Evaluation of Sandy Land Degradation Based on Geo-Information Techniques: a case Study South Part of Iraq

Prof. Dr. Mushtak T. Jabbar[1], Dr. Ammar S. Dawood[2]

[1]*Geology /Earth Sciences/ Highline collage/ Seattle, Washington, 98198 USA*
[2]*Department of Civil Engineering, College of Engineering, University of Basrah, Iraq*

Abstract: *This research utilizes the integrated using "3S" (RS-remote sensing, GIS-geographic information systems and GPS-global positioning system) technology and field investigation in the southern part of Iraq was taken as a case, to monitor, map, and quantify the land degradation risk detection techniques using a 1:250 000 mapping scale. According to the surface landscape indices, the sandy land was divided into four types, such as shifting sandy land, semi-shifting sandy land, semi-fixed sandy land and fixed sandy land, and the degraded land had been divided into light level degraded, moderate level degraded, severe level degraded and heavily level degraded corresponding. The data of sandy land in these two dates were interpreted and obtained by interpreting the images of TM in 2000 and ETM+ in 2010 with the visually interactive interpretation. The data of dynamic changes of reversing from sandy land and degraded land were obtained by overlaying databases in these two periods. The study results show that (1) there was 1749.7 km² of newly degraded land occurred, and most of the newly degraded lands are very severe degraded grades; (2) as a result, the degraded increased by 582.1 km² kept a stable sandy degradation land situation as a whole during the 10-year periods. Some constructive countermeasures, for the ecological protection and the ecological refugee settlement of the southern part of Iraq, are proposed in the paper.*

Keywords: *Geo-information technology, sandy degradation, landscape indices, arid region, Iraq*

I. INTRODUCTION

Sandy land degradation is a kind of desertification characterized by soil erosion, mainly resulted from the excessive human activities in arid, semi-arid regions and it is the main process of land degradation in Iraq (Al-Farrajii, 1998, Dejong, 1994, Jabbar, 2006). Iraq like many other countries in the arid and semi-arid region is exposed to land degradation problems, especially in the Middle and Southern parts of the Iraq, which are estimated to be about one million hectares (Al-Farrajii, 1998, UNEP, 2001). This problem started because of the negligibility of the problem which is now expected to have more than 90% of the cultivable lands (Dougramedji, 1999). Some of the main causes of land degradation in Iraq are the overgrazing, misuse of the plant coverage, and sand dune formation. Land degradation involves multiple causes, and it proceeds at varying rates in different climates (Hassan and Al-Dabbas, 1987). The movable sand dunes have a direct effect on the infrastructure such as highways, railways, irrigation canals, agricultural soils, soil erosion, sand storms, as well as the direct negative effect on the environment and human health (Al Janabi et al., 1988). Land degradation also affects plant growth, especially forages and rangelands that are considered to be one of the most crucial problems facing animal production in Iraq (Naqash and Shaker, 1986; Salman and Saadallah, 1986). The continuous use of unsustainable practices, damage of the infrastructure during the War, and poor maintenance worsened by sanctions, has caused a further soil and plant deterioration. Recent estimates showed that 75% of the total land in Iraq was arid and semi-arid regions and 50% of this land is subject to soil wind erosion particularly in the south western part of the Iraq, where the degradation of land becomes a serious problem (Dougramedji, 1999).

This paper has three foci: 1) to scale 30 m² pixel-level vegetation and soil indices data to national regional and local aggregate levels, 2) to provide a methodology for change detection of sandy land degradation in the southern part of Iraq, 3) to combine both approaches to detect sandy land degradation within all aggregate levels. We begin with a short review of various approaches for sandy land degradation measurement with satellite remote sensing imagery and present our ideas for change detection. The aggregate scaling and change detection analyses were performed for nearly three governorates in the southern parts of Iraq. Next, we present our findings for pixel and aggregate-level environmental change. We then compare our findings for pixel-level change detection of sandy land degradation and greening to the findings of past work on the greening of the location study. This comparison is completed, so that our approach to change detection can be standardized with the results of past studies. If our change detection methods are similar to past studies, then our aggregate-

level change detection should be comparable to that of the pixel-level assessment. Finally, we present the application of this study as a way to alleviate some methodological issues in land change science.

