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Research Application Summary

Monitoring sand accumulation in five villages west of Omdurman, Sudan by GIS

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Abstract

This study aimed at assessing the impact of desertification on the environmental situation in west Omdurman area. The study used GIS techniques to analyze the digital data obtained from satellite image to monitor desertification and thickness of sand accumulated in five villages west of Omdurman, Sudan. These villages are; Um Harout, Gabert Saeed, Wad Omer, Wad Abdo and El Zeriat. The study also used data and information obtained from relevant official sources. The analysis of digital data from the satellite image indicated that El Zereiat and Gabrat Saeed villages were covered by very thick sand (>50 cm) on rocky surfaces (mostly dunes). Wad Abdo area was covered by thick (25-50 cm) sand. Most of Um Harout and Wad Omer areas were covered by thin vegetation and thin sand sheet. The study recommended establishment of shelterbelts and windbreaks to reduce the effect of sand movement; use of water harvesting techniques for supplementary irrigation; and enforcement of the environmental laws and legislations for better management and protection of natural resources.

Key words: Desertification, digital data, irrigation, vegetation, windbreaks

Résumé

Cette étude visait à évaluer l'impact de la désertification sur la situation environnementale dans la région ouest d'Omdurman. L'étude a utilisé des techniques SIG pour analyser les données numériques obtenues à partir d'images satellites afin de suivre la désertification et l'épaisseur de sable accumulée dans cinq villages à l'ouest d'Omdurman, Soudan. Ces villages sont; Um Harout, Gabert Saeed, Wad Omer, Wad Abdo et El Zeriat. L'étude a également utilisé des données et des informations provenant de sources officielles pertinentes. L'analyse des données numériques de l'image satellitaire a montré que les villages El Zereiat et Gabrat Saeed étaient couverts de sable très épais (> 50 cm) sur des surfaces rocheuses (principalement des dunes). La zone de Wad Abdo était couverte de sable épais (25-50 cm). La plupart des zones d'Um Harout et de Wad Omer étaient recouvertes d'une fine végétation et d'une mince couche de sable. L'étude a recommandé la création

de brise-vent pour réduire les mouvements du sable; les techniques de récolte de l'eau pour l'irrigation supplémentaire; et l'application des lois et des législations environnementales pour une meilleure gestion et protection des ressources naturelles.

Mots clés: Désertification, données numériques, irrigation, végétation, brise-vent

Introduction

Desertification is the major environmental problem that has an adverse socio-economic impact, particularly in the arid, semi-arid and dry sub humid lands of developing countries such as Sudan. Desertification results in land degradation, which is described as a process that reduces the current and potential productive capacity of land (soil, land surface, vegetation and local water resources, (United Nations, 1992). Vegetation zones have been shifting southward as a result of overgrazing, wood cutting and accelerated soil erosion (Eckholm, 1977). There is need for assessment of desertification status and environmental changes for the purpose of monitoring and predicting the productive capacity of rangelands and marginal agriculture areas. This was to be detected as they were caused by shifting the climatic zones, human activities or a combination of both. Assessing the risk of desertification is a first step in this direction. However, the Sahelian areas do not have adequate data which can be used to measure trends in land degradation or desertification (Toulmin, 1995).

The problem. During the last decade there has been increased interest in environmental change, now considered as one of the most serious problems facing arid and semi- arid regions. West Omdurman area provides a case in point, as it has been dominated by desert encroachment. This process continues to cause damage to livelihood sin that area. West Omdurman suffered from desertification and drought combined with irrational use of natural resources resulting in land degradation of the area. These are reflected in soil erosion, reduction in vegetation cover and misuse of land (Doka and Hamid, 2006). The objective of this study was to assess the impact of desertification on the environmental situation in West Omdurman area. The study hypothesised that misuse of natural resources and overgrazing increases desertification and environmental changes and that sand movement may result from fluctuation in climate.

Environmental change in Sudan

According to (Suliman and Ali, 1983) the total area affected by desertification in Sudan is about 1,528,000 km^2. Nordwijk (1984) reported that the original vegetation cover was removed for cultivation and provision of fuel wood. Suliman and Ali, (1983) maintained that most of the forage species have disappeared because of grazing of early growing grass, which impaired plants to complete their life cycle. Thus completely denuded areas are created, and these act as foci for potential desertification. Also they reported that agricultural expansion in the previously productive range lands has led to over stocking of animals in squared pasture lands. On the other hand, the expansion of cultivation on marginal lands adds to depletion of natural vegetation. Dixey and Aubert (1962) estimated the advance of

sand dunes encroachment in some agricultural land in Sudan was at rate of 1 to 3 km per year.

