MULTI TEMPORAL REMOTELY SENSED DATA CARTOGRAPHY FOR SUSTAINABLE NATURAL RESOURCES MANAGEMENT PRACTICES: GEDAREF REGION, EASTERN SUDAN

SAEED MOSMAR ALAWAD
UNIVERSITY OF ALNELAIN
DEPARTMENT OF GEOGRAPHY
11121 KHARTOUM
SUDAN

Paper number: 23

KEY WORDS: Sensed data, multi temporal, mapping, land use/land cover, monitoring, sustainability

ABSTRACT

Sudan as large country of Africa (with 2.5 million sq. Km) does not posses sufficient maps to support conservation projects as well as sustainable natural resources management. Although cartographic database is essentially required for sustainability the financial situation is difficult in Sudan. The Sudan natural resource is rabidly changing. Gedaref Region-the East Central Sudan-was one of the richest natural resources base area of Sudan. The Region is known to have undergone tremendous and radical land use/land cover changes with in the last three decades. These changes can view not in the total high reduction in the natural vegetation of the land, but more seriously in the vast increases in land degradation. Gedaref natural resources degradation deals with overtime using multi-date remotely sensed data (1973 and 1993) to monitor, researching and understand the complexity land degradation causal factors. Land degradation researched through surface characteristics e.g. land use changes, deforestation, changes in density cover, increasing drainage density etc. The complex database displayed in cartographic form is to aid conservation and land use planning for sustainability.

1. Introduction

Natural resources namely soil, vegetation cover, water etc are of renewable nature found in ecosystem, which be utilized to satisfy basic human needs. In Sudan natural resources are severely degraded as a result of increases in human and economic pressure. As a results of food shortage in the Sudan large scale semi-mechanized rainfed farming introduced to the central clay plain along the semi-arid to sub-humid climatic zone. Land use/land cover changes and practices are the main process hinder sustainability in the area. Gedaref Region-study area- (figure 1) is one of these areas with richest natural resources base area but challenging with environmental problems. Land resources are depleted at increasing speed. The first challenge to Gedaref Region is to put clock back. For sustainable management natural resources potentialities should be inventor, depletion should be halt, and the degraded one should be resolved through implementing effective land use planning. This requires information on the resources for understanding the degradation causes (physical, economical and social). Informations to aid conservational project implementation are questionable in developing countries including Sudan. The main point is how can we use the available data sources and simple equipment to meet the gabs in land information (resource potential causal process of degradation and its trends). Cartographic product has to be promoted as a main agent to provide land information for rational resources conservation and preservation of resources qualities. However, land degradation is a wide terms used in different ways and caused by various processes but in this study refers to forest degradation and surface water erosion.

2. Study area characteristics

Gedaref region is restricted to the entire Southern part of the former Eastern Region of Sudan at present Gedaref state which adjoins the north western high lands of Ethiopia (Figure 1). This 33600 sq. Km. Area (approx.) bounded by the longitude 34 30 (east of Greenwich) to the west and the Ethiopian border to the east and runs from latitudes 11 00 to 14 30 N. it is dominated by semi mechanized farm and grazing by trans-human nomads. The area characterized by semi-level plain. A low ridge (basaltic) rises some one hundred meters above the ground level of the plain extending from Galabat in the southern part to Gedaref town in the extreme northern part (Whitman, 1971). The geological units in the area arranged as follows: superficial deposit (Quaternary), volcanic rock (Tertiary-basaltic), Nubian sandstone (Mesozoic) and basement complex (pre-camperian). The area dominated by almost semi level plain and brownish

cracking clay soils (Ali, 1973; van der Kevie and buraymah, 1976; Alawad, 1991). It is a semi-arid to sub-humid climatic area. Commencement, incidence and intensity of rainfall is subject to fluctuation with in the rainy season (Musa, 1986). The rainfall characteristic is one of the important factors that influence land use practices and trends of development. According to Harrison and Jackson (1958) the natural vegetation in the area was divided into two sub-divisions: Acacia mellefra thornland on clay and Acacia Seya-Balanites aegyptica Savannah. Semi mechanized farm and grazing (by trans-human nomads) is the main land use systems.