The emphasis of this paper is not the modeling aspects of sandy land degradation, but rather to develop an empirical methodology for change detection of sandy land degradation in the study location. No modeling procedures have been developed to estimate land degradation in the study. We assume a reduction in the productivity of the land to be a universal definition for sandy land degradation, and should be applicable from the global to the local context. Assessment of positive and negative amounts in vegetative cover and proportion of drifting sand area change will yield measurements for differing amounts of sandy land degradation. However, the issue here is what amount of vegetative cover and proportion of drifting sand area change should be considered as significant in terms of land degradation or land greening during the study period, especially since the Earth greened. To account for the full range of vegetative cover and proportion of drifting sand area change, it is necessary to derive a standardized amount of annual vegetation and soil indices change. This is necessary to quantitatively test for normal amounts of vegetative cover and proportion of drifting sand area change in the southern part of Iraq so that we can detect significant amounts of land degradation.

The objective of this study is based on remote sensing data and GIS to monitoring and analyze the dynamic change of land degradation from 2000 to 2010, which including the spatial distribution and quantities of the newly increased degraded land and the rehabilitated degraded land, the grades of degraded land, and to investigate the causes of dynamic change of land degradation, so as to derive the useful references for the restraining land degradation and the further gathering sandy land in the future.

II. MATERIALS AND METHODS

2.1 MATERIALS

The study area, located in the southern parts of Iraq, lies within longitude 45° 65′ to 48° 65′ E and from latitude 29° 13′ to 32° 84′ N with a total area of 48,855 km^2 (Figure I). This area is a typical representation of about 11.23% of the total area of Iraq. To study the land degradation risk detection, the Governorates of Basrah, Dhi-Qar, and Misan were selected as a study area. The Governorates are situated in the southern parts of Iraq. The soil of Iraq is considered as sedimentary soil, especially in the central and southern parts (Buringh, 1960). There are two main features of the study area. Firstly there is a great variation of temperature; in the summer, it is very high and in winter very low .The average of highest (annual) temperature is about 48° C, and the average lowest temperature is about 4° C. Secondly, there is no rainfall for about six months during the summer (May to October) when the land remains absolutely dry. The annual humidity is less than 50% and remains less than 30% during the daytime. The average evaporation exceeds 2450 mm/year with average annual rainfall less than 100 mm. The desert plants are adapted to these variations of meteorological factors, and represent 66% of the total cover; these plants begin to grow immediately after rainfall, and complete their life cycle by the end of the rainy period, and soon after the temperature begin to rise.

The images (Landsat TM 2000) and 8 thematic map (ETM 2010) were acquired in (June to September), 2000 and 2010 (Table I). All the five thematic layers were generated in GIS environment at a scale of 1:250,000. The software's packages used for this study were (ERDAS ver. 9.2), GIS (ArcGIS ver. 10.1), and SPSS (statistical analysis).

2.2 METHODS
2.2.1 FIELD WORK AND LABORATORY STUDIES:

Before visually interpreting images, the fieldwork was carried out to acquire the total situation of vegetation cover and land use in this area. The soil erosion map and vegetarian type map were collected in this region. The fieldwork, concurrent with the satellite acquisition over the study area, includes sampling soil and measurement of vegetation plots. The sampling spots were chosen to span the range of dominant surface features using 1:250 000 topographical maps and located by GPS. Biomass and coverage percentage of 30 x 30 meter sized plots were measured. The degraded land interpretation indicator system and land degraded grade indices were set up with the assistance of previous research as references (Zhu, 1984) (Table II).