Monitoring environmental change

Vegetation in areas at risk showed moisture stress that resulted in changes in the vegetation cover. Data of vegetation cover can be obtained from remote sensing satellites such as: LANDST, SPOT, MSS and/or TM. These can be used for monitoring environmental changes. They are combined with data from field check observations to increase the precision of information for continued monitoring of climatic change and desertification. FAO stressed the importance of integration between information derived from high resolution satellites images and GIS combined with ground data gathered through GPS (FAO, 1993).

Definition of remote sensing and Geographic Information System (GIS)

Sabins and Floyd (1986) defined remote sensing as collecting and interpreting information about a target without being in physical contact with the object. According to (Nasri, 1999) remote sensing may be defined as the acquisition of information about an object from a distance without being physically in contact to it, by detecting and measuring changes in the reflected electromagnetic energy. Aronoff (1991) defined GIS as a computer-based system that provides the following capabilities to manipulate geo-referenced spatial data: input (encoding), data management (storage and retrieval), analysis and output.

Materials and Methods

Location and extent of the study area. The study area is located in West Omdurman, between longitude 30 -31°, 32° -15'E and latitude 16° N. It is situated along the western

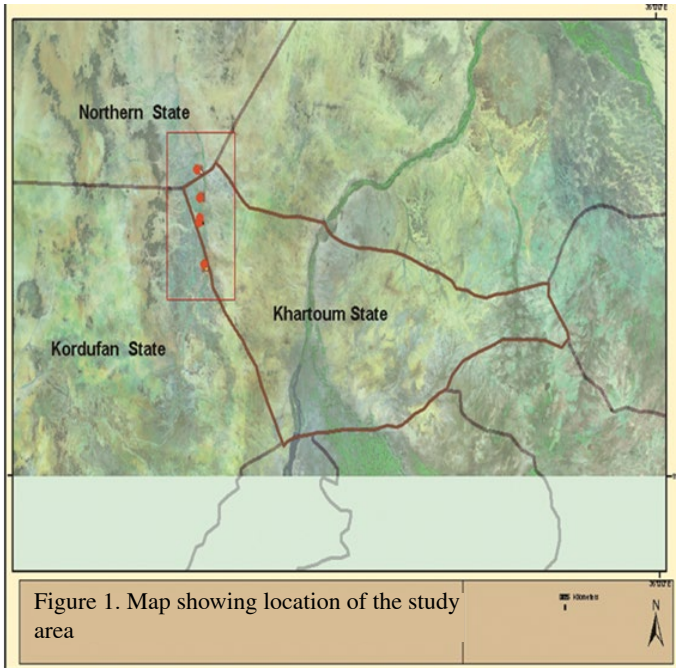

Figure 1. Map showing location of the study area

parts of White Nile and River Nile and extends westwards to Kordofan State and northwards to the southern boundaries of the Northern State (Figure 1).

Land scape

The land scape of the study area is plain, almost free from any high lands, except for some small rocky hills lying in the western part on the boundaries between Khartoum State and northern Kordofan State. The features of the main land have been formed as a result of complex natural processes acting on the geomorphic surfaces. The following geomorphic and drainage systems have contributed mostly to the shaping of the different land surfaces: a) Wadi Almugadam lower flood plain system and depressions; b) the River Nile drainage system; c) Wadi Almugadam drainage system; d) plateaus, hills and rocky areas and e) drainage channels.

Two types of data were used namely; primary and secondary data. Secondary data were collected from reports, documents, scientific papers and from the internet. The primary data were collected through remote sensing and GIS satellite imagery. The data collection methods and the analytical techniques used are discussed below.

Satellite imagery

One sub image from land-sat covering the study area was used in this study. The sub image from land-sat was composed of three bands each of wavelengths of the electromagnetic spectrum, acquired by the Thematic Mapper TM (2003).The characteristics of this image are shown in Table 1.

