

**WOODY VEGETATION DAMAGE ASSESSMENT
USING LANDSAT IMAGERY AND GIS**

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ABSTRACT:

This paper presents the application of landsat imagery for mapping and assessing the forests damage. To fulfil the goals of this study landsat thematic mapper (TM) hard copy images were used. Moreover the paper presents the advantages of the false color images, to differentiate between the vigorous vegetation and the dead forests. In addition to that the study has carried out a comparison operation for the land cover change in the study area in three periods, namely (1958, 1972, and 1985). For this task extra data were used; those are multispectral scanner hard copy images acquired in 1972, and land cover maps produced from aerial photographs acquired in 1958. This assessment and comparison was done with the aid and use of the GIS applications (Arc/ Info, software).

The comparison of the land cover over the three periods (1958, 1972, and 1985) showed a clear change (increase) in the forest damage.

1. INTRODUCTION:

The drought of 84-1985 in the Sudan has put clear signatures on the vegetation cover. Kurdofan and Darfor states, were the most affected areas by the drought. That is most of the vegetation cover was damaged and the (natives) have faced a great famine. This drought has led to a desertification phenomenon caused by the human being and the animals. The farmers posed by the decline of the soil productivity began to increase the area of their farms horizontally. Doing this they continued cutting the wooded areas, because the soil under the wooded area is of good fertility. Also an over grazing process was produced by the large amounts of animals which have suddenly lost the usual range and pasture. The inventory and assessment of the amounts of damage for this large area, needs the use of remotely sensed data.

The purpose of this paper is to try to develop a methodology based on the interpretation of landsat imagery (hard copy) as a mean of vegetation damage assessment, supported by field check data. Also to make use of the inventory of the wood areas, which were destructed and changed to cultivation areas, and comparing these areas with damaged areas in other data sets taken in different dates.

The study area chosen is Abu Zabad area. This area is included in the worksheet of Abu Zabad enclosed between latitudes 13° 00' - 14° 00' North and longitudes 28° 30' - 30° 00' East. Four training areas were chosen for the evaluation of the land cover change, which is caused by the effects of the desertification. These training areas are Sa'ata Ezzarqa, Hillat Said, Abu Ku', and Addibeibat area. All these training sites were interpreted for the damaged vegetation. This vegetation is damaged by the drought in some areas, and by cutting the wood trees for cultivation in others. Moreover animal over grazing also take place in some areas.

To fulfill these goals land use/land cover maps were produced for the study area (represented by the above mentioned training sites). These maps included the following land cover types:

1. Cultivated areas (and these includes the damaged areas, the cultivated, and over grazing areas).
2. Vegetation areas (areas not utilized).

2. Materials and Methods:

- (i) Two sets of landsat imagery were interpreted. The first data set was thematic mapper (TM) imagery composed of a false color scene and a true color scene (mosaic). The specifications of this set were explained in table 1 below.

Scene No.	Path/ Row	Acquisition date	Band combination	Color composite	Remark
1	175/51	03.11.1985	2,3,4	B,G,R	False color
2	175/52	06.11.1986	2,4,7	B,G,R	True color

Table 1: Specifications of the TM imagery set

- (ii) The second set of landsat data is a multispectral scanner (MSS) imagery acquired in Nov. 1972 in black and white. The images were of separate bands; those were band 4, band 5, and band 7.
- (iii) The third information data is a land use/land cover map, produced by the Sudan Survey Department (SSD) in cooperation with the Hunting Technical Service (HTS) at the SSD laboratories.
- (iv) The training sites of the two sets of images were interpreted and delineated, and the land use/land cover strata were labeled after the field checks.
- (v) The strata were then digitized using the GIS, (ARC/INFO) software.
- (vi) For the MSS data, bands 4 (green), and band 5 (red) are usually best for delineating cultural features such as urban areas, roads, new subdivisions, gravel pits, and quarries (Lillesand, and Kiefer, 1979). Therefore it was found very easy to interpret the vegetational features versus the cultivated areas.