Table I: Remotely sensed data that used in the study

Location	Satellite Sensor	*[a] WRS Path/Row	Date

Basrah	Landsat TM and ETM+	165/39, 166/39 and 166/40	2000 and 2010
Dhi-Qar	Landsat TM and ETM+	167/38, 167/39 and 168/38	2000 and 2010
Misan	Landsat TM and ETM+	166/38 and 167/37	2000 and 2010

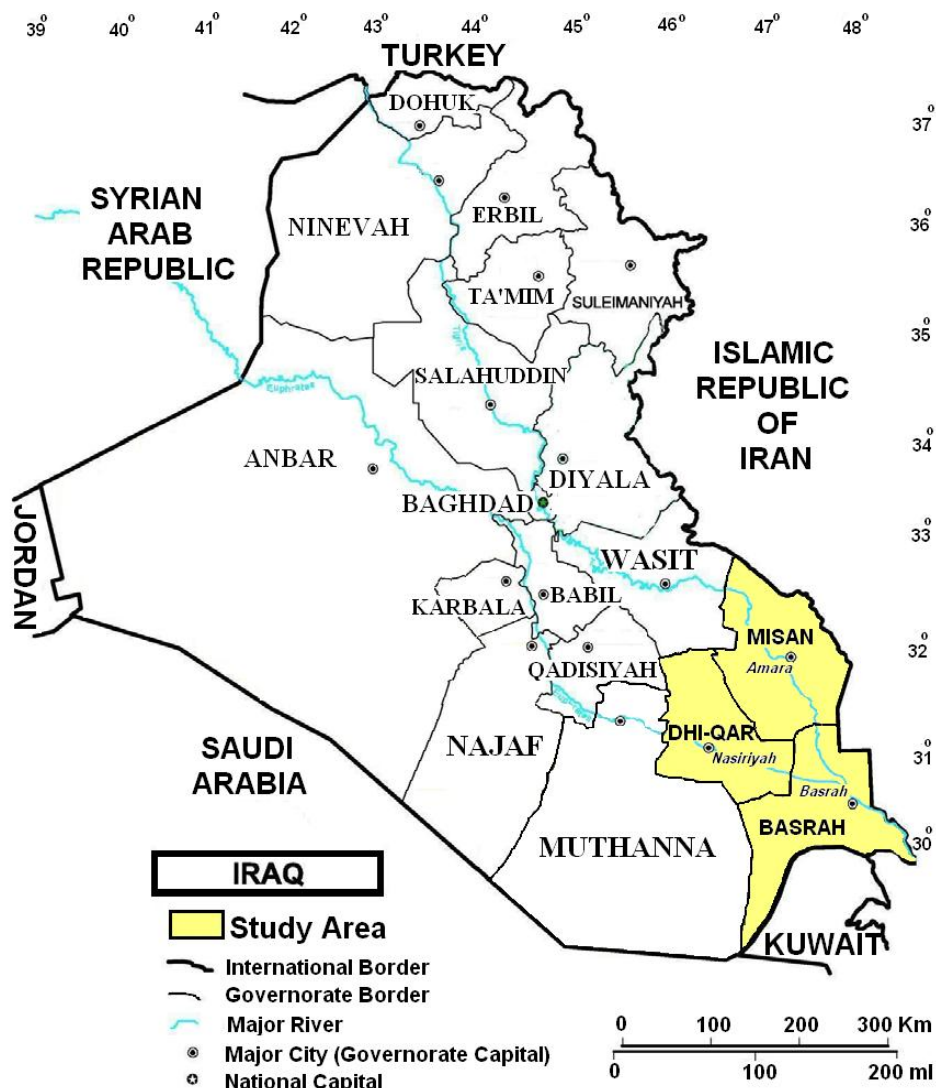*[a] WRS is the Worldwide Reference System (WRS), which is a global notation system for Landsat data