Gedaref Region has been one of the most active and important areas of the Sudan with promising natural resources. Around 1945 the Region had undergone an agricultural development through the introduction of semi-mechanized farm. The introduction of semi-mechanization has brought great challenge to the Gedaref Region. The expansion of the semi-mechanized farm was at the expense of other land use/land cover categories. The situation aggravated by the economic pressures as more people attracted to the area looking for land to cultivate following harmful system of practices. As a result the area characterized by severe land degradation.

3. Condition of map production

Seen on a world wide economic scale Sudan are economically poor. Sudan hardly in the status to produce adequate/essential thematic map series. Even the topographic maps the only available maps dated back to colonial period (1935) or at early time of independence (in the 60^{th}). The available thematic maps are not enough for conservation and sustainability since there is lack of baseline data about the environmental condition in the past. Both classical and sophisticated method of mapping facing constraint in Sudan. The classical methods are costly, business driven and time consuming while the lack of equipment, know how and carelessness interfacing with machines hinders the uses of the sophisticated methods for mapping. Providing valuable maps for conservation and sustainability can only be possible if simple remote sensing cartographic methods and equipment used. Since conservation and resources management sustainability relies on reliable information the ecological and environmental condition prevailing in the past, multi-date maps is essential.

4. Objective

The paper mainly focuses [1] on the uses of the available multi-temporal and multi-resolution remotely sensed data interpretation for mapping, inventorying and monitoring land degradation. [2] Assessment of land use/land cover changes and their adverse impacts to determine land degradation and [3] mapping of land use/land cover and drainage network using simple cartographic methods.

5. Material and Methodology

5.1 Material

To execute the research objectives the following materials were utilized:
1. Two sets of satellite landsat images covering a time span of 20 years 1973-1993 namely; Set of Multi-Spectral Scanner data dated 1973 and the other is Thematic Mapper (TM). The multi temporal landsat images were chosen to reflect the past land use/land cover status and help to detect the dynamic changes and trends in land use/land cover changes over time as well as drainage system.
2. Topographic maps at 1:250000 scale served as a source for some supplementary information during interpretation and navigation for field verification.
3. Field perspective is a requisite for verification of sensed data interpretation and collection of the unseen factors causes deforestation.

The main concepts are to get benefit of the available, low cost, reliable, efficient data sources for mapping and land resources monitoring.

5.2 Methodology

A method of various avenues followed for achieving the research objectives. The sensed data analysis for cartography development and information analysis comprises the following working area:

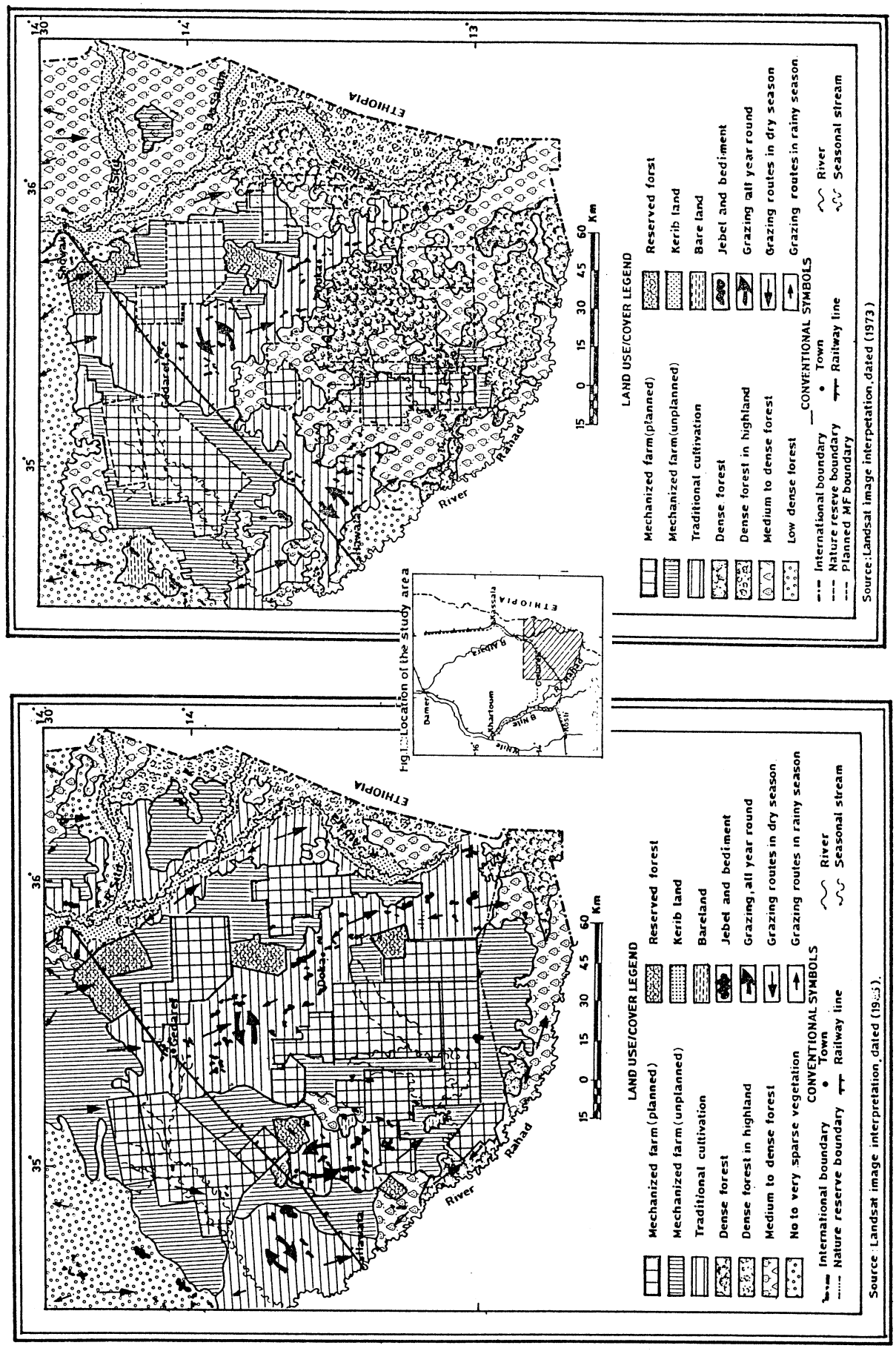


Fig. 2:Land use/cover-Gedaref region (1973)
Fig. 3:Land use/cover-Gedaref region (1993)
Fig.1:Location of the study area
ETHIOPIA
Gedaref
Doka
Rahad
River
Km
LAND USE/COVER LEGEND
Mechanized farm(planned)
Mechanized farm(unplanned)
Traditional cultivation
Dense forest
Dense forest in highland
Medium to dense forest
Low dense forest
Reserved forst
Kerib land
Bare land
Jebel and bediment
Grazing all year round
Grazing routes in dry season
Grazing routes in rainy season
CONVENTIONAL SYMBOLS
International boundary
Nature reseve boundary
Planned MF boundary
Town
Railway line
River
Seasonal stream
Source:Landsat image interpretation,dated (1973)
Source:Landsat image interpretation,dated (1993).

1. Satellite images analysis for land use/land cover mapping that refers to transformation of sensed data into usable and readable information. According to Lillisand and Keifer (1994) there are two methods for extracting information from remote sensing data Visual image interpretation and image analysis using computer environment. Visual interpretation was followed using simple equipment and facilities (e.g. optical magnifiers, light table, ProComp etc. For land use/land cover mapping classification system were established and developed to arrange information into groups and mapping units. Using this system land use/land cover categories can be recognized, recorded and tabulated. The step results in multi date land use/land cover and drainage network maps.
2. Image interpretation for soil degradation refers to the mapping of areas that affected by process of removal of the topsoil by water. The final map zones suffer from erosion hazards in 1993.
3. Map production after field verification is stop taken for map compilation, edditing, layout and design.
4. The final stage is the analysis of the cartographic products for assessing and monitoring the land degradation.

6. Results and discussion

Complex database displayed in cartographic forms as shown in figures 2 and 3 shows the land use/land cover changes over the two decades. Changes are present statistically in table 1. Overlay of the two maps, the baseline land use/land cover map dated 1973 superimposed with 1993 land use/land cover map confirmed the trends in land use/land cover changes and practices. Figures 4 and 5 displayed the drainage densities and system in the area. Figure 6 present areas suffer from erosion hazards in 1993.

