related activities such as mining, charcoal making, logging and wood fire is a central element to understanding the environmental changes and the driving forces (Meyer, 1995). Understanding such dynamics can assist policy makers to give a due attention and optimize their resource allocation either on the impact side through mitigation or driver side through prevention. Two drivers are known to causes of Land cover change, namely the natural calamities such as drought natural and floods and human activities that modify the land cover, including over grazing, agriculture, forest harvesting and urban sprawl (Vitosek et al., 1997). Such induced modifications and changes have many negative impacts such as soil erosion (Detenbeck, 1993) and loss of biodiversity (Skole et al. 1994). Thus, it is important to understand land cover changes and the driving factors that lead to these changes and the consequences of such changes (Ehrlich, 1998). The recent advancement in space technology proved supplemented with ground data proved to be very powerful tool that can provide accurate and timely information for monitoring and management of natural resource (Harries et al., 1995). As far as change detection concern, it is the process of identifying differences in an object or phenomenon by observing it at different times (Singh, 1989). The importance of change detection is to obtain up dated land cover maps and information about natural resources from remotely sensed data or field survey (Xiaomei, et al., 1999). Shomadi area (Fig.1) represents one of the areas that experienced serious land use/land cover change, in the country due to the following reasons: Rapid population growth, increase number of domesticated animal wealth, rapid and intensive horizontal expansion of Mechanized Rain-fed Farming System, frequent spells of drought, rainfall variability, poverty and increasing forest related activities such as illegal logging, charcoal making in addition to oil exploration and exploitation. As accurate, punctual and up to date information is a crucial for planning, monitoring and management of natural resources in sustainable manner; thus, a new design and advanced approach that can address this situation is needed. Several studies similar to this study are conducted in different regions worldwide, among these the study of land use in Lekki Peninsula area of Lagos, Nigeria during 1964 and 2003 where remote sensing was used. The study showed tremendous changes in urban sprawl as a result of great influx of people in the area and sharp decline in the extent of ecosystems such as the wetlands and wildlife habitats and loss of vegetation and open space (James, et al., 2009). Study

