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استخدام تطبيقات الاستشعار عن بعد ونظم المعلومات الجغرافية فى تقسيم نطاقات البيئية الزراعية لمصر

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وحدة الاستشعار عن بعد ونظم المعلومات الجغرافية معهد بحوث الاراضى والمياه والبيئة – مركز البحوث الزراعية

الملخص العربي

تواجه التنمية الزراعية كثير من التعديات مثل تدهور التربة والتغيرات المناخية والمشاكل التي يسببها الإنسان. ان التغيرات المناخية الكبيرة والجفاف الذي يحدث في أفريقيا له عواقب سيئة علي الزراعة وخصوصاً في الجزء الشمالي من أفريقيا. وفى هذه الدراسة قد تم استخدام تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية لتقسيم مصر إلي مناطق بيئية زراعية وعمل جدول لوصف هذه المناطق.

تم الحصول علي ٧٤ قيمة للبخر نتح المرجعي لجمهورية مصر العربية منتشرة من الشمال إلي الجنوب. هذه النقاط تم الحصول عليها من برنامج FAO-AQUASTAT حيث تم عمل تحليل إحصائي للصور الفضائية من LandSat ETM التي تم الحصول عليها في عام ٢٠٠٧م واستخدمت لتحديد مواقع محطات الأرصاد الجوية الزراعية التي تم الحصول علي هذه القيم منها. وتم عمل تحليل Geostatical وتم استخدام أكبر المتغيرات توافقاً في عمل طريقة Kriging حيث تم الحصول علي (٧) مناطق بيئية زراعية عن طريق دمج خريطة نوع التربة مع خريطة الغطاء النباتي وخريطة توزيع قيم البخر نتح المرجعى.

ترجع أهمية تحديد هذه المناطق إلي أنها سوف تحسن قدرة واضعى السياسات في تحديد سياسات التنمية المناسبة لكل منطقة والتي يمكن الوصول إليها عند توفر المعلومات المناسبة لكل منطقة زراعية.

APPLICATION OF REMOTE SENSING AND GIS IN AGRO-ECOLOGICAL ZONING OF EGYPT

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ABSTRACT: *Agricultural development faces a lot of challenges such as soil deterioration, climatic changes and human induced problems. High climate variability and drought in Africa have adverse effect on agriculture, particularly in the northern part of Africa. The capabilities of remote sensing (RS) and GIS were used in this study to classify Egypt into agro-ecological zones and produced an attributed table describes each zone. ETo values for 74 points spread all over Egypt from north to south were downloaded using FAO-AQUASTAT model. Statistical images of ETM of Landsat acquired in 2007 were used to locate agro-metrological stations and geostatical analysis was carried out. The most fitted parameters were used to apply kriging method. Seven agro-ecological zones were obtained by layering operation between land cover, soil and ETo zones maps. Such zoning will increase the ability of the Egyptian policy makers to prepare the appropriate developmental policies as a result of the availability of proper information on each zone.*

Key words: *Remote sensing, GIS, land use, agro-ecological zones, Egypt.*

INTRODUCTION

Egypt lies in the north-eastern corner of the African continent and has a total area of about 1 million km^2. Hot dry summers and mild winters characterize Egypt's climate, where rainfall is very low, irregular and unpredictable. Agriculture development faces a lot of challenges such as the soil deterioration, climatic change, and human induced problems. High climate variability and drought in Africa had adverse effect on agriculture, particularly in the northern part of Africa. The area suitable for agriculture, the length of growing seasons and yield potential, are expected to decrease due to climate change. Agro-Ecological Zone is a land resource mapping unit. It have an unique combination of land form, soil and climatic characteristics and/or land cover with a specific range of potentials and constraints for land use (FAO, 1996). FAO in collaboration with the International Institute for Applied Systems Analysis (IIASA), have developed the Agro-ecological Zones (AEZ) methodology and a worldwide spatial land resources database (FAO 1981; FAO/ IIASA/ UNFPA, 1982). Traditional approaches have been made to establish the land area into climatic regions. Modern tools such as satellite remote sensing and GIS have been providing an effectively monitor and manage natural resources. It has been well conceived that remote sensing and GIS have great role for sustainable development due to multi-stages character of the comprehensive approach to agro-ecological zoning (Pratap *et al*., 1992). GIS technology is very useful for automated logical integration of bio-climate, terrain and soil resource inventory information (Patel *et al*., 2000). Stein (1998) explores the use of fuzzy *c*-means clustering of attribute data derived from a digital elevation model to represent transition zones in the soil-landscape. The use of remote sensing sources for land cover mapping is becoming a very common use. Land cover maps are digital data sets constructed mainly from images provided by earth satellites.