3. Results:

3.1 Interpretation of landsat TM images:

In the first and second training sites (Sa'ata Ezzarqa, and Hillat Sa'id) which lie in the false color scene, the areas of the healthy vegetation were very clear, they are represented by the red color. This reflection is coming from the near infrared (NIR) band 4. The chlorophyll pigment is highly reflected by the NIR band 4. The cultivated areas appeared in a pale brown color characterized by their rectangular shapes. The fallow areas were shown on light tones in between the farms. The damaged areas were highly reflected by the visible spectral (vs) band 3 (the chlorophyll absorption band). This reflection depends on the degree of the death and damage. Therefore it is characterized by its green color where the vegetation is severely damaged and appears dark green where the vegetation is slightly damaged. The damaged vegetation has on the reverse lower reflection on the NIR band 4. The bare areas (sand) were shown by the yellow color. This reflection is coming from the composition of the visible spectral (vs) band 3 (green), and the NIR band 4 (red), see sample image-1. The final land cover classification of these two training sites is shown on maps. These maps are produced using the facilities of the GIS (Arc/Info software), see sample map-1. The third and fourth training sites (Abu Ku' and Addibeibat area), lie in both the two scenes (the false color one and the true color). In the true color scene, the healthy vegetation is represented by the green color. This reflection is coming from the NIR TM4 (green), and this is found along the wadies and in the depressions. The cultivated areas appeared in pinkish color and characterized by their rectangular shapes. This color is coming from the composition of the blue reflection that is coming from the (vs) band TM2, and the red reflection coming from the middle infra red (MIR) band TM7. The mountainous area in the south of (Addibeibat subset) appeared in (pinkish) color. This color is coming from the reflection of the rock in the MIR band TM7 (red), combined with the reflection of the scattered vegetation in the (vs) band TM2 (blue). This mountainous land is part of the famous Nubian Mountain.

Generally the interpretation and field checks showed that the land use in the study area is as follows:

- 1- Cultivated agricultural areas.
- 2- Forestry/ Fuel wood.
- 3- Populated.

3.2 Interpretation of Landsat MSS for Land use/ land cover:

The interpretation of the MSS images acquired in 1972 showed that the land cover of the area is composed of healthy vegetation (scattered in some areas and dense in the others), and cultivated areas in addition to the populated areas. The villages and towns represent the populated areas. These towns appear as dark tone masses and characterized by the light tone roads that are coming towards them. The vegetated areas are clearly identified in the (NIR) band MSS 5. These are characterized by their dark Grey tone.

3.3 Maps of the Aerial Photographs:

These maps were produced from an uncontrolled mosaic of aerial photographs acquired in 58-1958. On these maps the cultivated areas seem to cover small areas compared to the areas not utilized (vegetated areas). This means that there was enough rainfall, no major drought effects, and consequently farmers had no need to expand their farms against the vegetated areas. Also the soil productivity is good enough. From these results we come to an early conclusion that people at that time were not practicing the agricultural works, and they were nomads.

3.4 Comparison of the land use/ land cover Areas:

The maps of the land use/ land cover over the three periods gave a computation of the cultivated areas, (which stands as a witness to the destruction caused by the desertification). The percentages of these destructed (cultivated) areas of the four subsets were also computed, see tables 2, 3, 4, and 5. The areas for the different land cover types were computed using the facilities of the GIS system (ARC/INFO software). Fig. 1 shows the graphs of the percentages of change of the cultivated areas for the four subsets.