Table 1. Characteristics of imagery used in this study

Image	Path/Row	Sensor	Band	Resolution	Scale	Area (km^2)	Date
1	173/49	TM	1-3	30m	1:1000000	185 185	2003

Source: Satellite image, 2003

Hardware and software used included:

a) PC Pentium III 40 GB.HD, 800MHz speed and 96 RAM; b) Microsoft Word 98 for word processing and c) Internet and other sources.

Methods

An integrated approach using remote sensing (RS) and geographical information system (GIS) was followed. Arc View (Advanced Spatial Analysis using Raster and Vector Data) was used for analysis and final production.

Remote sensing methods. This RS facilitates the study of the surface vast areas form and remote device, which saves time and money. Remote sensing technology was used in this study to: 1) A acquire data on the study area in the form of an image; 2) Data imputes processing were used to: a) produce sub image; b) enhance sub image; c) produce the

color composite and d) perform clustering, filtering and classification. Remote sensed data produced by Land-sat Thematic Mapper (TM) image was visually interpreted using the facilities of image interpretation of the laboratory of the Remote Sensing Authority (RSA). Sand cover percentages and accumulation thickness had been detected and different maps were generated.

GIS Technique. GIS consisting of package of computer program used for data capture, input, manipulation, transformation, visualization, combination, query, analysis, modeling and output. The following GIS functions were performed in the process of analysis of digital data from satellite image.

Field work. Field work was conducted from 10/4/2007 to 20/5/2007 in an area of 128 km^2 (sample area) which represented the study area. GPS (Garmin 12) was used to navigate among check sites and to record the coordinates of each check site.

Results and Discussion

Sand cover percentages and accumulation thickness. Table 2 shows the percentages of sand cover and its accumulation thickness in five villages. It was found that Um Harout and Wad Omer areas had 87% sand cover percentage and accumulation thickness (C). These areas were covered by thin vegetation and thin sand sheet (62% cover) and a complex of bare ground with thin sand sheet and low hummocks (21% cover) (Fig. 2). Moreover, most of Wad Abdo area had thick sand accumulation of cover (B) occupying 57% of the total area. Most of this thick sand covers lies on dissected bare stony and rocky surfaces (43%). Consequently about (33%) of Wad Abdo area was covered by thick vegetation on Wadi flood plain (Fig. 3).

It was observed that Gabrat Saeed village had no sand cover percentage and accumulation thickness (D), which indicates no aeolian sand cover with percentage 39%, this area, is dominated by thick vegetation on Wadi flood plain which is represented by the existing forest. However, there was a thick (25-50 cm) sand cover (A) with percentage 31%; this may be due to fluctuation in climate and drought. Over grazing for a long time has been considered as the primary cause of desertification in Africa. But it is now thought that the long terms of drought are

Table 2. Sand cover percentage and accumulation thickness in study area

Sand cover percentage and accumulation thickness	Sand cover map units	Percentage of sand			
		Um Harout and Wad Omer	Wad Abdo	Gabart Saeed	El Zereiat
A	1-Very thick sand sheet with low dunes + Few vegetation	-	4.2	-	35
	2-Very thick sand on rocky surfaces	-	-	31	-
B	3-Rocky surfaces with patchy sand surfaces	2	14	30	-
	4-Thick sand sheet < 25 cm with hummocks	-	-	-	19
	5-Thick sand cover on dissected bare stony and rocky surfaces	-	43	-	-
C	6-Bare ground	4	5.5	-	16
	7-Complex of bare ground + thick sand sheet + low hummocks	21	-	12	
	8-Thin vegetation with thin sand sheet	62	-	-	18
D	9-Thick vegetation on Wadi flood plain	11	33.3	39	-
	Total	100	100	100	100

Source: Field survey, 2007.

A- Very thick sand > 50 on bare or rocky surfaces (mostly dunes). B- Thick (25-50 cm) sand covers. C- Thin (<25 cm) sand cover. D- No aeolian sand cover