Climate plays an important role in crop production. ETo is a combination of two processes water evaporation from soil surface and transpiration from the growing plants (Gardner *et al.,* 1985).The calculation of the ETo includes all the weather parameters prevailed in a specific area.

Agro-climatic zone is a land unit in terms of major climate, superimposed on length of growing period i.e. moisture availability period (FAO, 1983). In the past, Egypt was divided into three main agro-climatic zones, i.e. Delta (Lower Egypt), Middle Egypt and Upper Egypt. The previous zoning was more administrative than ecological. Further zoning for Egypt divided the country into 9 agro-zones: (1) Coastal zone; (2) Central Delta; (3) East and West Delta; (4) Giza; (5) Menia; (6) Asuitt and Sohag; (7) North Qena; (8) South Qena and (9) Aswan (Eid *et al.,* 2006). The previous classification depended on the calculation of annual reference evapotranspiration (ETo) for each governorate. When the difference between the ETo of several governorates was less than 5%, they grouped together in one zone (Eid *et al.,* 2006). In 2007, another classification report for agro-ecological zones were developed by Central Laboratory of Agricultural Climate at Agricultural Research Center (Medany, 2007). Regression equations were used in this report to predict reference evapotranspiration for each zone using average temperature and month. These zones were: (1) North Delta (Dakhlia, Gharbia, Damietta and Kafr El-Sheikh); (2) West Delta (Alexandria and Behira governorates); (3) Middle Delta, (Ismailia, Kalubia, Minofia, Port-Said, Sharkia governorates); (4) South Delta (Giza, Cairo, Beni Suef and Fayom governorates); (5) Middle Egypt (Sohag, Qena, Asyout and Minia governorates) and (6) Upper Egypt region (Aswan governorate).

The aim of this study is using the capabilities of GIS to divided Egypt into Agro-Ecological Zones and produce an attributed table describe each zone. The maps of land cover, soils classes, and ETo zones were used for this purpose.

MATERIALS AND METHODS

The target of this study is to use the technologies of remote sensing and Geostatistical analysis within the geographic information systems environment for dividing Egypt into several agro-ecological zones. Figure (1) shows the recommended framework flow chart for obtaining agro-ecological zones of Egypt. The flow chart explains the three steps for producing the maps of land cover, soils, and ETo zones. Then the overlay operation was used to create the agro-ecological zones.

1. Source of soil data

The soil map of Egypt (scale 1:4,000,000) which is produced by Hamad *et.al.* (1975) was used in this study. The map was scanned, geometrically corrected and converted into digital format using Arc-GIS9.2 software. According to this map, Egypt was classified into 33 soil types as shown in Figure (2) and Table (1).

2. Climatic data

Weather data for 74 points spread all over Egypt from north to south were downloaded using FAO-AQUASTAT model (1996). The Climate Information Tool in this site provides an interactive tool to query a spatial data-set containing mean monthly climate data. The data-set covers the global land surface at a 10 minute spatial resolution for the period 1961-1990. These data set were used because they cover a large number of points in Egypt more and better than the recent weather data. The tool displays the latitude, longitude and elevation of the chosen location, as well as many climate variables per month and corresponded ETo. Table (2) shows the data of coordinates, elevation and mean values of ETo of the Agro-meteorological stations.

Satellite images ETM+ of Landsat 7 acquired in 2007 were used to locate agro-metrological stations. Data in Table (2) used to create point's map of the calculated ETo means value as shown in Figure (3).