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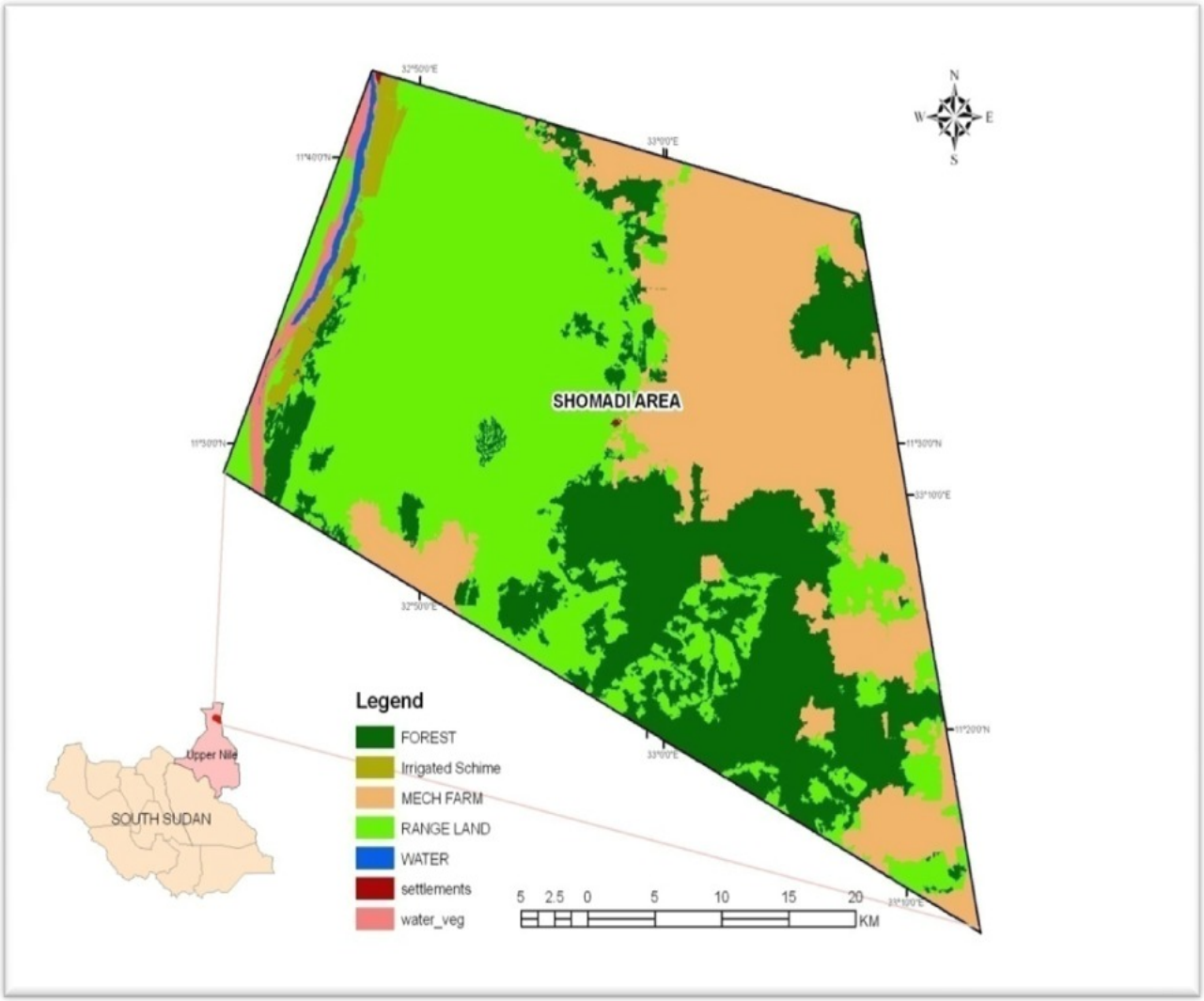
of landscape conversion showed changes on regional rainfall (Chase, et al., 2000). In Western Nebraska and Western Texas, the conversion from native short grassland to cropland after the mid-19th-Century manifested in biophysical effects that influenced energy, water cycling and albedo (Oke, et al., 1988). Rajendra P. Shrestha (2009) explained that the global land use change during 1986-2006 resulted in climate changes with several effects. The most important effects are: the long term effects on soils (humus, structure, erosion and soil-water relations), shifts of agro-ecological zones (both seasonal and long term), increased unpredictability of rangeland productivity; and reduced viability of imported breeds of livestock, greater invasion by shrubs in already disturbed forests; greater incidence of forest fires, higher frequency of droughts and floods and retreat of glaciers on mountains that results in more flooding/erosion. Similar results are obtained in studies conducted by the European Commission DG ENV (2006). A Study of Land use and land cover change detection through remote sensing approach in Kodaikanal taluk, Tamil Nadu during the period 1969-2008 reflected a drastic decrease in forest and waste lands and increase of agriculture and built up lands and water bodies (Prakasam, 2010). Land use and climate change study by Rajendra, et al., (2008) displayed many predictions, among these the global temperature rise predicted at 2.4 to 5.4 °C (but 7 °C in Africa -Hadley Centre UK), severe reduction in rainfall (e.g. West Africa, fringes of Sahara, most dry lands of Asia) = drought, water shortages, wind erosion, rainfall distribution, increased frequency and intensity of rainfall (e.g. East Africa, South Asia) = floods and soil erosion. Study of vegetation cover change of Mbeere District, Kenya using geo-technology during 1987 and 2000 showed decreases in forest, Land cover and water bodies by -14.3%, 29.5% and 17.4% respectively, while grassland and Settlement lands increased by 28.5% and 31.4% respectively (Peter, 2007). Other similar study was conducted by Kasturi, (2009) in Barak Basin in India during 2000 - 2006. The results showed a decrease in forest categories by -31.46%, while the non-forest categories showed an increase in land by 3.29 % for the same period. Daniel, et al., (2007) used of Landsat imageries of 1986 and 2002 to study land use cover mapping in a part of south western Nigeria. The results show that disturbed/degraded forest constituted the most extensive type of land use/land cover in the study area. The increasing population and economic activities were noted to be putting pressure on the available land resources.

## RESEARCH OBJECTIVES

The objectives of this research are to create thematic maps of Shomadi area using satellite data from 1972 to 2005, to detect and quantify spatial pattern of LULC change in the

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study area during 1972-2005 and to analyze the drivers those have contributed to the observable LULC change patterns.