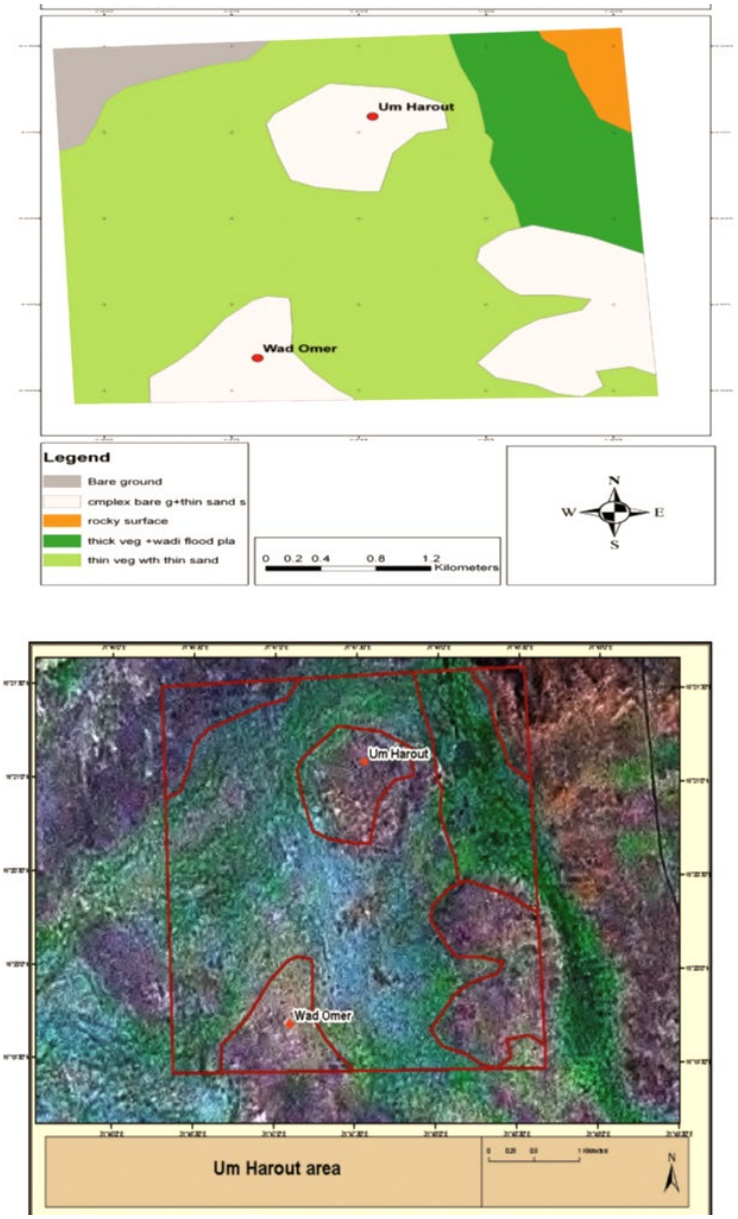

Figure 2 (a) and (b) . Sand cover percentage in Um Harout area

more important causes including over use of firewood for cooking resulting in reduced tree cover, overgrazing of rangeland and pastures, among others. The rest of the area is covered by rocky and patchy sand surfaces (B) 30 % (Fig. 4).

The sand cover percentage and accumulation thickness in El Zereiat village was (C), with percentage 46%. It appears also, there was very thick sand sheet (25-50 cm) with

low dunes and little vegetation, with percentage 35 % (Fig.5).This result showed that El Zereiat village was prone to accelerating sand encroachment since it is located within wind corridors. It may be concluded that Elzereiat and Gabrat Saeed villages had the same sand cover percentages and accumulation thickness (A), which was very thick sand (>50 cm) on rocky surfaces (mostly dunes) for each percentage value of 35% and 31% respectively. Wad Abdo area had sand cover percentage and accumulation thickness (B); which was thick (25-50 cm) sand cover with a percentage of 57%.

It was revealed that Um Harout, Wad Omer and El Zereiat villages were covered by thin vegetation with thin sand sheet and bare ground with cover percentage values of 87%, and 46% respectively. This result may be due to the over use of firewood from trees for