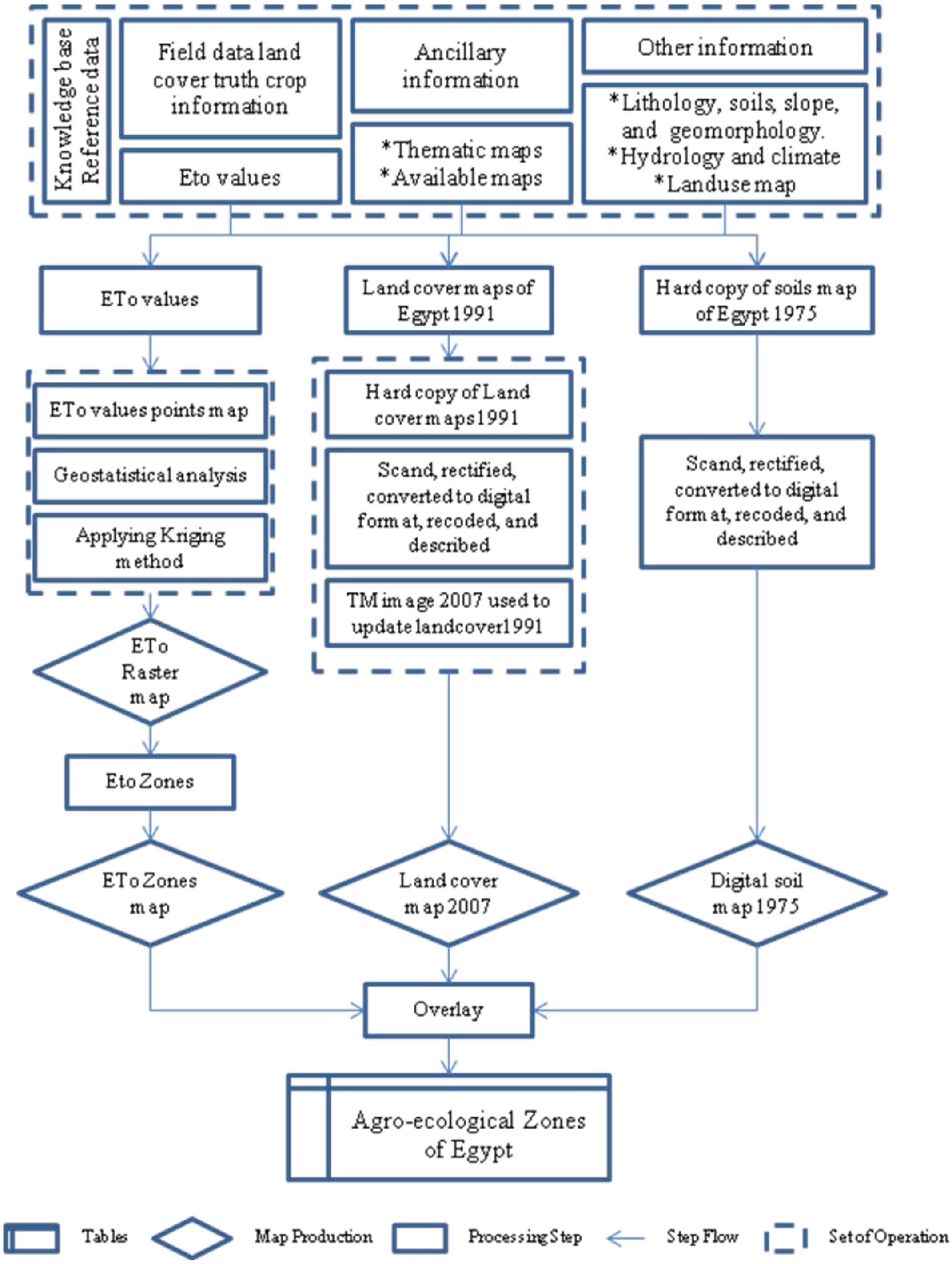

Figure (1) : Framework Flow Chart of obtain Agro-Ecological Zones of Egypt

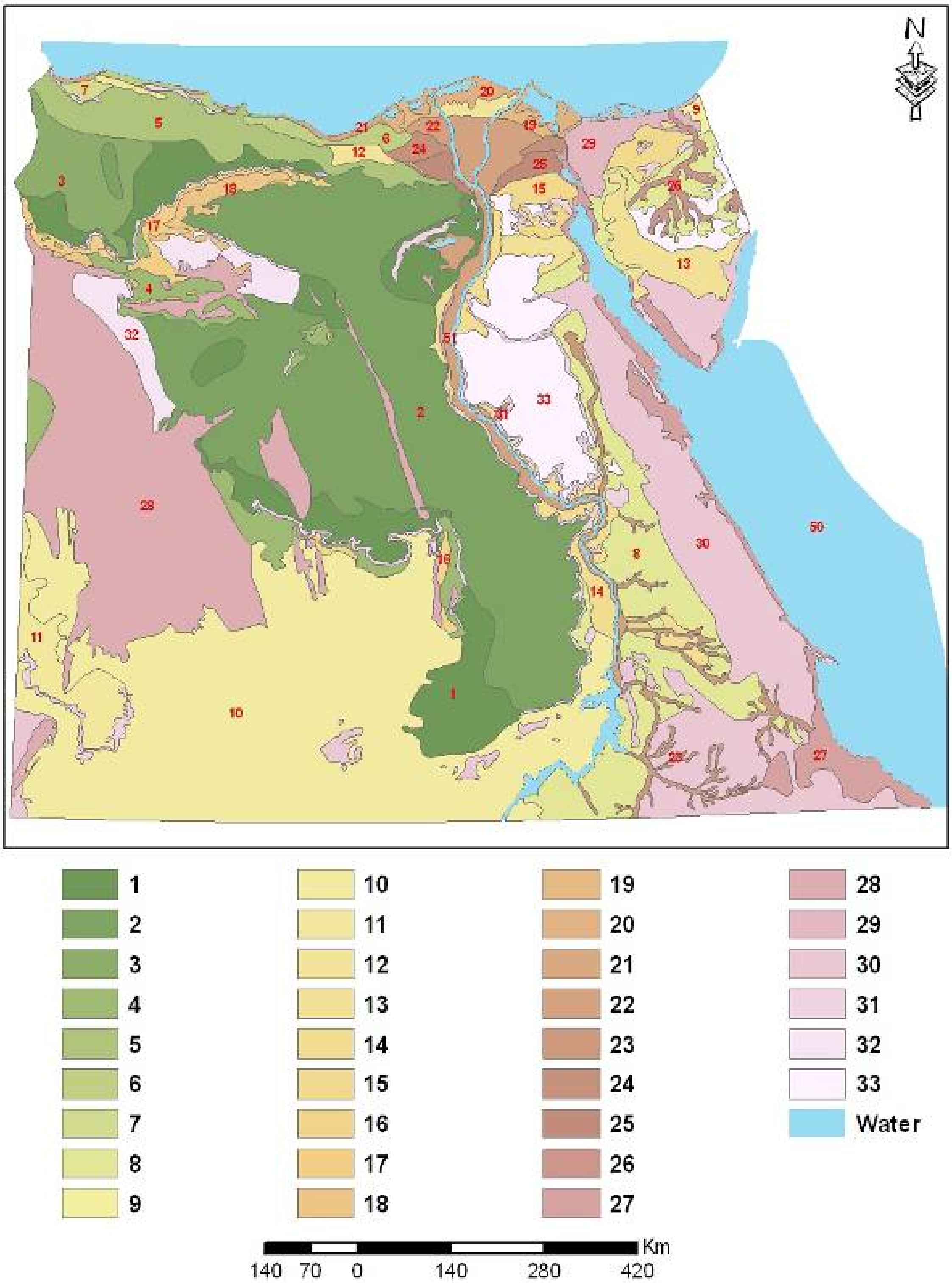

Figure (2) : Soil map of Egypt (Source: Hamad *et.al.* 1975)

Table (1): Main soil units of Egypt (Hamad *et al.,* 1975).