**MATERIALS and METHODS:**

Two approaches are adopted:

A) The Satellite Data. Various steps and processes are used to obtain land use/land cover change maps of the study area.The procedure include the following steps:

**1.Image acquired and sources.**

To analyze land use/land covers change, multi-spectral, multi-sensor, multi-spatial-temporal, free cloud images of landsat (Land + Satellite) MSS (Multi-Spectral Scanner) and Spot- 5- corresponding to Path/Row p186/185 - r053/052 (Nov.1972) and P173/172-r053/052 (Nov. 2005) respectively are obtained from the Remote Sensing Authority, Khartoum-Sudan and dowlnloaded from Global Lnad Cover Facelities (GLCF) web site (Table 1).

Table: (1) Show Data Source of Shomadi area

| Years | Resolution | Dataset | Band Composed | Path, Row |
|---|---|---|---|---|
| **1972** | **30 M** | **Mss** | **2,3,4** | **Path 186,186. Row 052,053.** |
| **2005** | **30 M** | **ETM+** | **2,3,4** | **Path 172 ,173. Row 053,052.** |

**2. Pre- processing operation:**

- Layer stacking:
- Mosaic.
- Enhancement: further processes, including: -

1. **Image correction**: This process is carried out by applying the integrated Remote Sensing (RS) and Geographic Information System (GIS) techniques, particularly, the ERDAS IMAGINE Version 8.5 and ArcGIS 9.2.

2. **Atmospheric correction:** This includes the followings:

- Normalization: It is the correction of variation between digital numbers (DN's) of satellites images that acquired at different times.
- Image registration: To conform the removal of all geometric distortions in the pixel grids such as register to the UTM. (UinversalTranfer Marchater) zone coordinate system. This was done by the known data collected from the field [Ground Control Points (GCP's)](first order transformation), and resampling the nearest uncorrected neighbor imagery (linear transformation) by applying the standard linear equation (y = mx + b) to the X and Y of the GCP's coordinates. Image with identified points was selected and matched to vectors till a semi- regular grid of GCP's which covers the whole scene was obtained. Then, GCP's was utilized to project the uncorrected imagery to a UTM coordinate system.
- **Registered vectors:** Image identifiable points to be selected and match to vectors until a semi-regular grid of GCP's covered the entire scene. The GCP's to be used to project the uncorrected imagery to a UTM coordinate system. Image fit are considered acceptable if the RMS (RMS error is the distance between the input (source) location of a GCP, and the resample location of the same GCP) error is < 15 m or one-half pixel wide (RMS = 0.5). Points with high error are discarded before registration.
- Geometric correction: pixels' grids were resampled to fit the grids of a map projection or any other reference image.
- Masking: To get rid of the irrelevant features like water, clouds etc.
- Then, the images were undergone further processes, including:

**3. Classification Scheme:**

produce land use land over maps for each of the two dates, unsupervised classification technique is preformed. To determine the land use land cover change, the two-land cover maps are compared, using simple image mathematics. The unsupervised classification includes the ISODATA algorithm which automatically generates the signatures. The ISODATA clustering method uses the minimum spectral distance formula to form clusters. It begins with either arbitrary cluster means or means of an existing signature set. Each time the clustering repeats, the means of these clusters are shifted. The new cluster means are used for the next iteration. The ISODATA utility repeats the clustering of the image until either a maximum number of iterations have been performed, or a maximum percentage of unchanged pixel assignments have been reached between two iterations. Then statistical analysis is carried out to know the changed areas of the classes.

**B) Vegetation:** In this study emphasis is put on tree species, their distribution and density.

**Sampling:** Mueller-Dombois technique (1974) the so called Point - Centered Quartered (PCQ) method is adopted. Where 100 meters tape, biltmore stick. meter stick. data sheet. pencil and. hand calculator are used.

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**Sampling technique:** Following the determination of the location of the study area by Global Positioning System (GPS), random points are located in the forest stand. To get an accurate and reliable data 3 - 4 readings are taken and averaged to get the representative samples. Where 100 meters transect tape is stretched to its full length (If there is slope, the tape should follow the elevation contour of the slope). Sample points are taken at 10 meters intervals along the tape. At each sample point, an imaginary "X" is defined that formed by the meter tape and a line perpendicular to the tape at the sample point. The "X" defines the four quadrants (NE, SE, SW and NW). The following parameters are recorded for the nearest vegetation tree. Samples of 10 points (40 trees) from each representative forest stands are taken. After data collection, the following parameters are determined:

1. Type of species.
2. Distance from the points to the nearest tree.
3. Tree frequency
4. Tree density from the following formula:
   Da = (10 m) $^2$ / A$^2$ = ……..trees/ha.