Fig. I: General Location of the study area

Table II: The grade indices of degraded land

Degradation class	Rate of shifting sand area (%)	Vegetation cover ration (%)	Feature description of surface landscape
Light	< 5	>50	Shifting sand has not yet occurred in the most land, there occur spot shifting sand by chance.
Moderate	5-20	20-50	The combination with patch shifting sand, sandy pile with windy bush and windy erosion.
Degradation class	Rate of shifting sand area (%)	Vegetation cover ration (%)	Feature description of surface landscape
Severe	20-50	5-20	Shifting areas distribute in large area, crowded with sandy piles and bushes.
Very severe	> 50	< 5	Dense shifting dune takes most part.

## 2.2.2 Satellite Data And Pr Processing Of The Images:

Landsat TM/ETM+ satellite images were taken over a span of 10 years (2000–2010) coupled with a field observations served as the basic sources of data. Radiometric corrections and cloud-free had been conducted. The 2010 image was first rectified and geo-referenced to the Albers equal area projection using ground control points from the 1:250 000 topographic map of the study area with the help of Intergraph MGE. The 2000 Scene was co-registered to the 2010 image using not less than 30 ground control points. In all cases, the nearest neighbor re-sampling method was used with a second order polynomial model. The RMSE of rectification was less than 0.5 in this study (Table III). Landsat TM bands 4, 3 and 2 color composites were generated for interpretation (Karnieli, 1997, Zha et al., 2003).

Table III: Geometric correction; the number of ground control points, type of re-sampling method and root mean square (unit pixel) for the corrected sense.

Corrected sense	No of GCP's	Re-sampled scheme	RMSE	Geodetic Datum	Map projection
2000 sense to map	50	nearest neighbor	0.5	WGS84	NUTM38
2010 sense to 2000 sense	50	nearest neighbor	0.3	WGS84	NUTM38

2.2.3 Post Processing Of The Images:

The degraded land interpretation indicator system and land degraded grade indices were set up with the assistance of previous research as references (Zhu, 1984). According to the characteristics of the surface landscape such as the moving dune ratio and the vegetarian cover ratio (Figure II), the sandy land was divided into four types such as shifting, semi-shifting, semi-fixing and fixed sand. Correspondingly, degraded land was classified into four types such as light degraded land, moderate degraded land, severely degraded land and heavily severe degraded land (Table II). Then sandy land databases at two times were derived by visual interactive interpretation TM images of 2000 and ETM+ 2010 using ArcGIS (Karnieli, 1997). The comparison of sandy land databases elaborated on different dates is a straightforward way to assess land degradation. Dynamic databases of the reversed land from sand and degraded land were obtained by overlaying databases of sandy land in two periods. Comparing the dynamic databases with sand data in 2000, the land degradation and the rehabilitated sand data were obtained. At the same time, the dynamic databases were overlaid with land use /land cover in the same period, which formerly were digitalized with the same scale. The transition matrix between no degradation land and the degraded land was generated. In order to obtain every Governorate the degradation data, the administrative division coverage was overlaid with the dynamic change map of land degraded.
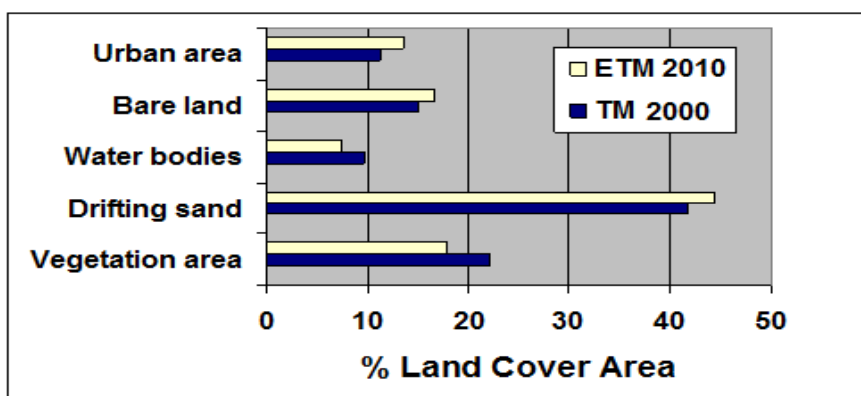
Fig. II: Land use/cover in the study area.