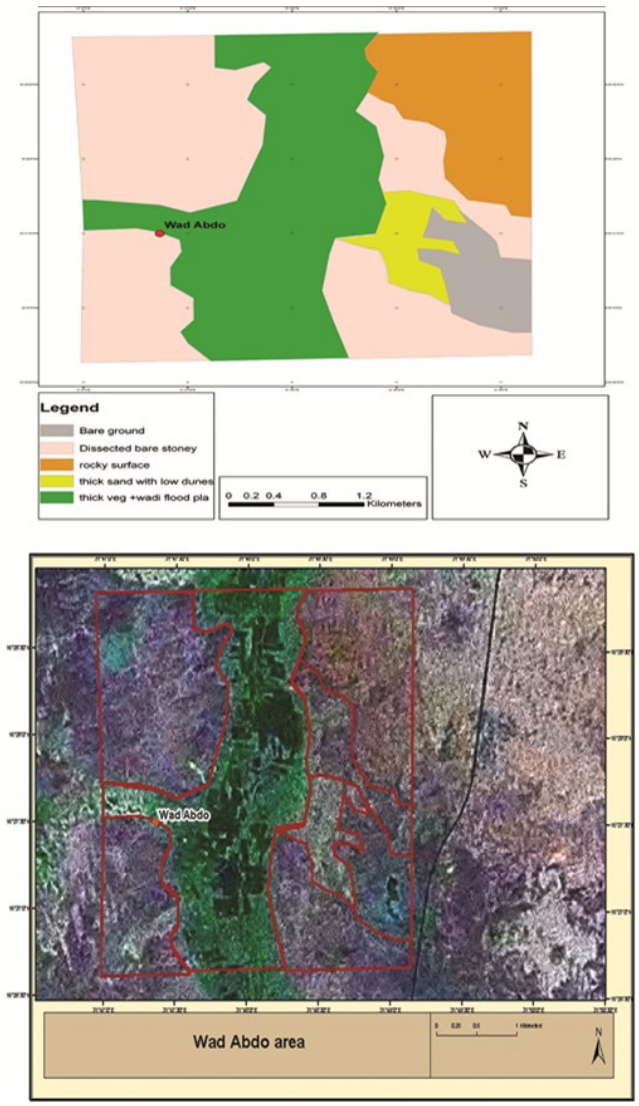

Figure 3 (a) and (b). Sand cover percentage in Wad Abbdo area

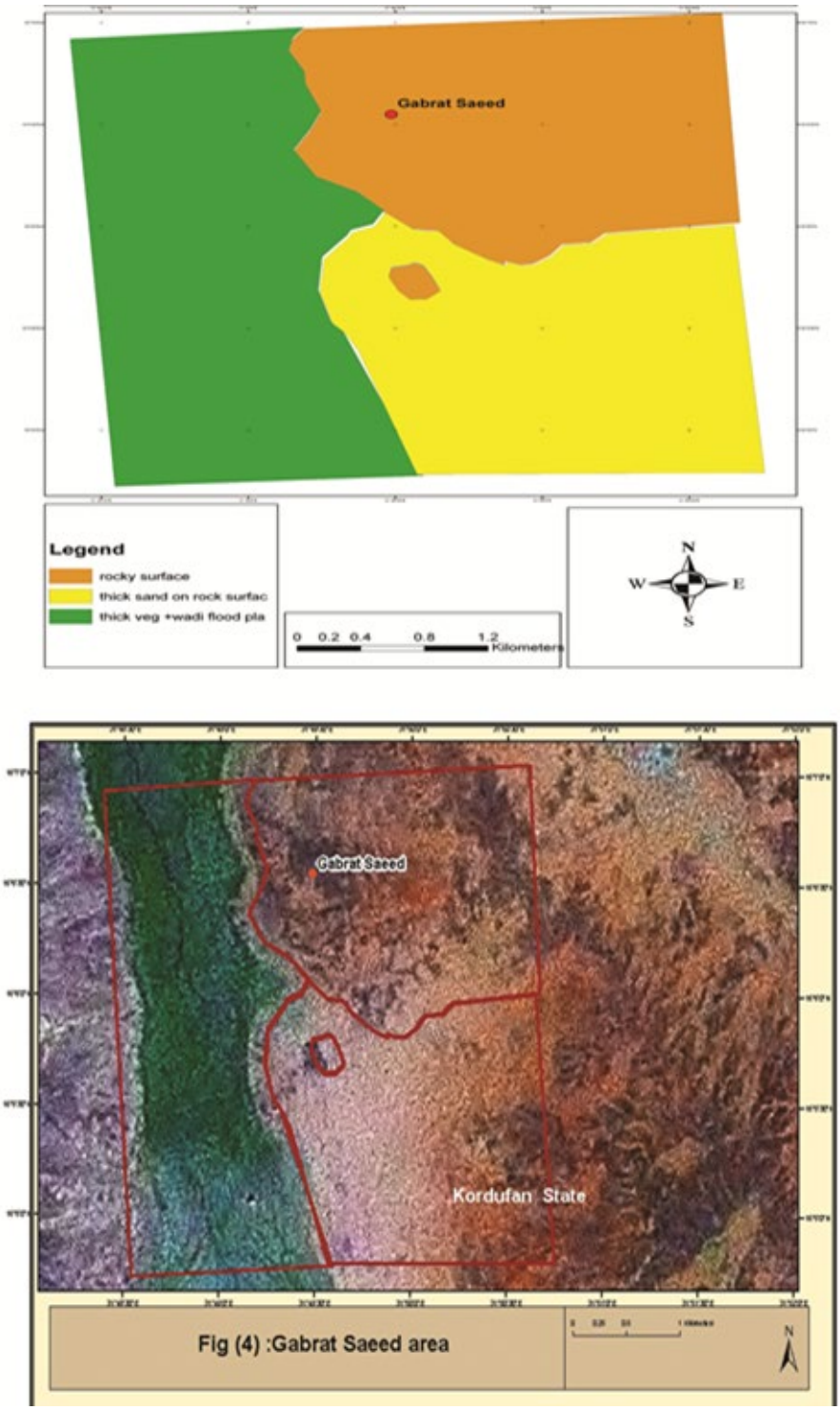

Figure 4 (a) and (b). Sand cover percentage in Gabrat Saeed area

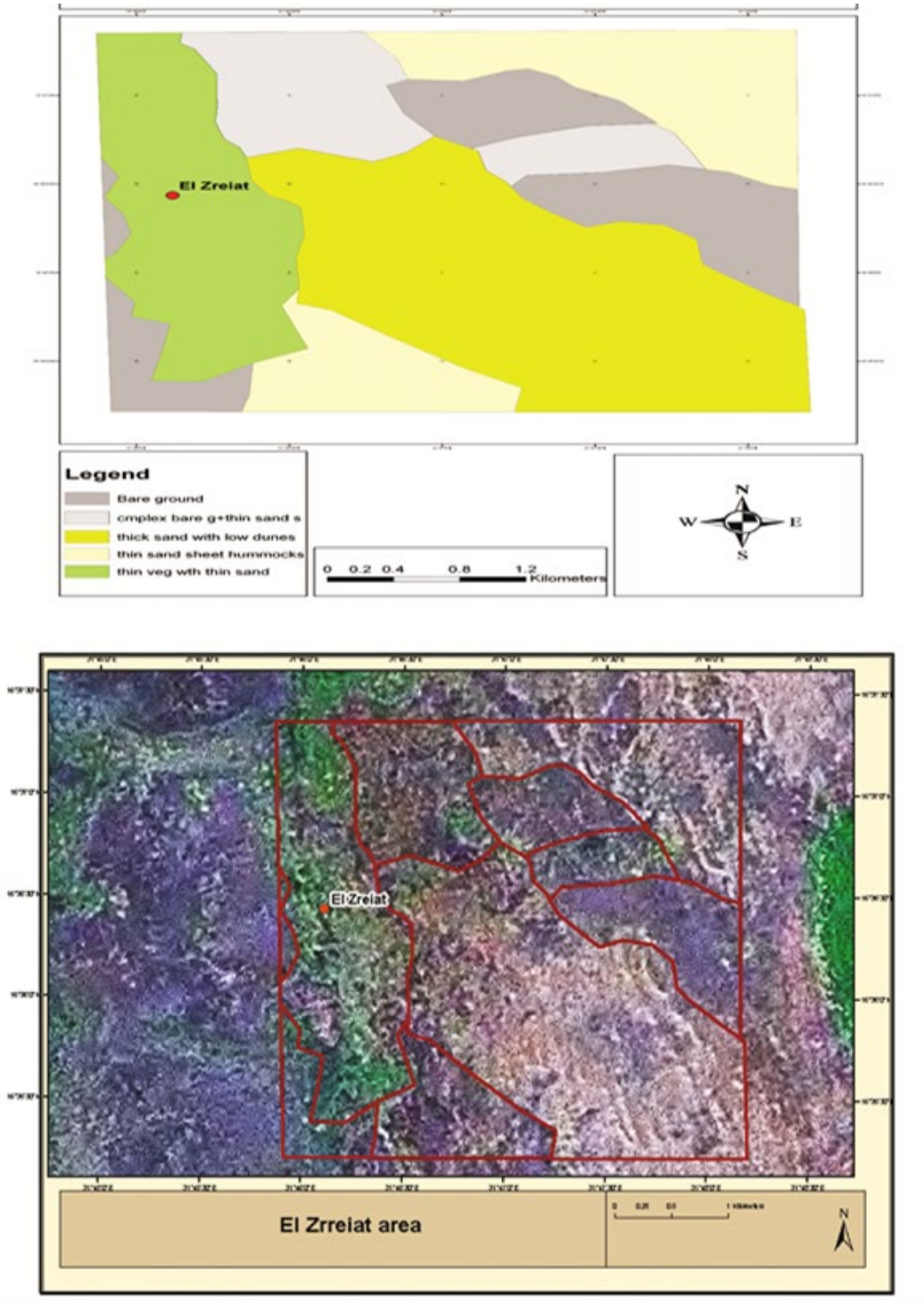

Figure 5 (a) and (b). Sand cover percentage in El Zeriat area

cooking, causing severe reduction in tree cover and increased desertification process. This result agrees with Grainger (1990) who reported that the reduction of vegetation cover takes place due to trees cleared are for cropping, chopping for fuel wood and overgrazing of rangeland or pastures. Also Abdallah (1991) ascribed desertification to over cutting of forest for charcoal production. From the field work, it was observed that the recent environmental situation corresponded with data collected remotely for the study. It was observed also that these villages had some shrubs and trees desirable by sheep grazing around the area. The people relied on sheep for milk production. However, that area received rainfall rarely and the deterioration of grazing pastures. People of all villages complained about deteriorating grazing land and sand encroachment, which led to death of their animals. Animal pasture was deteriorated by over grazing, over cutting of trees and the effect of sand encroachment. Furthermore, the