The Use of the Ordinary Kriging Techniques in measuring the sustainability in Sugar Beet Area, Nubariya, Egypt.

Erian[1], W. F. and Yacoub[2], R, K.
[1]Soil Department, Faculty of Agriculture, Cairo University
[2] Soil, Water and Environment Research Institute.

ABSTRACT

One of the most important indicators that illustrate the success of the sustainability in the newly reclaimed lands in Egypt is the increase of the stabilization. In this study, a set of villages represents a small part of Nubariya region and known as Sugar Beet area will be monitored as one cluster.

This study depends on the use of GIS for the correlation between the geo-statistical analysis and the analytical approach. The effective soil depth, the soil salinity, and the available moisture content data of the different villages have been used to determine their impact on community stability, agricultural production, and economic social status as indicators of stabilization and sustainability.

The effective soil depth, soil salinity, and available moisture content data of the different villages of 526 observations were used for interpolated by using Ordinary Kriging. Two types of data were used for interpolating the effective soil depth of the area to improve the quality of the maps. The first used the data observed from the field in grid system with spacing distance of 1000 meters and add some proposed observations at the edges of the area to reduce the error of missing information. The values of added observation were selected according to the nearest observation and in the same soil map unit. The second type used the information from the satellite image of the area (April 1998) to add some observations to the edges of the area. Correlation and regression analyses were performed, using the "SPSS" software. Analysis of variance (ANOVA) was used as different approach to analyze the relation between the effective soil depth data and the different soil map units. The result of the interpolated map was compared with the classified satellite image to see how much it is acceptable.

Our analysis of the above-mentioned aspects, with emphasis on their availability and efficiency, will be used to interpret the rate of stability in the different villages and identify factors promoting or suppressing the sustainability of these communities.
The decision-makers at local and regional levels can use these geo-information products in planning sustainable land management and sustainable development.

Key words: Agric. Sustainability, GIS and Geo-statistical analysis.

1. Introduction:

Egypt most essentials targets by the beginning of the Twenty First Century, is to achieve Egypt's dream by leaving the narrow valley and move towards the wide Egypt especially after the population in the Nile Valley has reached its utmost. According to **(El Ganzory, 1997)** by the end of this century, the cultivated area reached 7.8 million feddan (feddan = 0.42 hectares), the inhabited area reached 12.5 million feddan, and the population reached 62 million people. Hence the individual's share from the cultivated land lessened to 0.13 feddan from the inhabited area reached 0.2 feddan. On one hand, there are continuous increase in the cultivated land and the inhabited area; on the other hand the individual's share is also continuously decreasing. Accordingly moving out to the desert from the old valley is not merely a choice but it is an essential condition for life to go on for the present and future generations. The government current objectives are directed towards establishing new urban and rural communities in which the Egyptian investors and universities and the institutes' graduates can reside in. Such objective represents very essential and courageous solutions for the development movement in Egypt.

Sugar Beet Area is of about 74,610 fed. It represents one of the newly reclaimed areas in the west of the Nile delta, **Figure (1)**. It is divided into 5 zones and subdivided into 35 villages distributed on the years 1989 – 1992 over 9293 settler as part of national project for graduate's allocation, the villages location are shown in **Map (1).** At the start of lunching the community 100% of the land was given to graduates, either from universities or high institutes. The actual situation is that only 30.47% of the graduates are still permanently settling in the area, and traditional farmers now cultivate the majority of the land **(SIDES, 1999)**.

The assessment of stability of the new rural community such as in Sugar Beet Area, the system must fulfill a set of requirements. For instance, it is important to assess the natural resources (presented as soil qualities and uncultivated areas) and its impact on the social acceptably (presented as settling percentage), economic viability (presented as village's income and main crops production).

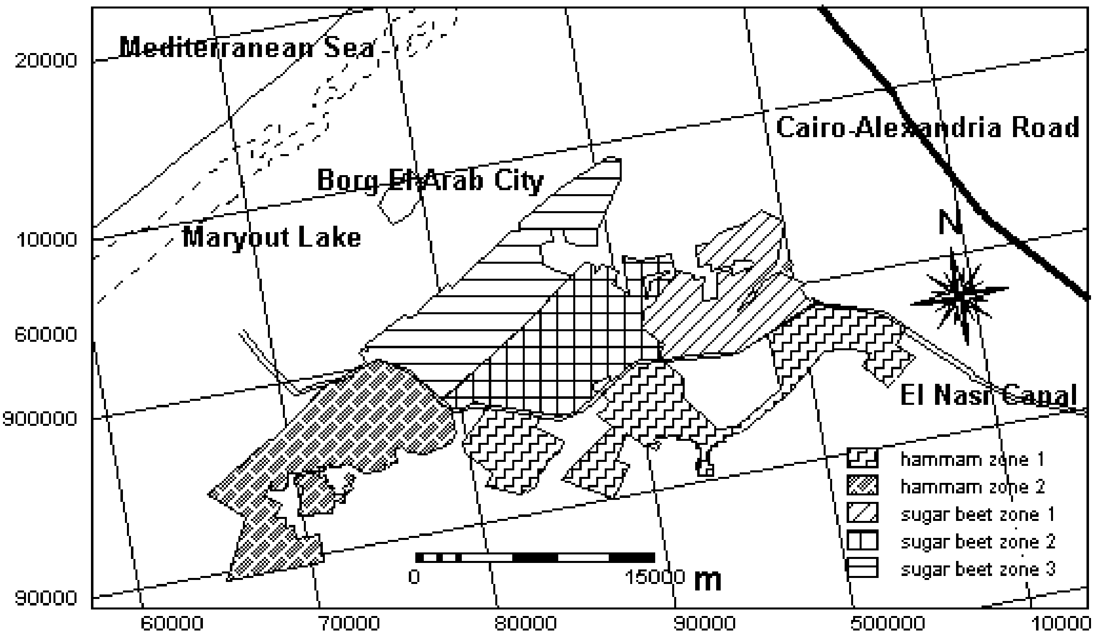
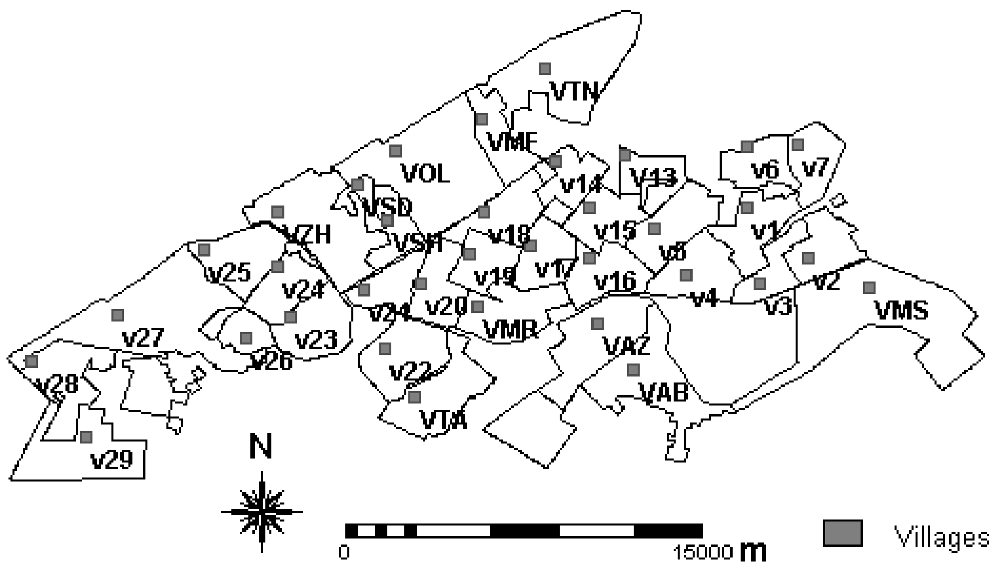


Figure (1) The Location Map of the Studied Area

Map (1) The Location Map of the Different Villages in the Sugar Beet Area



Institutional manageability, Technical adaptability and environmental soundness are also important issues for measuring sustainability and stability but are not part of this study. The assessment of the critical limitations impact on