**RESULTS and DISCUSSION**

Figure 2 and 3 illustrate the land use/ land cover classes produced from the unsupervised classification which is wielded in this study for the period 1972-2005, where six classes are generated these are forest lands , rangelands, agricultural lands, barren lands, water bodies, and built up. Table 1 presents figures that represent the statistical area of each land use/ land cover category as of 1972-2005.

Figure 2: Result of Land use land cover classification of Shomadi area derived from landsat MSS (1972).

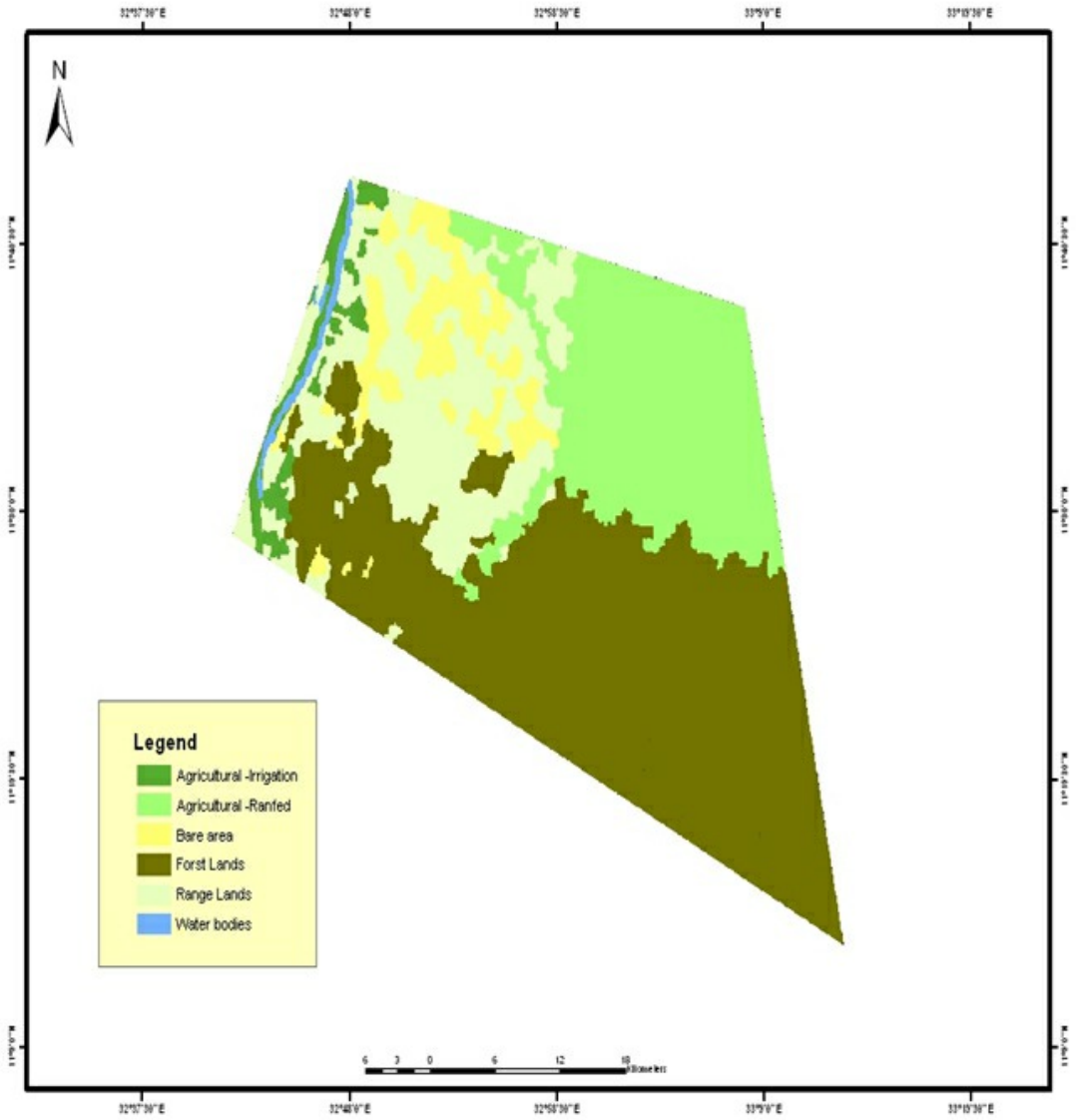


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**Figure 3:** Result of Land use land cover classification of Shomadi area derived from landsat ETM+ (2005).