Code	Soils Description	Area in Feddan	Area %
1	Stoney and loamy sand Lithosols on rough to undulating denuded terrain 1),Lithic Torriorthents, Torripsamments, Calciorthids, Lithosols 2) , Calcic and Takyric Yermosols, Lithosols 3)	14548054	4.88
2	Shadow or stoney loamy sand - sandy loam soils of the Peneplains with hill remnants and/or sand dunes , Lithic Calciorthids, Torri-and Quartzipsamments , Calcic and Takyric Yermosols, Eutric Regosols,Lithosols	41572095	13.95
3	Gravelly sand to gravelly loamy sand Lithosols with scattered Solonchaks ,Lithic Torriorthents, Salorthids, Lithosols ,Calcaric Regosols, Takyric Solonchaks, Lithosols	4356433	1.46
4	Sandy soils with stoney hill remnants of the Piedmont plains , Torriorthents, Torripsamments,Salorthids, Lithosols ,,Calcaric Yermosols, Eutric Regosols, Takyric Solonchaks, Lithosols	5198599	1.74
5	Gravelly sand Lithosols with brown loamy soils in scattered patches of the desert plains , Lithic Torriorthents,Calciorthids,Lithosols , Calcaric and , Eutric Regosols,Calcaric Yermosols,Lithosols	5781954	1.94
6	Arid brown loamy soils with remnants of rocky ridges of the coastal plains , Calciorthids, Gypsiorthids, Paleothids, Lithosols , Calcic and calcic Yermosols, Lithosols	1282430	0.43
7	Sandy and loamy sand soils with remnants of rocky ridges of the coastal pains , TORRIPSAMMENTS, Calciorthids, Lithosols ,Calcaric Regosols, Calcaric Yermosols,Lithosols	295893	0.10
8	Sandy soils and gravely Lithosols of the desert plains with rocky hills , Torripsamments, Lithosols , Dystric and Eutric Regosols, Lithosols	15121490	5.07
9	Arid brown soils with sand dunes ,Calciorthids,Torripsamments, Calcic and Haplic Xerosols	221324	0.07
10	SANDY SOILS OF THE Nubia sandstone plains with stoney hill remnants and rock exposures ,Torripsamments, Quartzipsamments, Lithosols , Eutric Regosols , Lithosols	48154806	16.15
11	Stoney sand Lithosols on rough terrain with rock lands ,Lithic Torripsamments,Lithosols ,Lithosols, Eutric Regosols	3328150	1.12
12	Sandy to loamy sand soils with Lithosols, Torripsamments, Torriorthents,, Lithosols , Eutric Regosols,and Lithosols	1125136	0.38
13	Loamy sand to sandy loam soils with Lithosols , Calciorthids, Torriorthents, Torripsamments, Lithosols ,Calcic Yermosols, Lithosols	3649587	1.22
14	Gravels and gravelly sand soils of the alluvial fans, outwash plains, Nile terraces and Piedmont plains , Calciorthids, Gypsiorthids,Torriorthents , Calcaric and Eutric Regosols, Calcic and Gypsic Yermosols , Lithosols	3388431	1.14
15	Gravels and gravels of a denuded rock land with sand dunes, Lithic Torriorthents, Torripsamments,Lithosols, Calcaric and Eutric Regosols	2425410	0.81
16	Reddish brown calcareous clayey soils of the desert oases , Paleargids, Chromusterts , Chromic Vertisols	531685	0.18
17	Solonchaks with rocky hill remnants , Salorthids and Lithosols , Takyria and Orthic Solonchaks, Lithosols	1636660	0.55

Table (1): cont.,

Code	Soils Description	Area in Feddan	Area%
18	Sabkha of the desert depressions , Typic and Aquollic Salorthids, Hydraquents, Psammaquents , Orthic and Gleyic Solonchaks	1586296	0.53
19	Salt affected soils of the lower Nile delta areas, Typic Salorthids, Takyric and Orthic Solonchaks	606083	0.20
20	Saltmarches of the lower delta plain Sulfaquents, Hydraquents and Fluvaquents, Gleyic Solonchaks	1274827	0.43
21	Lagoons-coasatl limestone ridges combination, Aquollic Salorthids, Sulfaquents, Hydraquents, Psammaquents, Gleyic Solonchaks	452363	0.15
22	Nile alluvium, Pellusterts, Vertic Torrifluvents, Eutric Fluvisols, Pellic Vertisols	4975074	1.67
23	Gravelly loamy sands of the drainage channels, Torrifluvents, Torriorthents, , Calciorthids, Eutric and CalcaricRegosols	3138275	1.05
24	Sands, clayloams with calcareous crusts and sand dunes of the delta lacustrine complex, Torripsamments, Torrifluvents, Calciorthids and Salorthids, Calcaric and Eutric Regosols,Calcaric Fluvisols,Orthic Solonchaks	707909	0.24
25	Gravels and gravelly sand soils of the deltaic phase with sand dunes, Torriorthents, CalciorthidsQuartzipsamments, Calcaric and Regosols	1016592	0.34
26	Yellowish brown soils of Wadi El Arish, Xeric Torrifluvents, Calciorthids, Calcaric Fluvisols, Calcic Yermosols	1151696	0.39
27	Gravely and gravelly sand beaches , sometimes with rock outcrops Torripsamments, Lithosols, Eutric Regosols, Lithosols	5905128	1.98
28	Sand dunes and sand sheets of the western Desert, Quartzipsamments,Eutric Regosols	29506240	9.90
29	Sand dunes and sand sheets of the Northern Sinai, Quartzipsamments, Torripsamments, Eutric Regosols	1993623	0.67
30	Rugged rock land mainly of the basement complex	23259547	7.80
31	Rocky escarpments of different country rocks	5158781	1.73
32	Denuded rock land with few sand dunes	3854441	1.29
33	Dissected limestone plateau with lithosols	10050855	3.37
50	Sea water	53134056	17.82
Total		298110699	100.00