sustainability and stability of the new rural community in Sugar Beet Area need a knowledge-based method. This is a very straightforward approach, because a number of relevant indicators from ecosystem, and socio-economic- system are selected based on which a comparison can be made between the different villages.
The eastern edge of the studied area is the Alexandria to Cairo desert road running from the southern edge of the Maryut company farm south towards the Nasr canal, kms 55 to 66 from Alexandria. The northwestern border lies close to the Alexandria to Mersa-Matrouh road and railway line. To the south and west lies the western desert. The area is commanded by pump stations 3, 4 and 5 on the Nasr canal and the latter two area currently under construction together with the canal extension between km 31 and 55.
The bulk of the studied area lies in a horseshoe shaped basin between two limestone ridges, the land titling gently from SW to NE with contours varying from 52.5 m at the desert road. The land is generally flat with slopes less than 1%, although the NE corner is undulating and has stepper slopes.
According to **(ULG, 1979)** the most striking structural feature is the series of ridges and troughs, which run across the studied area. Essentially the geological section can be described as follows:
Recent and Holocene – Aeolian sand and fluviatile loam. Most noticeable in the southern part of the area. **Late Pleistocene –** Lagoonal clays sometimes gypsiferous sometimes with sand. Generally found throughout the area although absent at high elevations such as the Alum Shaltut Ridge. They have been formed during a succession of high and low sea levels.
Pleistocene – Deltaic sands and gravels sometimes with clay beds. The limestone ridges were formed during this period and were probably marine coastal beach ridges formed by successive high sea levels.
Pliocene – Marine grey clays sometimes with calcareous sandstone beds. These are found throughout the area at varying depth.
The aquifer system comprises an impermeable of marine clays over which lie two distinct zones. The lower zone has a high permeability while the upper zone of lagoonal and littoral faces has a low permeability. Although semi-confining, the upper zone is not impervious and does not produce a permanent water table. The area is surrounded by impervious or low permeability restrictions, which generally prevents discharge of groundwater out of the area. Therefore, the aquifer can be considered as a groundwater basin retaining any water, which flows into it.
The climate of the studied area is semi arid with an annual rainfall varying from 136 mm at El Ameriya to the north to 35 mm at south Tahrir to the south. No rain falls between June and September and even during November to February, the main rainy season, the rainfall is localized and unpredictable. The mean monthly maximum temperature rise to 32.2^o C at west Nubariya with an absolute maximum of 41^o C. The mean monthly minimum temperature drops to 7.5^o C. The area is subject to high winds. In the spring the winds are particularly strong, dry and frequently dusty and known locally as Khamasin. However, there is considerable variation between day and night wind speeds with velocities over 5.0 m/s recorded between 8.00 – 16.00 hrs. Nighttime velocities can fall to 50% of the daytime velocities.
In this current study the effective soil depth, soil salinity and available moisture content data of the different villages have been carefully studied and mapped as relatively homogenous units using the ordinary Kriging algorithm. The resulted mapping units were then used for the determining of their impact on community stability.

2. Materials and Methods:

2.1. Materials used:

2.1.1. The integrated land and watershed management system **ILWIS** developed in **ITC**, (Version 2.2), has been used as the main software for this study. The system provides its users with state of the art data gathering, data input, data storage, data manipulation, analysis, and data output capability by integrating conventional **GIS**.

2.1.2. The following maps were used:

- The topographic maps of the area sheets **NH35-K5b** "Alam Musaylikh**", NH35L-5d** "El Hammam", **and NH35-L6a** "Alam al Jataa", **and NH35L-6b** "Jabal Khashm al Qaud", **and NH35L-6c** "Burj al Arab", **and NH35L-6d** "Iking Maryut", scale 1:50,000 produced by the **Egyptian general survey authority (1992).**
- The geological map of Egypt, scale 1:2,000.000 produced by the **(Ministry of Industry and Mineral Resources, 1981).**
- The uncultivated land unit within Sugar Beet Areas area has been produced after, (**Erian, et al 1999).**

2.2. Methodology:

2.2.1 Panchromatic aerial photographs scale 1:25,000 taken during the year 1975 were studied stereoscopically and further divisions were made using the geo-pedological approach after, **(Zinck, 1997).** The main elements used were Relief and gray-tone. During the year 1998, the effective soil depths, soil salinity and drought data of 100 detailed soil profiles and 346 mini pits of 80 cm depth from soil surface, followed by auger holes were observed from the field in a grid system with spacing of approximately 1000 meters. Other information about 80 observation points the represents the limestone and the very shallow soils, the edges of the studied areas and some of the uncultivated parts of the area were collected.
Particle size distribution, following the pipette method, using sodium hexameta-phosphate, **(Kilmer and Mullins, 1954).** Analyses for soil samples were carried out for chemical analysis: Calcium carbonate content was determined in

the soil using Collin's Calcimeter, **(Nelson, 1982).** Gypsum content was determined using acetone according to **(Black, 1982; Hesse, 1971).** The electrical conductivity of the saturated soil extract was carried out according to **(Rhoades, 1982).** 100 undisturbed samples were collected from the same locations in cores with the dimensions of 2.5-cm length and 5 cm diameter. These were meant for studying the moisture retention at field capacity, permanent wilting percentage and interval points, by the pressure membrane apparatus**, Klute (1986).**

2.2.2 The rating values for effective soil depth, after, **(Erian et al., 1991 and Erian et al , 1996)** and could be presented as follows:

The effective soil depth classes:

- The very deep soils (d1: more than 120 cm).
- The deep soils (d2: between 90 – 120 cm depth from the soil surface), and
- The moderate deep soils (d3: between 60 – 90 cm depth from the soil surface),
- The shallow soils (d4: between 30 – 60 cm depth from the soil surface),
- The very shallow soils (d5: less than 30 cm),

The soil salinity classes are calculated as an average of the EC (1:1) within 80 cm:

- The non-saline soils (z1: less than 2 dS/m).
- The slightly saline soils (z2: 2 - 4 dS/m), and
- The moderately saline soils (z3: between 4 - 8 dS/m),
- The strongly saline soils (z4: between 8 – 16 dS/m),
- The very strong saline soils (z5: more than 16 dS/m),

The drought classes**:**

The studied area depends on flooding irrigation with intervals of irrigation: 14 days are without irrigation and seven days of irrigation in both Winter and Summer times. In most cases, the farmer is only allowed for one-day irrigation every 21 days. Accordingly the following classes were identified:

- The very high moisture availability soils (m1: more than 21 days between irrigation before soil drying),
- The high moisture availability soils (m2: between 18 - 21 days between irrigation before soil drying),
- The moderately moisture availability soils (m3: between 14-17 days between irrigation before soil drying),
- The low moisture availability soils (m4: 10 - 13 days between irrigation before soil drying), and
- The very low moisture availability soils (m5: less than 10 days between irrigation before soil drying).

2.2.3. Geo-statistics offers methods for interpolation and analysis of spatial structure and the ability to provide risk-qualified predictors of exceeding threshold values is an indispensable tool for environmental decision-making. Kriging can be seen as a point interpolation, which requires a point map as input, has been used as the main technique for geo-statistical analysis. The ILWIS (2.2), ordinary Kriging algorithm was applied to delineate the most accurate purified boundaries for the different land qualities. In order to obtain a semi-variogram model for the data represents, the effective soil depths, soil salinity, and drought, the sill, the range and the nugget for each land quality were estimated and presented in a fitting curve. The sill represents the maximum level of the semi-variance, the range represents the lag at which the sill is reached, and the nugget represents intercept of the variance. The weight factors are averaged input point values, similar to the moving average operation. The weight factors in Kriging are determined by using user-specified semi-variogram model parameters that based on the output of the spatial correlation operation. The distribution of input points, and are calculated in such a way that they minimize the estimation error in each output pixel. The estimated or predicted values are thus a linear combination of the input values, **Stein (1998).** The geo-statistical analysis is a two-step-procedure. The first step is the calculation of the experimental semi-variogram and fitting a model; and the second is the interpolation to study the spatial variability of soil properties.

The formulae of each model as follow:

The Spherical Model Formulae is: $\gamma(h) = C_0 + C * [(3h / 2a) - (h^3/2a^3)]$

Where: **γ is the estimated value** a **is the Range parameter**

h is the distance C **is the Sill parameter** C_0 **is the Nugget parameter**

The crossing technique was applied to identify the current land capability of the studied area.

2.2.4 For statistical analysis the information about settlement, income and different crops production are given in **Tables (1)**, after the Social and economical data of 1998 survey of the Sustainable Integrated Development and Environmental Sector of Caritas **(SIDES, 1999).** The survey was implemented under the authors supervision and in cooperation with CAPMAS (The Central Agency for Puplic Mobilization and Statistics), license no. 624/1998 published in El-Wakaa El Masria, issue no. 290 on 20 December 1998, covering Sugar Beet area (35 villages), Nubariya, Egypt.

2.2.5 **The flowchart of the study is modified after,** (Erian & Yacoub, 1999), **and presented in** Figure (2)

Table: (1) The main Economical Stability Element of the different villages of Sugar Beet Areas