Table 1: Land use/land cover changes between 1973-1993 in Gedaref Region

Land use/land cover categories	Area in 1973	Area in 1993	% of area in 1973	% of area in 1993
Agricultural land				
-Semi mechanized farm				
*demarcated	1259020	2012855	14.4	28.0
* undemarcated	0042480	2292900	00.5	26.0
- Small scale rainfed farm	1201130	1504755	13.7	17.0
Sub total	2502630	5810510	28.6	66.2
Forest land				
-Natural forest	4464666	1366381	51.1	15.9
-Reserved forest	0147775	0261800	01.7	03.0
Sub total	4612441	1678181	52.8	18.9
Grazing land	1007830	0729470	11.5	08.3
Kerrib land	0360750	0300520	04.2	05.3
Jebel (hills) pedmont/bareland	0256350	0271320	02.9	03.1
Total area	8740001	8740001	100	100

Note: percentage is out of the total land of the study area 8740001 Feddans

The results represent two factors that occur in the region, which affect land resources. These are:

1. Land use/land cover changes:

Examination of the cartographic and statistical data shows very clear distinct features, of the spread of semi-mechanized farm and deforestation at the expense of natural forest. The increasing needs for agricultural lands, fuel and woody materials for commercial and domestic uses aggravated by economy-political forces are the main causes of the land use/land cover changes and land degradation in the region. The changes are abrupt extending over larger areas. The (1973) land use/land cover map (Figure 2) shows that most of the Gedaref Region carried open to dense natural vegetation. The transformation of natural forest to traditional rainfed namely burned system of cultivation (Hariq system of rainfed cultivation) was concentrated along the central part of the region and mainly around settlements. On the contrary 1993 land use/land cover map (Figure 3) indicated substantial increases and encroachments of semi mechanized rainfed cultivation in the expenses of natural green cover. The maps indicated that land clearing for rainfed cultivation practices is progressing from north and is approaching southwards towards river Rahad. The semi-mechanized area has already invaded the buffer zone of the Dinder Game Reserved Area (Park) the main and well-known natural game reserved area in the Sudan. Calculated areas of land use/land cover according to planimetric measurement shown in table 1 disclosed that the rainfed areas increased to cover about 66%of the total area in 1993 compared to 28% in 1973. In 1973 forest area covered about 52.8% of the total area in the region. This has decreased to cover only 18.9% in 1993 map, with a decrease of about 46% in twenty years. The grazing land has also been degraded by the invasion of the rainfed cultivation. In 1973 map pastureland covered about 11.5% of the total area. By 1993 it covered about 8.3% with a decrease of 26% in twenty years.

2. Surface runoff erosion:

Precipitation, vegetation cover, soil characteristics and topography are the factors that affecting surface water erosion (Hudson, 1986). Increasing in drainage density was performed forces in assessing water erosion because it is generally correlated to be the most simple and an effective tools using remotely sensed data. The consequences of land use/land cover changes 1973-1993 was a reduction in infiltration capacity of the soils and increasing over land flows that

developed new drainage channels that not found in 1973 (Figures 4,5). The drainage density in the study area has increased profoundly from 0.0963 Km/Km2 in 1973 to 0.2176 Km/Km2 in 1993 with an increasing rate of 126%.

Fig. 4:Drainage density-Gedaref region (1973)