III.   RESULTS AND DISCUSSION
3.1 The Sandy Degradation Land Situation Of This Area In 10-Years

GPS being an efficient GIS data collection technology, allowed users to compile their own data sets directly from the field as part of 'ground truthing' (Al-saadi, 2002). Ground-truth surveys were an essential component for the determination of accuracy assessment for sand drifting, vegetation change, and classified satellite imagery.

From 2000 to 2010, in this area, except that the areas of degraded land in Basrah Governorate were larger than the assessment of surface landscape indices, the other Governorates in the southern part of Iraq showed the tendency that the areas of the reversed sandy land were less than those of degraded land (Table IV).

The area of reversion sandy land in this area was 1167.7 Km^2, which mainly distributing in Misan Governorate with 3.3% among reversion areas. The areas in Basrah and Dhi-Qar were the smallest with the reversion areas of 2.1% and 2.3% respectively. In the same period, the newly increased degraded land was 1749.7Km^2, 4.7% of which distribute in Basrah Governorate and 5.4% in Dhi-Qar Governorate. The small degradation areas were in Misan Governorate with the rate of 0.9%. As a result, the degraded land increased by 582.1 Km^2 kept a stable sandy degradation situation as a whole during the 10-year periods.

Table IV: Area of degraded land and reversed land from 2000 to 2010.

Location	Location Area (km^2)	Newly increased degraded land		Reversed sandy land		Net increase or decrease
		Area (Km^2)	(%)	Area (Km^2)	(%)	
Basrah	18,050	848.4	4.7	378.2	2.1	+ 470.2
Dhi-Qar	13,552	745.3	5.4	320.1	2.3	+ 425.2
Misan	17,253	156.1	0.9	469.4	3.3	- 313.3
Total	48,855	1749.7	3.6	1167.7	2.5	+ 582.1

3.2 Degradation Land Types

Dune reactive or encroach land occupied about 810.1 km^2 , the grassland degradation land occupied about 468.9 km^2, farmland degradation land occupied about 341.2 km^2, accounting for 46.3%, 26.8% and 19.5% of the total newly sandy degradation land area respectively, accounting for 1.6%, 0.9% and 0.7% of the total study area respectively (Table V). The dune reactive or encroach and grassland degradation were the main sandy degradation types, because the southern part of Iraq is surrounded by big desert in the northwest and natural environment is atrocious, irrational human activities will aggravate the process of grassland vegetation degradation and thereby lead to the occurrence of moving sand or the formation of sand dunes.

The very severely sandy degradation lands were almost the dune reactive or encroach and grassland degradation land. The new cultivation converted from salinized land and sand land at the margins of the southern part of Iraq was another type facing the very severely sandy degradation.

Table V: The different of newly increased sandy degradation area type

Degradation type	Area (Km^2)	Area percentage (%)
Grassland degradation	468.9	26.8
Farmland degradation	341.2	19.5%
Dune reactive or encroach	810.1	46.3%
Sandy degradation land	1749.7	100%