Village Name	Se%	FIN(LE)	PIN(LE)	W(Er)	Wi(LE	B(Er)	Bi(LE)	T(To)	Ti(LE)	M(Er)	Mi(LE)	Cl(To)	Cli(LE)	N%	D%	I%	Um%	CAD%	MC%	S%
V1:village1	29.02	6680	954	10	290	6	162	10	349	10	178	19	185	16	17	39	2	1	100	32
V2:village2	35.03	5301	840	11	332	6	185	9	402	10	86	18	180	43	3	62	9	4	56	34
V3:village3	46.43	4337	654	8	133	7	42	7	604	9	19	17	165	30	10	50	11	2	66	38
V4:village4	35.90	4621	811	10	408	6	234	7	221	9	128	18	144	15	10	41	20	2	77	72
V5:village5	24.46	4141	647	10	520	7	269	9	530	11	169	21	216	18	11	40	18	0	57	26
V6:village6	33.62	4814	756	9	198	6	153	6	-62	10	29	19	188	27	15	48	12	0	85	71
V7:village7	40.10	4041	676	9	265	6	240	8	659	8	83	17	170	27	12	53	12	41	81	51
VMR:Markzia	34.68	4124	1014	8	193	6	120	8	551	8	163	16	193	20	1	19	4	4	19	37
VSD:Said Darwish.	32.08	3033	750	9	220	6	143	7	577	10	127	15	269	33	3	32	14	9	53	74
VSH:Salama Hegazi	20.00	2928	624	10	229	4	185	9	907	7	31	16	283	32	12	39	11	4	0	40
VMFMohamed Farid	48.07	4030	860	11	312	7	142	9	581	10	86	17	94	33	10	43	8	0	0	38
VTN:El-Tanmia	33.47	4527	1049	9	202	7	202	8	459	9	101	18	147	30	9	35	9	2	61	65
V13:villag13	28.73	3975	716	9	270	6	286	9	906	9	301	18	271	28	15	41	9	2	43	30
V14:villag14	24.40	7575	1573	11	413	6	90	8	826	9	154	20	157	5	20	17	13	13	93	63
V15:villag15	38.27	4597	999	9	409	7	292	9	340	10	323	21	241	12	14	23	8	18	25	19
V16:villag16	41.50	6039	1594	9	220	6	230	7	781	10	167	19	236	8	3	16	5	2	35	48
V17:villag17	34.67	5124	1112	8	256	6	164	7	935	9	216	17	322	22	3	21	13	1	35	35
V18:villag18	44.13	3701	870	8	107	6	194	10	113	7	89	20	227	23	6	29	8	3	11	55
V19:villag19	80.22	4409	1308	10	303	7	45	7	558	8	171	21	239	27	6	23	5	2	63	47
V20:villag20	20.38	3813	906	7	47	5	49	7	325	6	66	20	143	30	6	40	6	0	42	45
V21:villag21	39.88	3484	931	8	122	5	159	6	311	7	161	18	184	28	4	37	12	10	43	38
V22:villag22	8.60	3239	688	9	220	5	162	7	-10	8	99	21	203	29	6	38	14	3	53	85
V23:villag23	26.87	5169	1068	9	88	6	192	7	156	8	62	19	226	23	9	38	7	14	71	26
V24:villag24	50.20	3635	804	11	396	6	218	8	137	9	120	23	240	19	10	29	8	16	1	30
V25:villag25	19.39	2904	649	10	214	7	103	7	260	8	-82	17	138	14	8	24	14	0	14	85
V26:villag26	29.46	3478	805	8	150	6	333	8	185	8	-9	18	190	53	9	42	7	2	2	32
V27:villag27	22.64	3873	847	9	235	6	246	8	145	9	-26	20	179	22	5	33	9	5	58	58
V28:villag28	20.00	3399	888	8	78	4	64	7	241	6	1	20	238	18	2	26	8	2	0	73
V29:villag29	10.26	3444	774	6	-108	6	150	5	-67	5	-34	.	.	29	4	57	3	0	59	57
VTA:El-Takaml	13.06	3395	847	8	104	6	88	7	613	7	-1	16	145	22	8	27	8	1	0	38
VAZ: Abo Zahr	25.30	3275	653	9	247	6	232	8	246	8	107	21	221	20	4	33	12	1	28	69
VAB:Abdel Baset	16.85	3801	794	10	218	6	192	8	989	7	1	16	97	34	4	37	1	0	67	56
VMS: Mostafa Ismail	11.76	3945	820	6	-36	6	201	5	-288	8	-16	23	222	36	10	40	5	2	21	81
VZH:El-Zehour	22.65	4189	1040	10	244	7	160	9	346	9	119	19	161	25	6	24	12	21	61	31
VOL:El Olla	24.23	6096	1473	9	261	9	442	8	477	10	236	20	184	13	3	18	8	4	74	44

Source: SIDES, 1999

- Se: Settling %
- FIN:Family Income
- PIN: Personal income
- W: Wheat Production
- Wi: Wheat net income
- B:Beanst production
- Bi:Beans net income
- T:Tomato production
- Ti: Tomato net income
- Cl:Clover production
- Cli: Clover net income
- M:Maize production
- Mi: Maize net income
- N: Never attened
- D: Dropped out from School
- I: Illiteracy
- Um: Unemployment
- CDA: Community Development Assossiation Effeciency %
- MC: Mother & Child care
- S:Feeling of Security
- LE: Egyptian Pound
- Er: Erdab/feddan
- To: Ton/feddan

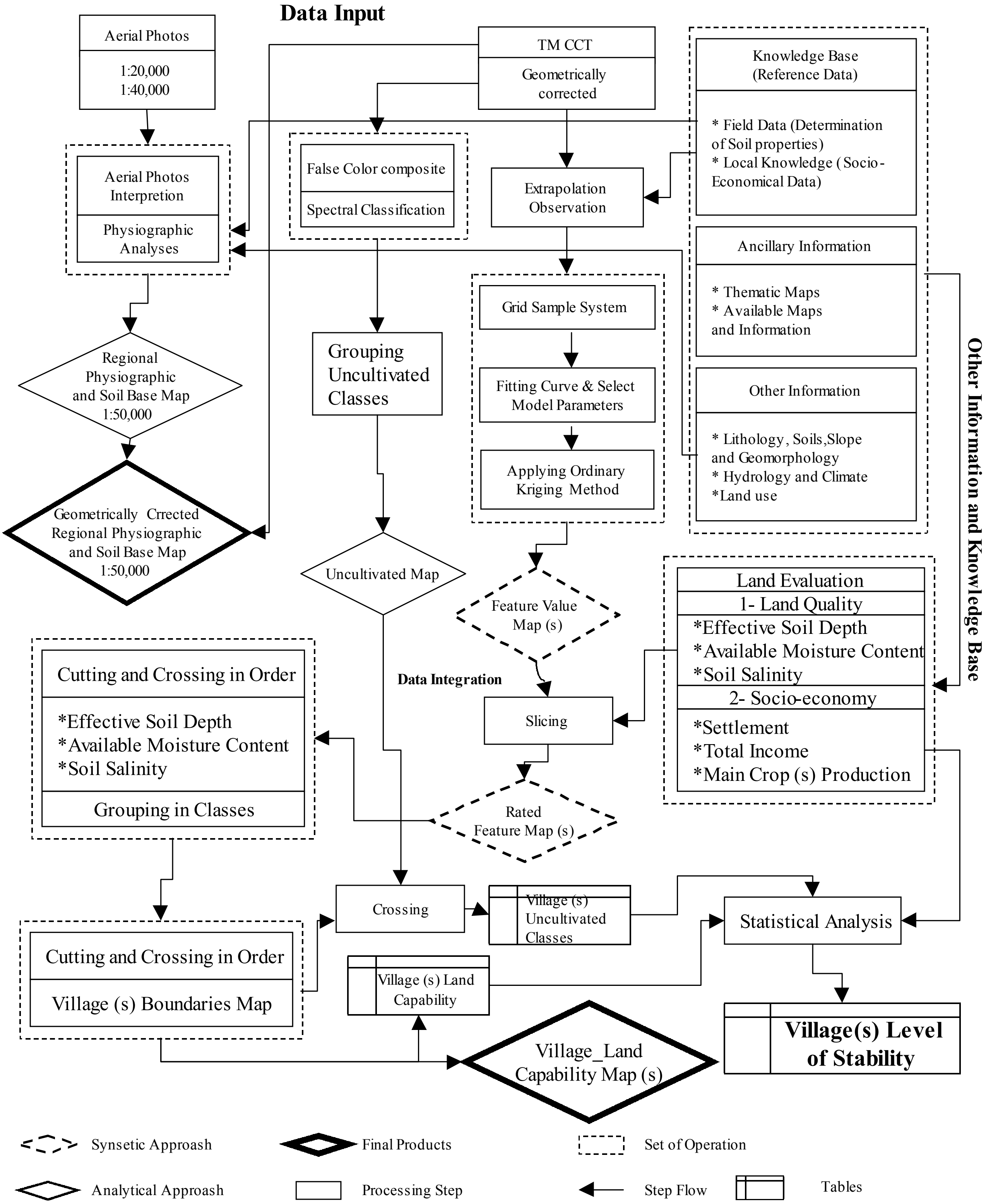


Figure (2) Recommended Framework Flow Chart

Source : After Erian and Yacoub, (1999)

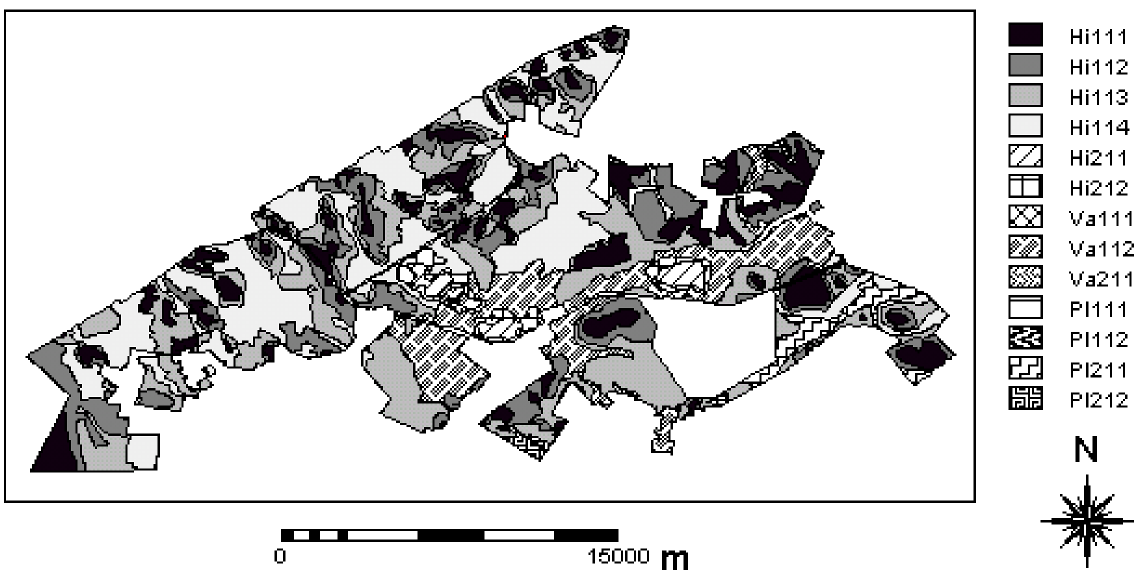
3. Results and Discussion:

3.1. Aerial Photo-Interpretation Field Observation Studies:

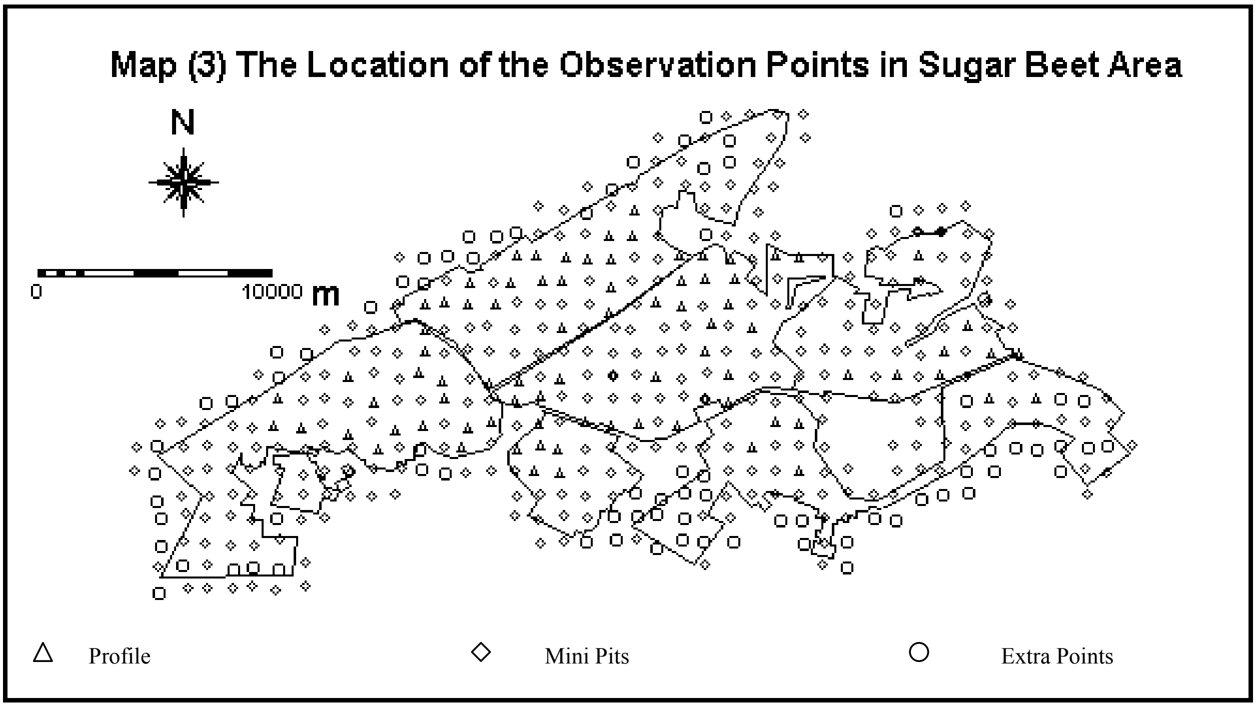
The most important element used and played the decisive role in the photo-interpretation of the studied area were the relief and the gray tone elements. The combination of the geomorphic approach as a hierarchic classification system of geo-forms using the existing body of knowledge in geo-morphology, with the photo interpretation map and field observations improved the results. The total area and percentage of each physiographic mapping unit is shown in **Table (2)**, and the physiographic map is presented in **Map (2).** The location of the observation points is presented in **Map (3).**

Table (2) The Physiographic map legend.

Environmental Deposits	Landscape	Unit	Relief	Unit	Lithology	Unit	Landform	Unit	Area in feddan	Area in %
Marine Deposits	Elongated Hills	**Hi**	Extensive Ridges	**Hi1**	Pliocene formation	**Hi11**	Summit	**Hi111**	8550	11.48
							Back	Hi112	13,790	18.51
							Foot	Hi113	19832.6	26.71
							Toe Slope	Hi114	18214.3	24.53
			Ridge Remounted	**Hi2**		**Hi21**	Summit	Hi211	1228.6	1.65
							Foot	Hi212	1549.1	2.09
	Mena Valley	**Va**	Depression	**Va1**		**Va11**	Outer	Va111	43	0.06
							Inner	Va112	9371	12.62
				Va2		**Va21**	Outer-leveled	**Va211**	12	0.02
Colluvial Deposits	Plain of Maryout Tableland	**PI**	Series of Terraces	**Pl1**	Pliocene Miocene formation	**Pl11**	Terrace 1	Pl111	36,388	8.66
							Terrace 2	Pl112	776	0.18
Colluvial Eolian Deposits	Plain of Marmarica Formation		Flat	Pl2	Miocene formation	**Pl21**	Flat covered by sand	Pl211	1593	2.15
							Sand sheets	Pl212	297	0.40



Map (2) The Physiographic Soil Map of Sugar Beet Area



3.2. Interpolating using Ordinary Kriging:

Descriptive statistic of the Effective soil depth, Available moisture content and Soil salinity are shown in **Table (3).**

Table (3) Descriptive statistic of the selected soil properties

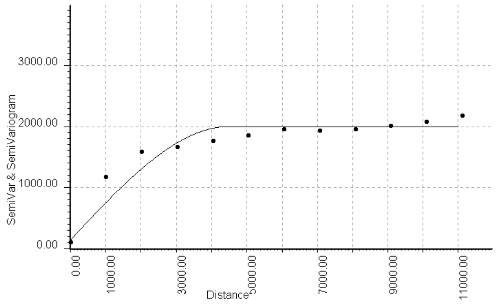
Parameters	Effective Soil Depth	Available Moisture Content	Soil Salinity
Number of data	526	446	446
Minimum	0.0	20.0	0.9
Maximum	160.0	220.0	29.4
Mean	86.9	124.2	8.99
St. Deviation	46.457	54.011	6.611
Variance	2158.3	2917.1	43.7
St. Error	2.026	2.353	0.288
T-Test One tailed Two tailed	1.835 < T-true 1.645 95 % 90 %	2.263< T-true 1.960 97.5 % 95.0 %	1.335 < T-true 1.282 90.0 % 80.0 %

Semi-variograms were calculated and fitted using nonlinear regression. The best variogram model for the study area. The effective depths, available moisture content, and soil salinity of the observations were interpolated separately using the ordinary Kriging and the results of the value maps are shown in **Maps (4,5 & 6).** The fitting models and the model's perimeters are shown in **Figure (3)**. According to **Erian, et al (1999),** the analysis of the variance (ANOVA) was carried out between the effective soil depth and the soil mapping units as presented in **Table (4).** In this analysis, the probability (P) value of the F-test shows that the probability of the random distribution of the variable is highly significant*** at level 0.01, where as the calculated value of the F-statistic (96.24) is larger than the value of F-test (3.60) at significant level 0.01. The data indicates that the effective soil depth is a soil property that differentiates the 11 groups of the soil map units.

Table (4) : The equation of Effective soil depth by soil map units

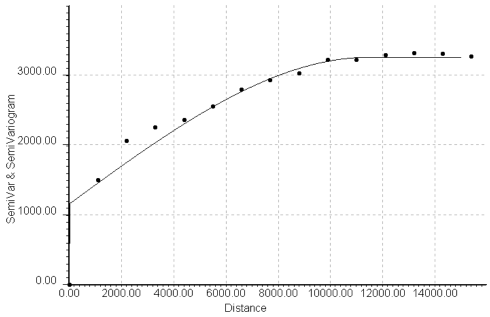
Group	Sum of Squares	df	Mean Square	F-Calculated	Sig.(P)
Between Groups	468839.517	11	42621.774	96.240	0.000
Within Groups	135517.630	445	442.868		
Total	604356.148	456			

The result of the effective soil depth interpolated map was compared with the uncultivated area of the spectral classification, **after, Erian, et al (1999)** and also with the soil map for acceptability as presented in **Map (7) and Table (5)**. The classification of the interpolated maps were rated in five classes and presented as in **Maps (8,9, and 10).**