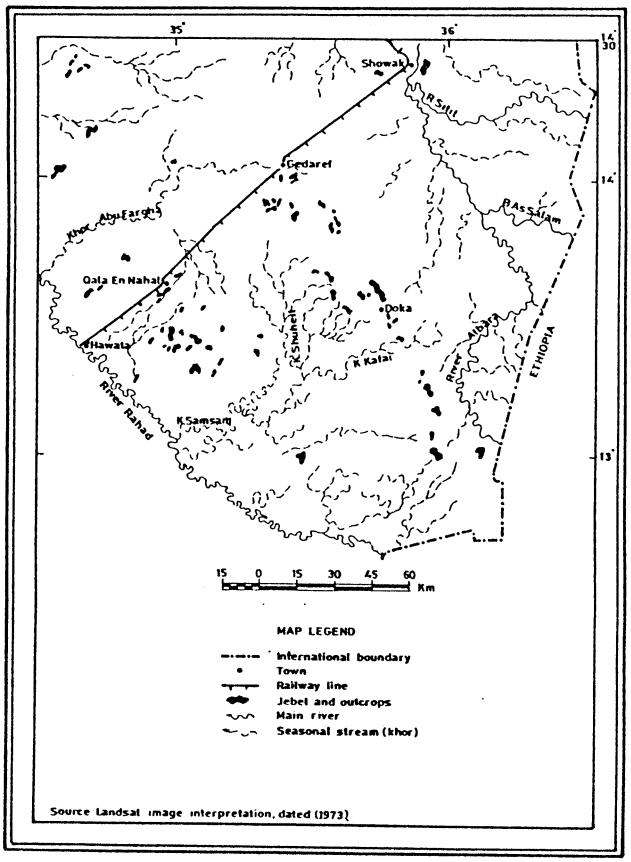
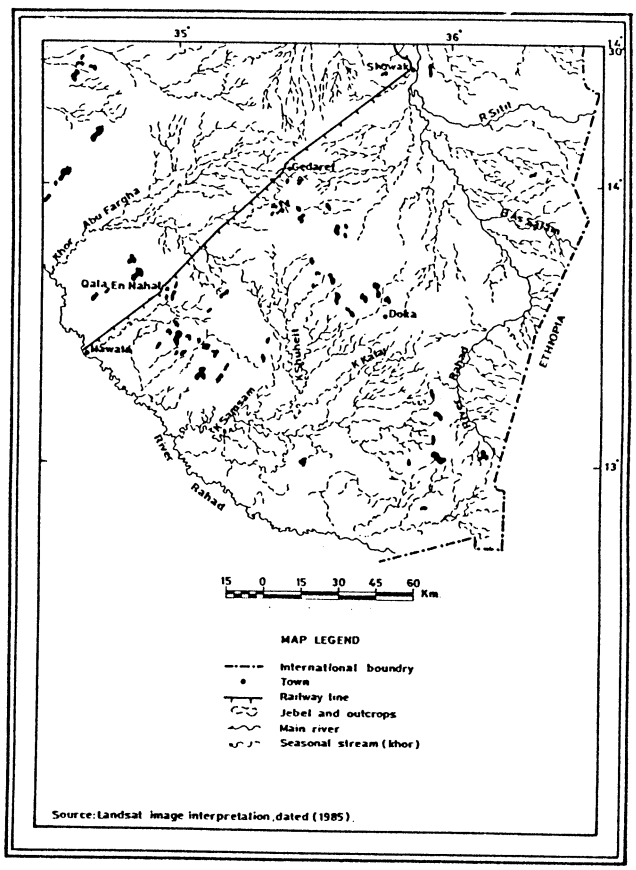
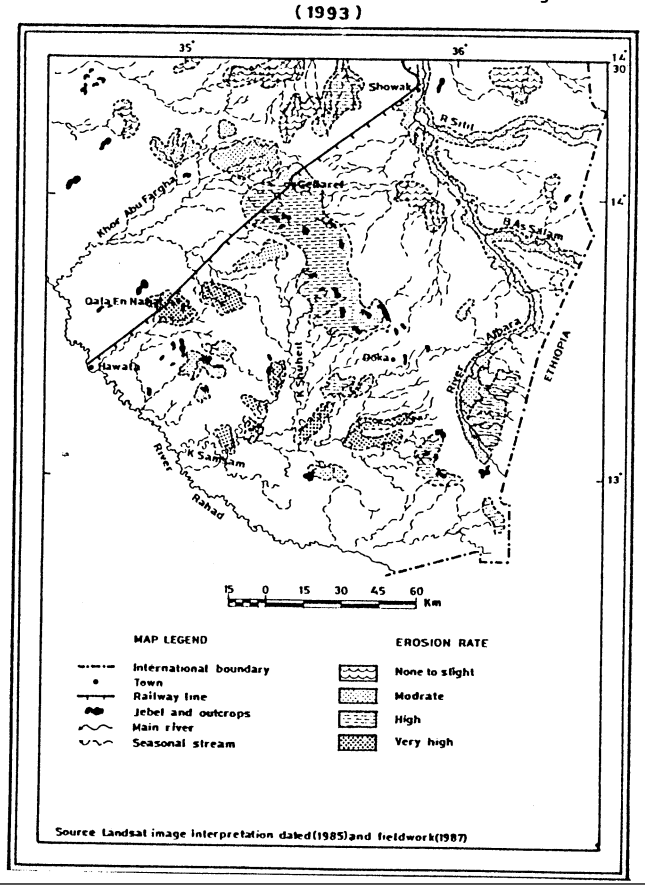


Fig. 5:Drainage density - Gedaref region (1993)



The 1973 images show slight degradation rate, while the 1993 map (Figure 6) shows substantial increases in degradation rate. The degradation range between slight to high.