Year	Total area in (Hectares)	Cultivated area in (Hectares)	Percentage of The cultivated area
1958	213207.5	22736.39	10.66%
1972	213207.5	34402.14	16.14%
After 84-1985	213207.5	85384.84	40.05%

Table 2: The amounts and percentages of the cultivated areas in Sa'ata Ezzarqa Subset

Year	Total area in (Hectares)	Cultivated area in (Hectares)	Percentage of The cultivated area
1958	189271.7	36451.26	19.26%
1972	189271.70	61679.53	32.59%
After 84-1985	189271.7	92114.51	48.67%

Table 3: The amounts and percentages of the cultivated areas in Hillat Sa'id subset

Year	Total area in (Hectares)	Cultivated area in (Hectares)	Percentage of The cultivated area
1958	159340.77	39409.17	24.73%
1972	159340.77	57180.26	35.89%
After 84-1985	159340.77	99919.21	62.71%

Table 4: The amounts and percentages of the cultivated areas in Hillat Abu Ku' subset

Year	Total area in (Hectares)	Cultivated area in (Hectares)	Percentage of The cultivated area
1958	149964.77	13148.86	8.77%
1972	149964.77	4628.83	3.09%
After 84-1985	149964.77	13959.10	9.31%

Table 5: The amounts and percentages of the cultivated areas in Addibeibat area.

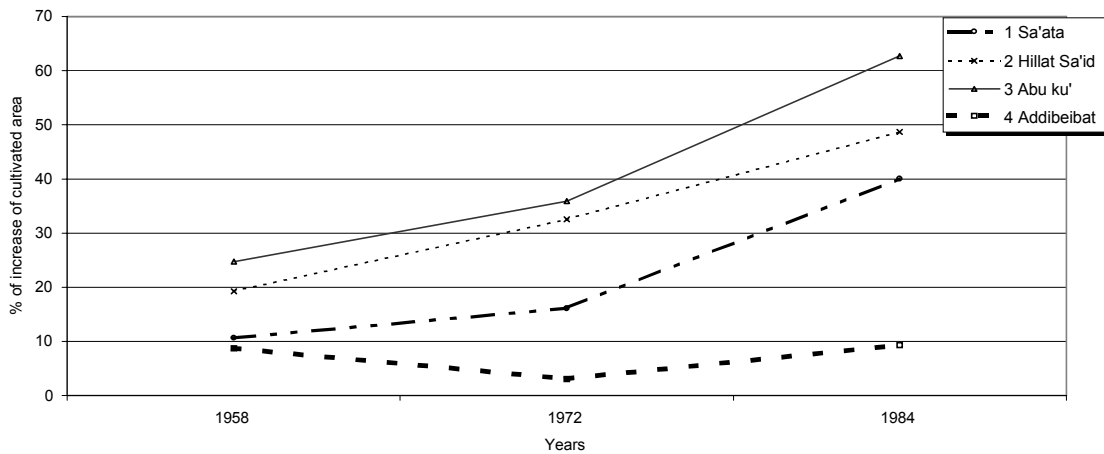


Fig. 1: A graph showing the increase of cultivated area relative to the total training area

4. Discussion:

The study provides a rich information about the land use/land cover change that has happened in the area since the year 1958, through the year 1972, and up to the period after the drought of 84-1985.

Tables 2, 3, 4, and 5 showed generally an increase of the cultivated area through the three imaged periods, and the vegetated (forest) areas were decreasing. In table 2, which explains the land use situation at the first subset (Sa'ata Ezzarqa), the amount of the total area of the subset is 213207.50 hectares. Of this area about 22736.89 hectares were cultivated (or destructed) in 1958, giving a percentage of 10.66% of the total area. On the year 1972, the total cultivated area was 34402.14 hectares giving a percentage of 16.14%. The last period after the drought of 84-1985, the total cultivated area was 85384.84 hectares, giving a percentage of 40.05% of the total area. These records show a change (increase) of the destructed area of 11665.25 hectares, giving an annual change of 833.23 hectares through the period 1958-1972 (14 years), with an annual percentage of change (increase) of 0.39% over the whole training area. For the period 1972-1985 (13 years) the change is 50982.7 hectares, giving an annual change of 3921.75 hectares during these 13 years, with an annual percentage of change of 1.84% over the whole training area. This is shown on table 6 below:

Range of time	Cult. area in 1958 (hect.)	Cult. Area in 1972 (hect.)	Cult. Area in 1985 (hect.)	No. of years	Amount of change (hect.)	Annual change (hect.)	% of annual change
1958-1972	2276.89	34402.14	_____	14	11665.25	833.23	0.39%
1972-1985	_____	34402.14	85384.84	13	50982.70	3921.75	1.84%

Table 6: Annual change of the destructed areas at Sa'ata Ezzarqa area

The amounts of change for the other three training areas (Hillat Sa'id, Abu Ku', and Addibeibat) with the percentages of the annual change are shown below in tables 7, 8, and 9 respectively.

Range of time	Cult. area in 1958 (hect.)	Cult. Area in 1972 (hect.)	Cult. area in 1985 (hect.)	No. of years	Amount of change (hect.)	Annual change (hect.)	% of annual change
1958-1972	36451.2	61679.53	_____	14	25227.27	1802.12	0.9%
1972-1985	_____	61679.53	92114.51	13	30434.98	2341.15	1.24%

Table 7: Annual change of the destructed area at Hillat Sa'id area

Range of time	Cult. area in 1958 (hect.)	Cult. Area in 1972 (hect.)	Cult. area in 1985 (hect.)	No. of years	Amount of change (hect.)	Annual change (hect.)	% of annual change
1958-1972	39409.17	57180.26	_____	14	17771.09	1269.36	0.8%
1972-1985	_____	57180.26	99919.21	13	42738.95	3287.61	2.06%

Table 8: Annual change of the destructed area at Abu Ku' area

Range of time	Cult. area in 1958 (hect.)	Cult. Area in 1972 (hect.)	Cult. area in 1985 (hect.)	No. of years	Amount of change (hect.)	Annual change (hect.)	% of annual change
1958-1972	13148.86	4628.83	_____	14	8520.03	608.57	0.41%
1972-1985	_____	4628.83	13959.1	13	9330.27	717.71	0.48%

Table 9: Annual change of the destructed area at Addibeibat area

5. Conclusion:

By taking the averages of the percentages of change over the four training areas, it is found that the average percentage of annual change is 0.43% in the period 1958- 1972, and about 1.41% in the period 1972- 1985.

Tables 6, 7, & 8 showed an increase in the annual destructed area over the period of comparison in the first three training areas namely: Sa'ata Ezzarqa, Hillat Sa'id, and Abu Ku').

In the fourth training area (Addibeibat): table 9, different results were recorded. In this area the amount of the destruction was noticed to be 13148.96 hectares in the year 1958. This amount was decreased to 4628.83 hectares in the year 1972, and again it has increased to about 13959.1 hectares in the year 1985 (which is the year of the severe drought). The field check has shown that this area lies in the south part of the railroad (Obeid- Errahad- Abu Zabad- Nyala). This area is covered with dense vegetation; the main species of it is the *Acacia melliphra* species, which constitutes a large shelter-belt. The root system of this tree species constructs a very consolidated soil that can hardly be dissected or blurred by the wind or the other agents. Also the area has got a large system of drainage (streams and Khors). This drainage system do capture the amounts of waters for a long season, which will in turn keep the vegetation cover more green and dense, a condition that makes it hard enough to be removed or blurred by the farmers. Also the rainfall in this part of the study area is better than that of the northern and western parts, where the other training areas lie.

The study provided a rich information about the land use/land cover change that happened in the study area. It provided an excellent technical assistance for combating the desertification phenomenon and the declining soil productivity in the area. The conclusion drawn have shown the dynamics of the landscape change in the area and clearly revealed the need for sustainable use of the land in the future. This could be easily achieved by integrating Landsat data with GIS.

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