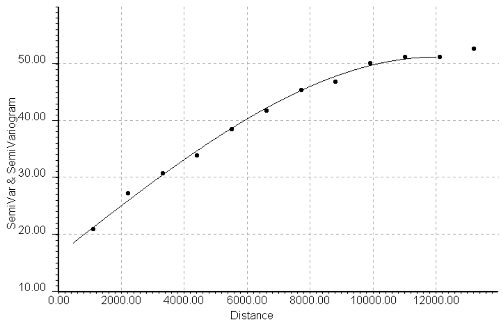
Effective Soil Depth (Spherical),

$$\gamma(h) = 140 + 1980 * [(3h / 10000) - (h^3/(10000)^3)]$$



Available Moisture Content (Spherical),

$$\gamma(h) = 1150 + 3250 * [(3h / 23000) - (h^3/(23000)^3)]$$

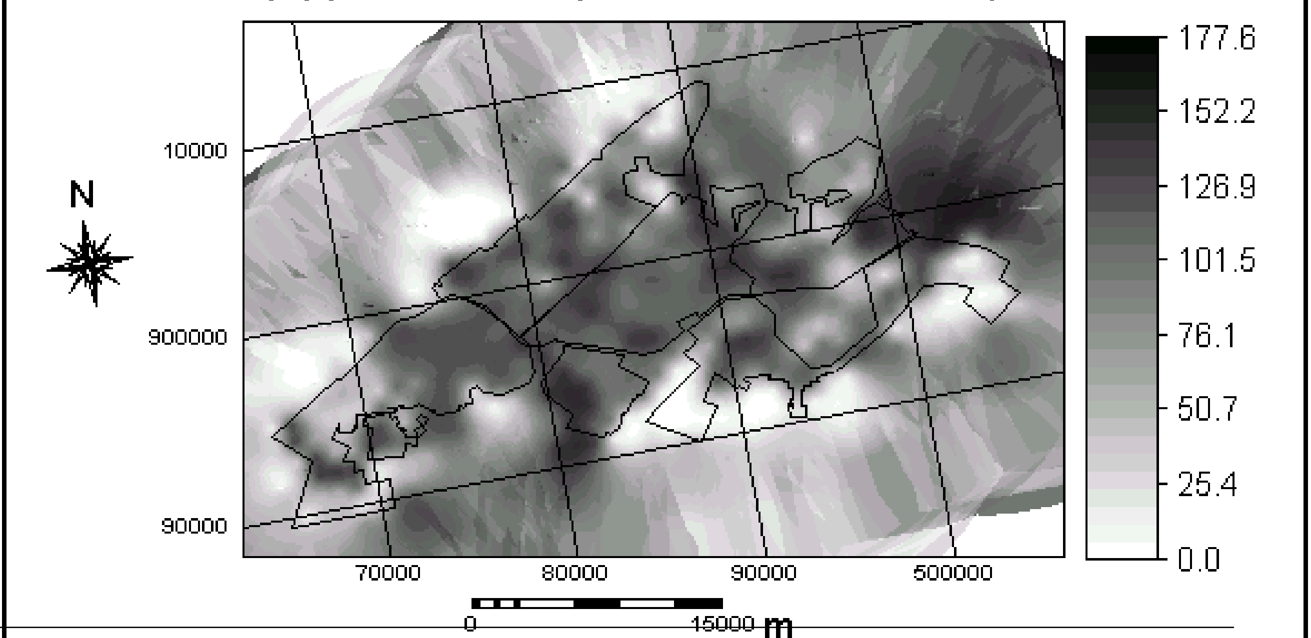


Soil Salinity (Spherical),

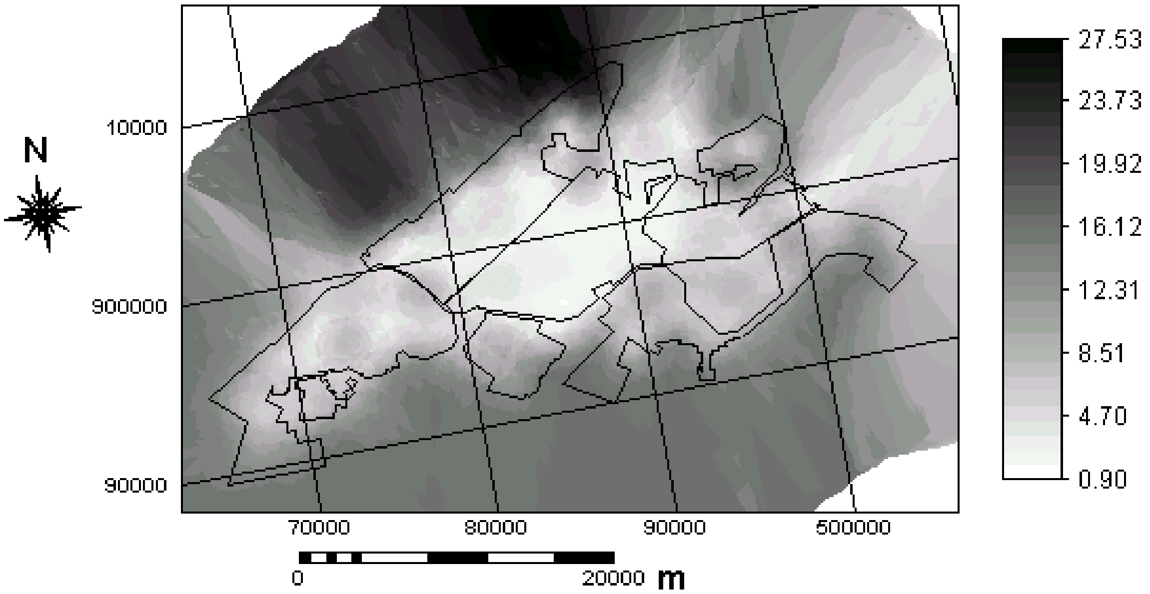
$$\gamma(h) = 16.5 + 51.1 * [(3h / 24000) - (h^3/(24000)^3)]$$

Figure (3) The Fitting Model of the Effective Soil Depth, Moisture Availability and Soil Salinity

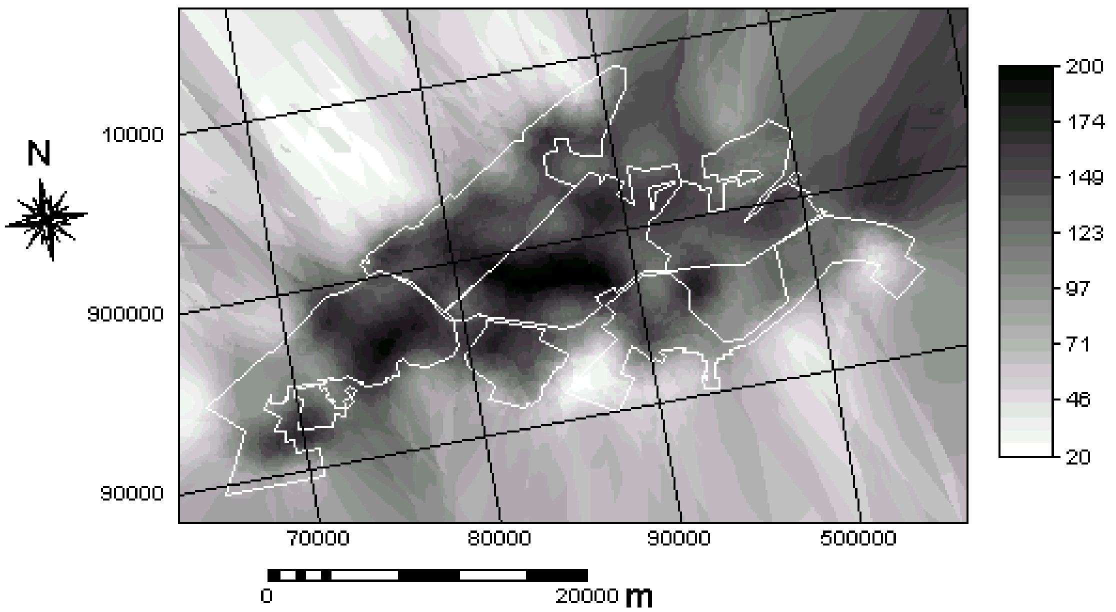
Map (4) The Value Map of the Effective Soil Depth