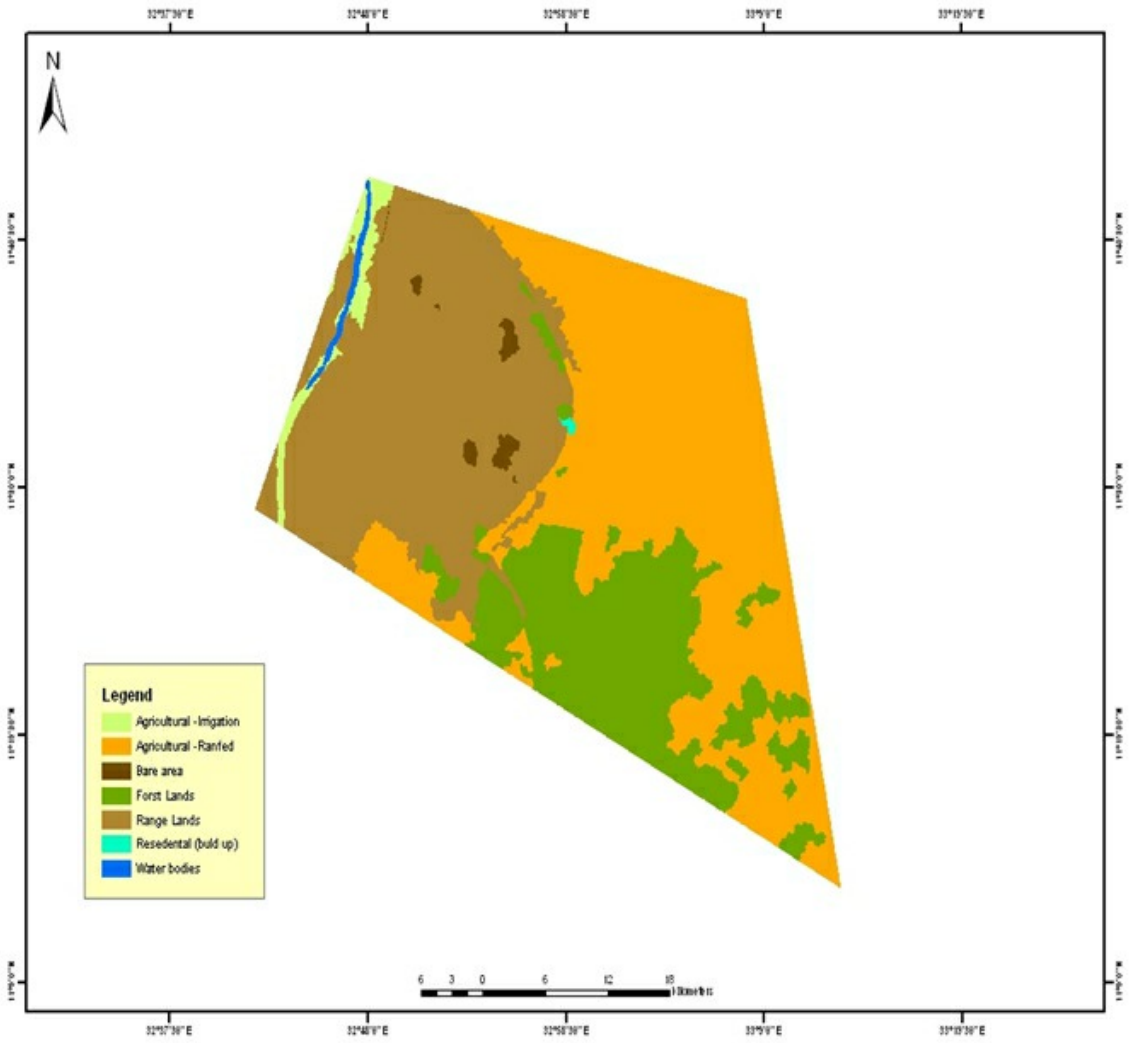


**Table 2:** Land use lands cover categories of Shomadi in s.qkm (1972-2005).

| Years | Bare area | Agricultural Lands | Forest Lands | Range lands | Water bodies | Built up | Total |
|---|---|---|---|---|---|---|---|
| 1972 | 43.6616 | 578.8476 | 562.0667 | 494.0701 | 12.7069 | 1.485 | 1692.8379 |
| 2005 | 12.9582 | 741.2139 | 346.9545 | 582.0228 | 8.4987 | 1.1898 | 1692.8379 |