Fig. 6:Present degradation/erosion rate,Gedaref region (1993)



It is worth mentioning that the rate of the erosion rate varies with the infiltration capacity of the soil, the vegetation cover as well as topographic features.

The results of the performed study showed the tremendous land degradation and environmental changes occur in Gedaref Region.

It is evident that the transformation of the natural vegetal cover and introduction of semi mechanization, land use practices and woody material harvesting is the main factors led to stake up the normal changes that could occurs. According to the interpretation of the multi-temporal remotely sensed data the observed changes started in early seventies of this century a time span that coincides with Sudan strategy for horizontal increases in agricultural investment and the invasion of the draught period over the Sahelin zone.

The sensed data provide repetitive coverage over large areas permitting capability in mapping land resources and assessing land degradation. The information provided is so important and essential since any strategy for sustainability in the region should consider the past ecological condition.

7. Conclusion

The outcome of the performed study present the following conclusions:

1. The Gedaref Region once it was one of the richest natural resources base area of the Sudan suffer from the spread of the semi mechanized farming (large areas has been cleared off its natural vegetation cover to facilitate tractors ploughing) wood cutting for commercial and domestic purposes.
2. The spread of the mechanization and deforestation is at the expenses of the other land resources e.g. pasture, forest, indigenous small-scale rainfed cultivation, game reserved area etc.
3. It seen pertinent to assume that the environmental changes are the consequences of the radical changes in the vegetal cover since deforestation enhanced soil degradation and increases of the surface runoff and erosion processes.
4. The application of the remotely sensed data cartography methodology for land resources mapping and monitoring has demonstrated a number of points;
   a. Sensed data used provide smart and powerful tools and means for land resources mapping and monitoring and generating of efficiently reliable fast and useful information for sustainability.
   b. Multi temporal remotely sensed data analysis is mostly powerful in detecting the dynamic processes of land resources and changes that occurs over time.
   c. Major land use/land cover at level 1 and 11 can be separated easily using landsat images.
   d. The 1973 data provide biological conditions that exist in the area before the period of draught and the spread of mechanization in the region that can help in understanding and putting the clock back.
5. The simple methods used for mapping and monitoring land resources within the various constrains in developing countries (Sudan) where sophisticated technological support is not at hand it is thus possible to produce thematic maps for sustainability.

Therefore remotely sensed data can best be adopted to fit the land resources inventory and mapping in the developing countries where bad economic situation existing, sophisticated technologies are expensive, technologies know how is lacking, equipment are badly used, base line information are scarce if not totally existed etc.

References

Al Awad, S. M., 1991. Land use/land cover practices, changes and consequences. Gedaref Region, Eastern Sudan. Unpublished M.A. thesis, University of Khartoum, Sudan.

Ali, M. A., 1973. Key for the identification of soils in Eastern Sudan. Kassala Province. Soil Survey Administration, Wad Medani, Sudan.

Harrison, M. N., Jackson, J. K., 1958. Ecological classification of the vegetation of the Sudan. Forest bulletin no 2, forest Department, Khartoum, Sudan.

Hudson, N., 1986. Soil conservation. BT Batsford Limited, London, 324 p.

Lillisand, T.M., Kiefer, R.W., 1994. Remote Sensing and Image Interpretation, 3rd eddition, John Wiley and Sons, New York, 750p.

Van der Kevie, V. W., Buraymah, I.M. 1976. Exploratory soil survey of Kassala Province: A study of physiography, soil and agricultural potential. Soil Survey Administration, Sudan, report no 78.

Musa, S. B., 1986. Evaporation and soil moisture depletion in the Gedaref Region of East Central Sudan. Unpublished Ph. D. thesis, Swansea.

Whiteman, A. J., 1971. The geology of the Sudan Republic. Clareden Press, Oxford.