Map (5) The Value Map of the Soil Salinity



Map (6) The Value Map of the Available Moisture Content



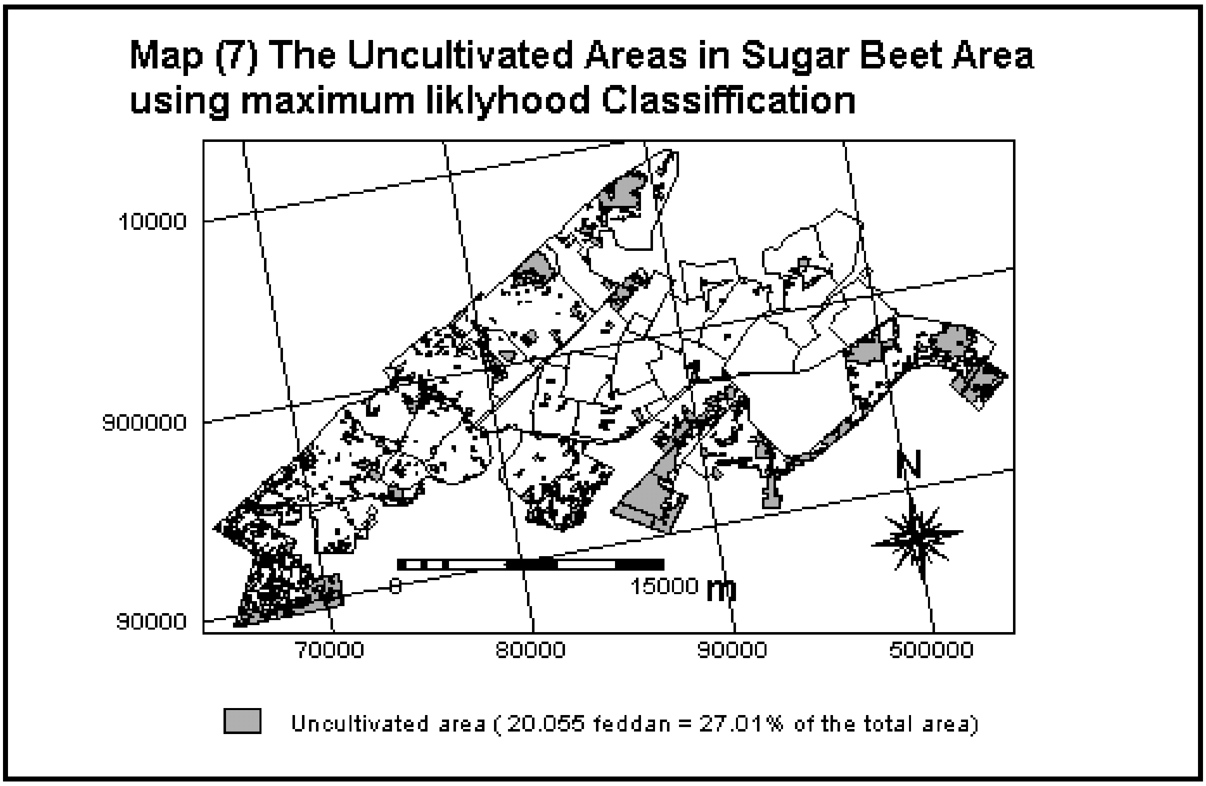
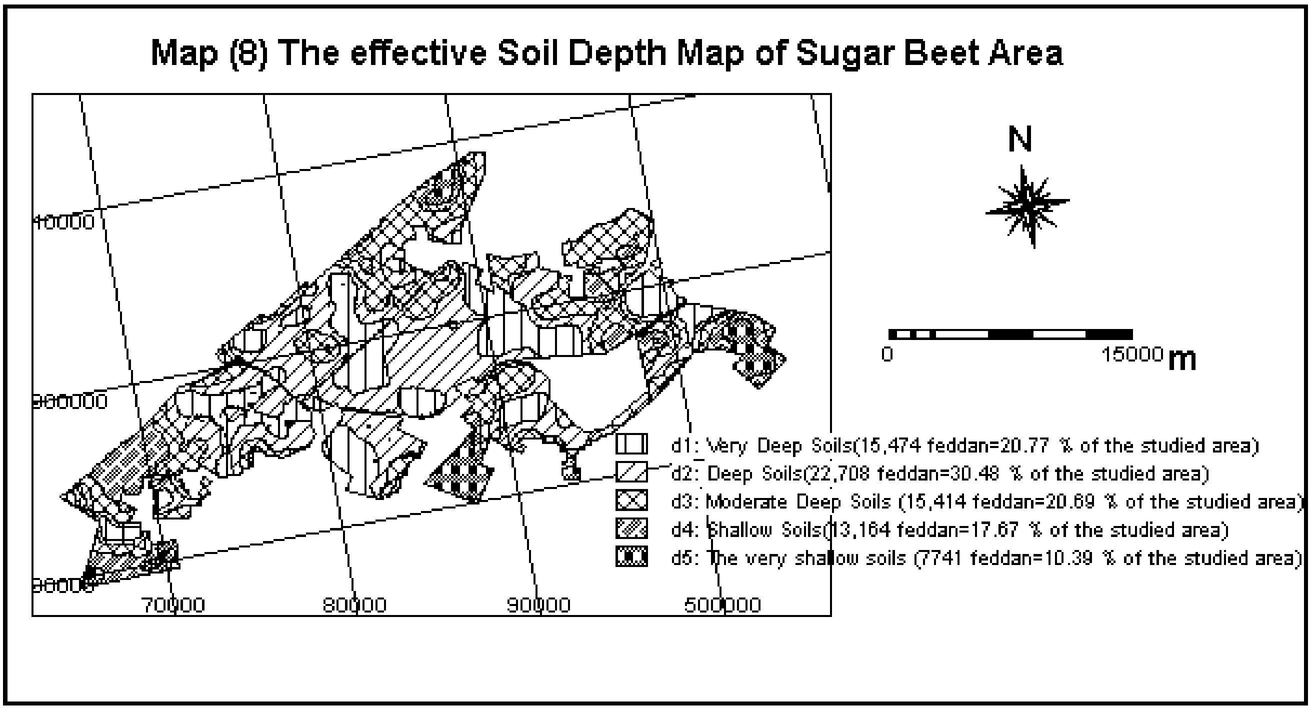
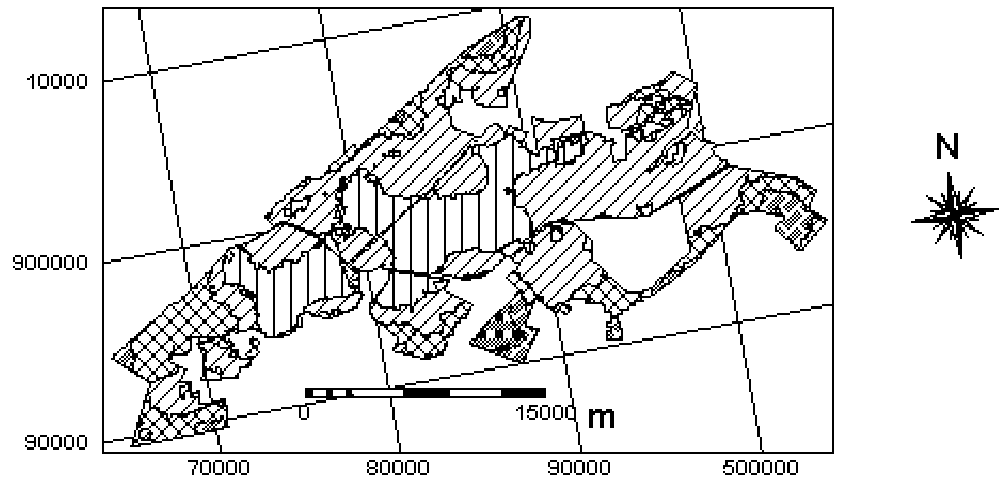


Table (5): Comparison between three studied approaches

Approach	Unit	Area Feddan	Area %	**Total %**
Aerial Photo interpretation	Hi111 (Soil map unit)	8550	11.48	29.99
	Hi112 (Soil map unit)	13,790	18.51	
Geo-statistical Analysis	D5 (Rocks out crop)	7741	10.39	28.06
	D4 (Shallow Soils)	13,164	17.67	
Spectral Classification	Uncultivated area	20,055	27.01	27.01

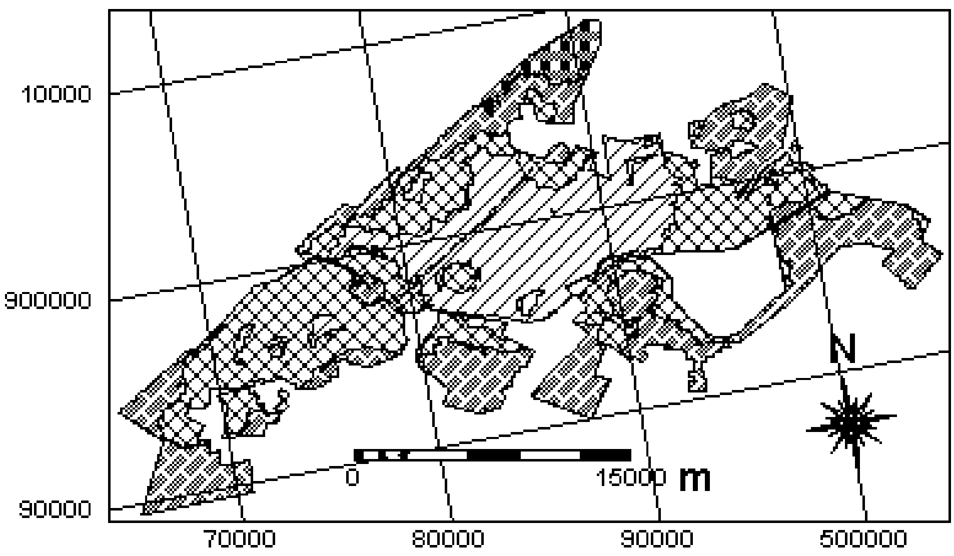


Map (9) The Drought Classes Map of the Sugar Beet Area



m1: more than 21 dayys between irrigation before soil drying (18,029 feddan = 24.20% of the total area)
m2: between 18 - 21 dayys between irrigation before soil drying (37,615 feddan = 50.48% of the total area)
m3: between 14 - 17 dayys between irrigation before soil drying (14,028 feddan = 18.83% of the total area)
m4: between 10 - 13 dayys between irrigation before soil drying (3834 feddan = 5.15% of the total area)
m5: less than 10 dayys between irrigation before soil drying (1006 feddan = 1.35% of the total area)

Map (10) the Soil Salinity Map of Sugar Beet Area



z1: non saline soils(196 feddan = 0.26 % of the studied area)
z2: Slightly saline soils (18,656 feddan=25.04 % of the studied area)
z3: Moderatly saline soils (27,662 feddan=37.13 % of the studied area)
z4: Strongly saline soils (25,951 feddan=34.83% of the studied area)
z5: Very strong saline soils (2034 feddan=2.73 % of the studied area)

The result illustrated that only 51.25 % of the total studied area are deep to very deep soils, 20.69 % of the studied area is moderately deep soils, and 28.06 % of the total area are shallow to very shallow soils. The study also illustrates that more than 6.5 % of the area drying in less than 13 days from irrigation and 74.69% are keeping a relatively enough water content after 18 days from irrigation. And 37.56 % of the studied area has strong to very strong salinity with EC (1:1) more than 8 dS/m and 26.30 % have EC (1:1) less than 4 dS/m.