**Table 3:** Land use land cover categories as percentage - Shomadi area (1972-2005).

| Land use categories | Year | | | |
|---|---|---|---|---|
| | 1972 | % Area | 2005 | % Area |
| Bare lands | 4366.16 | 2.58 | 01,295·82 | 0.76 |
| Agricultural lands | 57884.76 | 34.19 | 74,121.39 | 43.79 |
| Forest lands | 56206.67 | 33·20 | 34,695.45 | 20·50 |
| Rangelands | 49.407·01 | 29.19 | 58,202.28 | 34.38 |
| Water bodies | 01,270.69 | 00·75 | 00,849·87 | 00·50 |
| Built up (residential area) | 00,148·50 | 00·09 | 00,118·98 | 00·07 |
| Total | 169283.79 | 100·00 | 169,283.79 | 100·00 |

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**Plate 1:** Horizontal expansion of mechanized rain-fed farming (opening new farm).

**Plate 2:** fire and its effects on vegetation cover in Shomadi area 2010.

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**Plate 3:** Forest related activities (wood fire, logging etc ) in Shomadi area 2010

**Plate 4:** Petroleum exploration (opening of new wide and long roads) Shomadi -2010

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**Plate 5:** Overgrazing-Shomadi are (2010)

The alteration of natural environment by human in different ways such as horizontal expansion of agricultural lands (Plate 1), increased forest related activities such as charcoal, firewoods and logging (Plate 2), frequent fire setting (Plate 3) opening of new roads for petroleum exploration (Plate. 4), over grazing along with natural calamities led to decrease in land cover in the study area.

The statistical analysis (Table 3) reflected a decrease in forest lands from 33.2 % to 20.5 % during the period 1972-2005. The study of land cover of Shomadi area by ground survey (2010) revealed a decrease in forest trees, where the trees density ranging from 26 – 1886 trees/ha. From observation, *A. seyal and Balanites aegyptiaca* are the most endangered tree species due to discriminated cuttings.The barren lands from 2.58 % to 0.76 % during 1972 to 2005. The water bodies from 1.27 % to 0.5 % during 1972 to 2005 while the agricultural lands and range lands increased from 34.19% to 43.79 % and 49.40 % to 34.38 % respectively during the period 1972 to 2005.

The forest areas decreased due to the introduction of mechanized rain-fed farming, spells of drought, many people shifted from farming to forest activities as a result of poor crop yield and fast earning from forest products. Barren land also diminished due to horizontal agricultural expansion and frequent fire settings. As far as water bodies concern, the decrease is attributed to the frequent drought and low rainfall. The result is supported by the findings by Peter, (2007) showed decreases in forest, Land cover and water bodies by -14.3%, 29.5% and 17.4% respectively, while grassland and Settlement lands increased by 28.5% and 31.4% respectively. Another similar study conducted by Kasturi, (2009) in Barak Basin in India (2000 - 2006), the results reflected a decrease in forest categories by -31.46%, while the non-forest categories showed an increase in land by 3.29 %. Agricultural and range lands remained healthy because agriculture has swollen great forest land, while the range land extended in the area of forest land. Another study of Land use and land cover change detection by remote sensing approach in Kodaikanal taluk, Tamil nadu (1969-2008) resulted in a drastic decrease in forest and waste lands and increase of agriculture and built up lands and water bodies (Prakasam, 2010).

## CONCLUSION

This study used powerful techniques to created thematic maps which provide accurate, up-to-date information on land use and vegetation cover that can help in planning, monitoring and sustainable management of natural resources (land, vegetation, water etc.) in this area and similar regions nationwide. The conversion of vast forest lands to crop lands has negatively influenced the well balanced natural ecosystems. The population dynamics and increase of animal resources exerted high pressure on

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vegetation cover. The crop failure and yield drop increased the poverty level, thus, many people shifted from farming to forest related activities. The continuous decrease in forest lands and water bodies are serious indicators of vegetation and hydrological changes that need further study using high resolution satellites. The anthropogenic activities and natural calamities led to change in land use pattern, land cover, habitat disturbance, disappearance of some fauna and flora species, changes in water regime, losses of biodiversity and changes in environmental settings in the study area.

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