3.3 Evaluation Of Degradation Land Areas

The grades of land degraded (Table VI) showed that the total newly sandy degradation land area was about 1749.7 km^2; the very severely sandy degradation land occupied the largest percentage, about 976.3 km^2 in area, accounting for 55.8% of the total sandy degradation land area and 2.1% of the total study area; the area of severely sandy degradation land was about 412.9 km^2, ranking the second place and accounting for 23.6% of the total sandy degradation land area and 0.9% of the total study area; the moderately sandy degradation land was 216.9 km^2 in area, accounting for 12.4% of the sandy degradation land and 0.5% of the total study area, the slightly sandy degradation land was 143.5 km^2 in area, accounting for 8.2% of the sandy degradation land area and 0.3% of the total study area. In Basrah and Dhi-Qar Governorates, the very severe degraded land took most part with respective areas of 62.8% and 64.5% for very severely degradation. The other Governorate took the area of 39.9% of the very severe degraded land. Of the severely degraded land, 23.6% of which distributed 16.7% in Basrah, 15.9% in Dhi-Qar and 38.2% in Misan Governorate. The areas of moderately degraded land in the study area were the large with the areas of 216.9 Km^2. The smallest area was in Slight grade with the area of 143.5 Km^2 which distributed 150.5 Km^2 in Basrah, 117.2 Km^2 in Dhi-Qar and 162.7 Km^2 in Misan Governorate. These data showed that quarter of the study area faced the danger of sandy degradation which is different to restore and control.

Table VI: The area of degradation grades from 2000 to 2010.

Location	Degradation class[*a]			
	Slight	Moderate	Severe	Very severe

	Area (km^2)	Proportion (%)	Area (km^2)	(%)	Area (km^2)	(%)	Area (km^2)	(%)
Basrah	150.5	8.6	208.2	11.9	292.2	16.7	1098.8	62.8
Dhi-Qar	117.2	6.7	225.7	12.9	278.2	15.9	1128.5	64.5
Misan	162.7	9.3	220.5	12.6	668.3	38.2	698.1	39.9
Total	143.5	8.2 [b]	216.9	12.4	412.9	23.6	976.3	55.8

[a] indices were set up with the assistance of previous research as (Zhu, 1984)
[b] (Slight) total area (km^2) / Total newly increased degraded areas (km^2) $\times$ 100

3.4 Assessment of Surface Landscape Indices

By further analysis of table VII, the shifting sand land mainly transferred into semi-fixed and semi-shifting ones with the respective areas of 549.3 km^2 and 1033.8 km^2, which respectively occupies 31.4% and 59.1% of the newly sandy degradation land. The area of reversed fixed sandy land was 165.1 km^2, which takes only 9.4% of total areas. In space distribution, the reversed sandy land was mainly in the Basrah and Dhi-Qar Governorates, accounting 9.9% and 7.1% among the areas of sandy land reversion and with 18.1% in Misan Governorate. Without a doubt, the results suggest, that the gravity of vegetation cover change and drifting sand development as problems in the south part of Iraq. The results of this study indicated that land degradation resulted from natural and anthropogenic factors. The overlay of land degradation severity layers, interpreted from multi-temporal remotely sensed materials in a GIS, in conjunction with field investigation, revealed that the spatial extent of degraded land in the area has drastically expanded during the ten-year study period (2000-2010).

Table VII: The area of surface landscape type from 2000 to 2010.

Location	Semi-shifting sandy land	Semi-fixed sandy land	Fixed sandy land	Total
Basrah	517.5	246.1	84.8	848.4
Dhi-Qar	469.5	223.6	52.2	745.3
Misan	46.8	79.6	28.1	156.1
Total	1033.8	549.3	165.1	1749.7

IV.   POSSIBLE SOLUTIONS FOR SANDY DEGRADATION CONTROL

We believe that the main cause of sandy degradation is natural and anthropogenic factors on land. Therefore, degradation control should not only concentrate on enhancing the carrying capacity of lands but also on decreasing anthropogenic activities. The following possible solutions for sandy degradation control were proposed.

First, vegetation plays a very important role in degradation. Make an effort to convert degraded farmland into grassland, to popularize sandy-land a forestation techniques, and to establish protective forests to form a preliminary sand-control system. Second, efforts should be made to change current farming structures, to popularize grain-grass intercropping, to develop a three-crop planting rotation for grain, forage, and other cash crops to enhance soil fertility, and to form a stable eco-agricultural system. Third, promoting the development of regional economies and improving farm incomes could help resolve some sandy degradation problems. The technical innovation including water-saving techniques should be encouraged. Besides what was mentioned above, ecological immigration policy can also be considered by local government.