3.3. Crossing:

The crossing technique was applied in the following order to the rated maps: The effective soil depths, soil salinity and drought using **ILWIS (2.2), GIS** capabilities. According to **Erian, et al (1999)** the produced capability map scale is suitable for the village level survey interpretation. The resulted scale is a function to the minimum mappable area of the produced map. **Elbersen (1985)**, identified that if the minimum mappable area is of about 3.12 ha (= 7.4 feddan), the publication scale can reach 1:50,000 corresponding to the semi detailed soil survey level. Such map could be successfully used for the soil survey interpretation on the village level.
The resulted map was crossed with the village's map is shown in **Table (6)**. The result were than grouped into 3 main groups where the group (1) represents the soils with the minimum limitations (class "1" and "2") , group(2) represents the marginal level for limitations (class "3") and the last group represents the severe limitations (class "4 "and "5") as shown in **Figure. (4).**

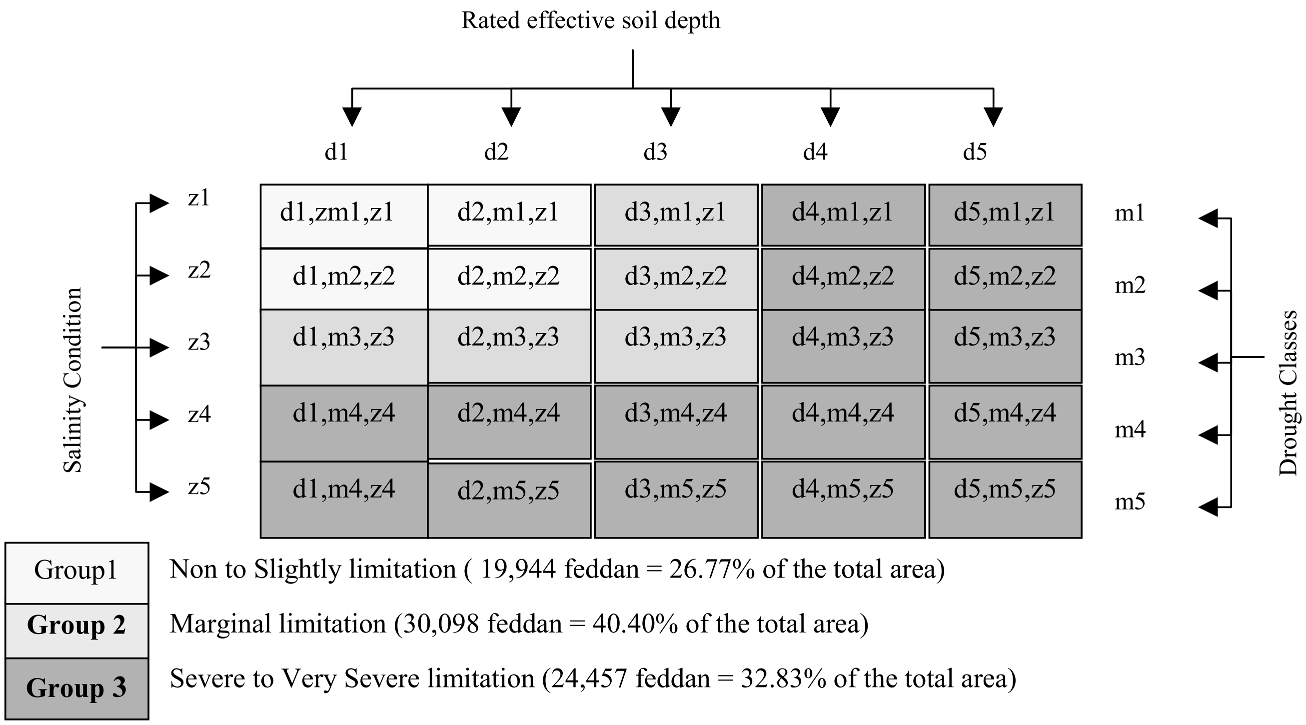


Figure (4) Decision making of grouped classes

Table (6) The main Soil Quality Limitation of Sugar Beet Area

Village Name	U	C1	C2	C3	d5	d4	s5	s4	m5	m4
village1	63	0	41	59	0	504	0	800	0	0
village2	0	1	72	27	0	0	0	418	0	0
village3	0	0	52	48	0	372	0	167	0	0
village4	20	11	89	0	0	0	0	0	0	0
village5	20	57	42	1	0	0	0	25	0	0
village6	63	0	18	82	0	40	0	1022	0	0
village7	1	0	5	95	0	170	0	1254	0	0
Markzia	143	98	2	0	0	0	0	0	0	0
Said Darwish.	135	6	94	0	0	0	0	0	0	0
Salama Hegazi	86	46	52	2	0	17	0	0	0	0
Mohamed Farid	63	21	52	27	0	32	16	362	0	0
El-Tanmia	952	0	8	92	494	684	2039	1476	0	547
villag13	19	0	52	48	0	0	0	0	0	0
villag14	114	29	52	20	31	106	0	206	0	0
villag15	0	100	0	0	0	0	0	0	0	0
villag16	57	90	10	0	0	0	0	0	0	0
villag17	3	97	3	0	0	0	0	0	0	0
villag18	109	62	38	0	0	0	0	0	0	0
villag19	5	100	0	0	0	0	0	0	0	0
villag20	37	77	23	0	0	0	0	0	0	0
villag21	10	57	43	0	0	0	0	0	0	0
villag22	119	7	43	50	0	0	0	1022	0	0
villag23	115	0	76	24	0	12	0	411	0	0
villag24	40	19	66	16	0	0	0	219	0	0
villag25	208	0	98	1	0	25	0	0	0	0
villag26	48	8	85	7	0	30	0	52	0	0
villag27	837	0	56	44	1	1955	0	1578	0	171
villag28	496	0	25	75	0	659	0	1043	0	86
villag29	1409	0	3	97	421	1336	0	2584	0	311
El-Takaml	1902	4	6	90	1514	124	8	3350	964	728
El Sheakh Abo Zahr	895	0	45	55	135	272	0	1351	25	228
Abdel Baset	969	0	39	61	136	97	0	1891	0	207
El Sheakh Mostafa I	2490	0	13	87	1294	1262	0	5100	22	1491
El-Zehour	279	24	57	19	0	52	0	639	0	0
El Olla	784	23	54	22	5	286	0	1027	0	78

U: Uncultivated Area in feddan
C1: Area with slight limitations in feddan
C2:Area with marginal limitations in feddan
C3: Area with sever limitations in feddan
d5: rock out crop in feddan
d4: Shallow soils in feddan
s5: Very strong saline soils in feddan
s4: Strong saline soils in feddan
m5: Dry after less than 10 daysfrom irrigation in feddan
m4: Dry after 10 - 13 days from irrigation in feddan

3.4. Sustainability:

The impact of land quality limitations on sustainability and stability of the villages of Sugar Beet area is present in **Table (7).** The results illustrate that 32.83 % of the soils in the area suffers from a highly to very high severe land quality limitation. And 40.4 % of the studied area has marginal land quality limitations.

Table (7) Statistical Correlation of the Soil Quality Limitations and their Impact on Community Stability

Element of Stability	Code	C1	C2	C3	d5	d4	z5	z4	m5	m4	U	Se
Area with Slight limitations	C1											
Area with Marginal limitations	C2	-.452**										
Area with Severe limitations	C3	-.657**	-.374**									
Effective Soil Depth	d5	-.244	-.352*	.551*								
Effective soil Depth	d4	-.368*	-.187	.540**	.014							
Soil Salinity	z5	-.131	-.193	.299	.195	.175						
Soil Salinity	z4	-.456**	-.350*	.769**	.847**	.632**	.116					
Moisture Availability	m5	-0.118	-.201	.301	.728**	-.031	-.027	.426*				
Moisture Availability	m4	-.279	-.323	.562**	.905**	.535**	.263	.905**	.392*			
Uncultivated Areas	U	-.362*	-.298	.627**	.876**	.626**	-.177	.944**	.475**	.918**		
Settling %	Se	.441**	-.098	-.375*	-.375*	-.337*	-.039	-.505**	-.226	-.380*	-.519**	

**	Correlation is significant at the 0.01 level (1-tailed)
*	Correlation is significant at the 0.05 level (1-tailed)

The statistical analysis, which is shown in **Table (8),** illustrate the main findings that could be summarized as follows:

- In general, all villages could be considered in critical status concerning its stability and settlement percentages. The average settling percentage in the studied area is 30.47 %. The maximum settling percentage is in village 19 (80.22%) and the minimum settling percentage is in village "22" (6.8 %). The stability and settlement percentage has directly affected by the land quality limitations. The statistical analysis present a negative significant correlation of (-0.375*) with sever to very severe land quality limitations (C3 – that represents 32.83 % of the total area). The shallow soils (d4 – that represents 30.09 % of the total studied area), the very shallow soils (d5 – that represents 20.21 % of the total studied area) and the strong saline soils (z4 – that represents 53.83 % of the total studied area) are considered to be the major constrains for settlements. The shallow (d4) and the very shallow soils (d5) shows a negative, significant correlation with the settling percentage of (-0.375* and -0.337*) respectively, while the strongly saline soils shows a negative very significant correlation of (-0.505**) with the settling percentage.