low and scare rainfall lead to failure of agriculture. As a result, people migrated searching for work to increase their income. A common trend has been movement to trading and other marginal jobs due to low and inadequate income derived from pastoralism and agriculture.

Recommendations

The study recommends the following: 1) Establishment of shelterbelts and windbreaks to mitigate and prevent the sand encroachment (based on suggestions by the respondents); 2) use of various conservation techniques such as mulching and water harvesting approaches to improve soil structure and water availability in a way to increase productivity; and 3) Application of appropriate laws and legislation for the management and protection of the environment.

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Reference

Abdallah, M. H. 1991. Energy potential from economically available crop residues in the Sudan. *Energy* 16: (8) 1153 -1156.

Aronoff, S. 1991. Geographic Information Systems: A management perspective. Ottawa: WDI pub. 294 pp.

Dixey, F. and Aubert, G. 1962. Arid zone research in the Sudan. Arid New sletter about UNESCO. Major project on Scientific Research on Arid land, pp.16-5.

Doka, E. M. A. and Hamiud, A.A. 2006. The desertified western lands of Khartoum state. Their characterization and assessment for agriculture development. Sudan.

Eckholm, E. L.R. 1977. Spreading deserts. The land of man. World watch paper No. B, Washington D.C. 40pp.

Food and Agriculture Organisation (FAO). 1993. Sustainable development of dry lands and combating desertification, FAO. Position paper, FAO of the UN, Rome. Available on http: //www. Fao.org/docrep/vo265E.

Grainger, A. 1990. The threat of desert. Earth scan, London.

Nasri, S. 1999. Fundamentals of remote sensing. In: proceedings of training workshop on the use of remote sensing techniques and geographic information systems in monitoring and combating desertification 4-24 July 1999. Damascus – Syria pp. 221 – 231.

Sabins and Floyd, JR. Floyd, F. 1986. Remote sensing principles and interpretation 2nd edition. Freeman, W. Hand Company New York. P1; 21.

Suliman, M.M. and Darrage, A. 1983. Desertification with special emphasis on carrying capacity and pastoral resources. pp. 2-28. IES pre-assement of natural resource in Sudan, IES.

Toulmin, C. 1995. The desertification convention. The strategic agenda for the EU, EC Aid and Sustainable Development, Briefing paper. No. 4 International Institute for Environmental and development (IIED). London.

United Nations. 1992. Managing fragile ecosystems: Combating desertification and drought, chapter 12 of Agenda. New York: United Nations.