V.   CONCLUSION

This study detection and evaluation of the sandy degradation in 10-years and quantified the landscape transformation condition using geo-information technology based on landscape ecology theory. It was feasible and effective that selecting remote sensing data as the basic information sources, using GIS software as analysis processing tool. From the above analyses, we can conclude the following results: The areas of degraded land reduced by 75,373 ha from 2000 to 2010 and were in the reversion situation as a whole. On the other hand, the rapid growth in population and the development of regional industry (such as the exploitation of oil) put considerable pressure on limited land and water resources of the region. All these make fragile ecosystems further deteriorated and lead to the loss of land and make it become degraded land. The areas of degraded land increased by 29,523 ha in 2000 and 2010, and the grades of degraded land were aggravated. According to the dynamic change features of degradation, the reserved degraded land was mainly semi-fixed and semi-shifting sandy land with a small area of fixed sandy land. So it was lightened in degraded land grades, which results in the degradation again with the lack of water resource. In the future, the moderate and severe degradation land should be mainly fathered and controlled to prevent from re-degradation.

REFERENCES

[1] Al-Farrajii, F.A.H. Combating desertification in Iraq. Desertification Control Bulletin , 1998. No. 33 pp. 2-10.

[2] Al Janabi, K.Z. Ali, A.J., Al-Taie, A. and Jack, T.J. Origin and nature of sand dunes in the alluvial plains of southern Iraq. J. Arid Environ, 1988. 14: 27-34.

[3] Al-saadi, K.M. Use of remote sensing data for detection the desertification in dry climate areas. First Iraqi scientific symposium in meteorology and seismic (Dryness in Iraq). Baghdad, 1988. 26-27/Feb./2002.

[4] Buringh, P. Soil and soil conditions in Iraq. Ministry of Agriculture, Directorate General of Agricultural Research and projects, Baghdad, Iraq. 1960.

[5] Dejong S. M.. Derivation of vegetative variables from a Landsat TM image for modeling soil-erosion. Earth Surface Processes and Landforms, 1994. Vol. 19, Iss .2, pp. 165-178.

[6] Dougramedji, J.S. Aeolian sediment movements in the lower alluvial plain, Iraq. Desertification Control Bulletin, 1999. No.35 pp. 45-49.

[7] Hassan, H.A. and M. Al-Dabbas. Environmental Function for Determination of Sand Origin, J.A.W.R.R., 1987. vol. 6, No. l pp. 55-74.

[8] Jabbar M T. Land degradation assessment with the aid of geo-information techniques. Earth Surface Processes and Landforms ,2006. 31: 777–784.

[9] Karnieli, A. Development and implementation of spectral crust index over dune sands. International Journal of Remote Sensing, 1997. 18: 1207--1220.

[10] Naqash, A.B. and Shaker, S.N. Aeolian sedimentation processes in lower Mesopotamian Plain; J. Water Res. 1986. 5 (1): 486-508.

[11] Salman, H.H. and A.S. Saadallah. Dust fallout in central and southern Iraq. J. Water. Res. 1986. 5 (1): 599-620.

[12] UNEP. The Mesopotamian marshlands: the demise of an ecosystem. Early Warning and Technical Assessment Report, UNEP/DEWA/TR.01–3. http://www.grid.unep.ch/activities/sustainable/tigris/mesopotamia.pdf (accessed May 2003).

[13] Zha, Y., Gao, J., & Ni, S. Use of normalized difference built-up index in automatically mapping urban areas from TM imagery. International Journal of Remote Sensing, 2003. 24(3), 583−594.

[14] Zhu, Zhenda, The principles and methods for compiling the map of desertification of China. Journal of Desert Research, 1984. vol. 4, 1, pp. 3-15,