- It has been recognized a very significant correlation of (627**) between the critical land quality limitations (C3) and the total uncultivated areas (u) from one side, and a negative and very significance correlation between the uncultivated areas and the settlement of (-519**) from the other side.

- The basic economic activity in the studied area is working in the fields of agricultural production. The main crop productions in most of the villages are of less than 40 - 60% of the highest production of the area and correspond closely to the land quality limitations of the area. Wheat is consider to be the main winter crop and occupy area of about 34.02% of the total arable land, Clover is the second winter crop and cover an area that represent 27.94% and Beans is the lower coverage crop and occupy 7.31% of the arable land. In summer time Tomato is considered to be the main crop and occupy 24.92% of the total arable land. Maize is the second summer crop in area coverage with a total of 19.01% and 25.33% for different types of vegetable cultivation. The severe to very sever land quality limitations (C3) shows a negative and very significant correlation with the Wheat and Tomato productions of (-0.585** & -0.521**) respectively. A negative and significant correlation with the Maize production of (-0.404*).

- The annual family average income in LE is around 4300 LE. The maximum is more than 6000 LE in villages 1, 14, 16, and El Olla and the minimum is less than 3000 LE in villages 10 and 25. In the meantime the annual average income per person is around 900 LE (0.7 US$/day). The maximum is more than 1500 LE (1.18 US$/day) in village 14 and 16, and the minimum is less than 650 LE (0.53 US$/day) in villages 5, Salama Hegazi and 25. Accordingly the total annual income per person in most of the villages is below the poverty line, which is one US$/day/person – **UNDP (1998)**. Thus, promoting the economical power of such society, and introducing types of production of " additional value" will help develop the individuals economic abilities, and upgrade their life–styles and stability.

– It appeared that the impact of land quality limitations on settler's loyalty to the land was recognized and that the settlement percentages are very low since in the other hand the limitations are very high.

Table (8) Statistical Correlation of the Soil Quality Limitations and their Impact on Economic Validity, Social Viability and Community Stability.

Indicator	code	C3	U	FIN	PIN	Se
Areas with sever limitations	C3			-.021	-0.089	-.220
Uncultivated Areas	U	.577**		-0.170	-0.085	-.502**
Wheat Production	W	-.585**	-.519*	0.364*	0.143	.320
Wheat Net Income	Wi	-.544**	-.528**	0.353*	0.132	.346*
Beans Production	B	-.212	-.005	0.397*	0.357*	.262
Beans Net Income	Bi	-.174	.004	0.134	0.066	-.104
Tomato Production	T	-.521**	-.431*	0.188	-0.001	.173
Tomato Net Income	Ti	-.240	-.296	0.233	0.257	.201
Maize Production	M	-.404*	-.340	0.443**	0.146	.326
Maize Net Income	Mi	-.226	-.340	0.451**	0.431**	.383
Clover Production	Cl	.063	.157	0.157	0.181	.049
Clover Net Income	Cli	-.223	-.188	-0.060	0.043	.145
Never Attended to school	N	.044	.149	-0.454**	-0.474**	-.030
Dropped out from school	D	-.004	-.165	0.357*	-0.062	.036
Illiteracy	I	.094	.048	-0.221	-0.634**	-.105
Unemployment	Uem	-.420*	-.337	-0.114	-0.258	-.027
CDA	CDA	.013	-.251	0.015	-0.043	.115
Mother & Child Care	MC	.299	-.081	0.555**	0.200	-.058
Filling of Security	S	.306	.307	-0.229	-0.152	-.127
Settling	Se			0.176	0.265	
**	Correlation is significant at the 0.01 level (2-tailed)					
*	Correlation is significant at the 0.05 level (2-tailed)					

ACKNOWLEDGEMENTS

The authors would like to convey their sincere thanks and gratitude to Caritas Egypt – Sustainable Integrated Development and Environment Sector, for allowing them to use their Soil & Water laboratory equipment and chemicals for analyzing all the soil samples and providing the Hardware's and Software of SIDES-MIC (Management Information Center). Also, for supplying them with the social and economical data of 1998 survey. The survey was implemented under the authors supervision and in cooperation with CAPMAS **(The Central Agency for Puplic Mobilization and Statistics), license no. 624/1998 published in El-Wakaa El Masria, issue no. 290 on 20 December 1998, covering Sugar Beet area (35 villages), Nubariya, Egypt.**

4. References:

Black C. A. (1982). " Methods of Soil Analysis. Part 2, Chemical and Microbiological Properties".
Agronomy series no. 9, ASA, SSSA, Medison, Wisconsin, USA.

Egyptian general survey authority (1992). The Topographic Maps Sheets NH35-K5b "Alam Musaylikh", NH35L-5d "El Hammam", NH35-L6a "Alam al Jataa", NH35L-6b "Jabal Khashm al Qaud", NH35L-6c "Burj al Arab", NH35L-6d "Iking Maryut", and Scale 1:50,000.

Elbersen, G.W.W. (1985). " Soil Survey Methodology and Specification"**. ITC lecture note, K5 (SOL 27),Enschede, The Netherlands.**

El Ganzory, K. (1997). " Egypt and the Twenty First Century", **published by El Ahram El-Ektsady, handbook no. 114, July, Egypt.**

Erian, W.F., Hanna F. and Valenzuela C. R. (1991). "Digital Image Processing and Land Evaluation of the Sugar Beet Zone, Nubariya District, Egypt- II Potential Land-use." J. Agric. Sci. Mansoura Univ. 16 (8): 1901 – 1912.

Erian, W.F. (1996). "GIS monitoring for physical and socio-economic factors affecting the sustainability of newly formed rural communities in desert areas Egypt." The Fifth International Conference on Desert Development, August 12-17, organized by the International Center for Arid and Semiarid Land Studies Office of International Affairs, Texas Tech University.

Erian, W.F. (1997). "The Use of the Sustainable Development Multi-Indicators For Evaluating The Stabilization in Some New Rural Communities in Desert Areas of Egypt" The International Conference on Geo-Information for sustainable Land Management, 17-21 August. Organized by ITC, Enschede, and The Netherlands.

Erian, W.F, Zaghloul, k. F and Gomma F. A. (1997) " The Use of GIS to Combine Soil Map with the Suggested Irrigation scheduling in the Sugar Beet Zone, Nubariya, Egypt." The International Conference on Earth Observation and Environmental Information (EOEI97), 13-16 October Alexandria, Egypt.

Erian, W.F. and R. K. Yacoub (1999) "The use of GIS to Combine Analytical and Synthetic Approaches for Obtaining Efficient & Effective Soil Survey Interpretation" The Sixth International Conference on the Development of Dry lands, August 22-27, organized by the International Desert Development Commission, in cooperation with ICARDA, Cairo, Egypt.

Hesse, P. R. (1971). " A Text Book of Soil Chemical Analysis". John Murruy, London, 85 pp**.**

Kilmer, V.J. and Mullins, J.F. (1954). " Improved Stirring and Pipetting Apparatus for Mechanical Analysis For Soils". Soil Sci. 77:437-441

Klute, A. (1986). " Water Retention, Laboratory Method in Methods of Soil Analysis", part 1 (A. Klute ed). American Society of Agronomy inc. Soil Science Society of America, Inc, Medison, Wisconsin, USA.

Ministry of Industry and Mineral Resources (1981). "The geological map of Egypt"

Nelson, R.E. (1982). " Carbonates and Gypsum"**.** In Methods of Soil Analysis, Part 2, pp. 181-198. American Society of Agronomy, Inc., Medison, Wisconsin, USA.

Rhoades, J. D. (1982). " Soluble salts" **Methods Of Soil Analysis. Part 2, Chemical and Microbiological Properties. Agronomy series no. 9, ASA, SSSA, Medison, Wisconsin, USA.**

SIDES (1999). "Workshop: Towards Sustainable Development For the New Rural Communities: Information Management for Development", Organized by the Sustainable Integrated Development and Environment Sector (SIDES) – Caritas Egypt, 28-30 June

Stein, A (1998). "Spatial statistics for soils and the environment", soil survey course, ITC, lecture note, Enschede, The Netherlands.

UNDP, (1998). " Human Development Report".

Zinck, J.A. (1997). "Physiography and Soils". ITC lecture note, K6 (SOL 41), Enschede, The Netherlands.