Source: Hamad *et al.,* (1975)

Table (2): The data of coordinates, elevation and ETo of the metrological stations

Station	coordinates		Elevation	ETo	Station	coordinates		Elevation	ETo
No	Y	X	Z	Means	No	Y	X	Z	Means
1	30.86	28.29	98m	3.6	38	26.36	25.71	149m	5.5
2	30.86	30.86	11m	4.2	39	24.75	34.39	462m	6.2
3	31.18	33.43	23m	3	40	24.43	33.11	156m	7.2
4	31.18	34.07	79m	3	41	24.43	32.14	403m	7.2
5	31.18	33.11	17m	3.2	42	24.43	30.86	304m	7
6	31.18	32.46	9m	4.5	43	24.43	29.57	348m	6.4
7	31.5	31.5	4m	2.9	44	24.11	28.61	297m	6.2
8	31.5	30.54	5m	2.9	45	24.11	27.32	450m	5.8
9	30.86	29.25	48m	3.4	46	24.11	26.36	711m	5.6
10	31.18	28.29	29m	3.4	47	24.11	25.39	723m	5.6
11	31.18	27	194m	3.4	48	23.14	35.04	299m	6.1
12	31.5	26.04	98m	3.5	49	22.82	34.07	461m	6.6
13	30.54	34.07	258m	4.6	50	22.5	33.11	254m	7
14	30.21	33.11	482m	4.6	51	22.82	31.82	222m	7
15	30.21	32.46	15m	5	52	22.82	30.21	171m	6.7
16	30.54	31.5	23m	4.9	53	22.82	29.25	226m	6.5
17	30.21	30.54	120m	4.8	54	22.5	29.57	246m	6.6
18	29.57	29.25	242m	5.2	55	22.5	27.96	305m	6.3
19	29.57	27.96	110m	5.3	56	22.18	26.36	727m	6
20	29.57	26.68	-90m	5.4	57	22.5	35.68	274m	5.7
21	29.57	25.71	90m	5.4	58	22.5	35.36	383m	5.8
22	28.93	34.07	1 173m	5.3	59	31.02	30.21	7m	3.1
23	28.61	32.46	425m	5.4	60	31.02	30.86	8m	4.1
24	28.29	31.5	341m	5.7	61	31.02	31.5	18m	4.4
25	28.29	30.54	58m	5.9	62	30.38	31.18	20m	4.9
26	28.29	29.25	162m	5.9	63	29.73	30.86	31m	5.5
27	28.29	27.96	196m	5.6	64	29.09	30.54	41m	5.7
28	28.29	26.36	133m	5.4	65	28.13	30.54	87m	5.9
29	28.29	25.39	135m	5.4	66	27.16	30.86	209m	6.2
30	27	33.11	638m	5.9	67	26.52	31.5	258m	6
31	26.68	32.14	416m	5.9	68	25.88	32.14	354m	6.2
32	26.68	30.86	291m	6.2	69	25.23	32.46	120m	6.8
33	26.68	31.82	316m	5.9	70	24.59	32.79	111m	7.3
34	26.68	30.54	260m	6.3	71	23.63	32.79	182m	7.6
35	26.68	29.25	282m	6	72	22.98	32.46	203m	7.3
36	26.68	27.96	186m	5.5	73	22.66	31.82	173m	7
37	26.68	27	258m	5.3	74	22.34	31.5	190m	6.8

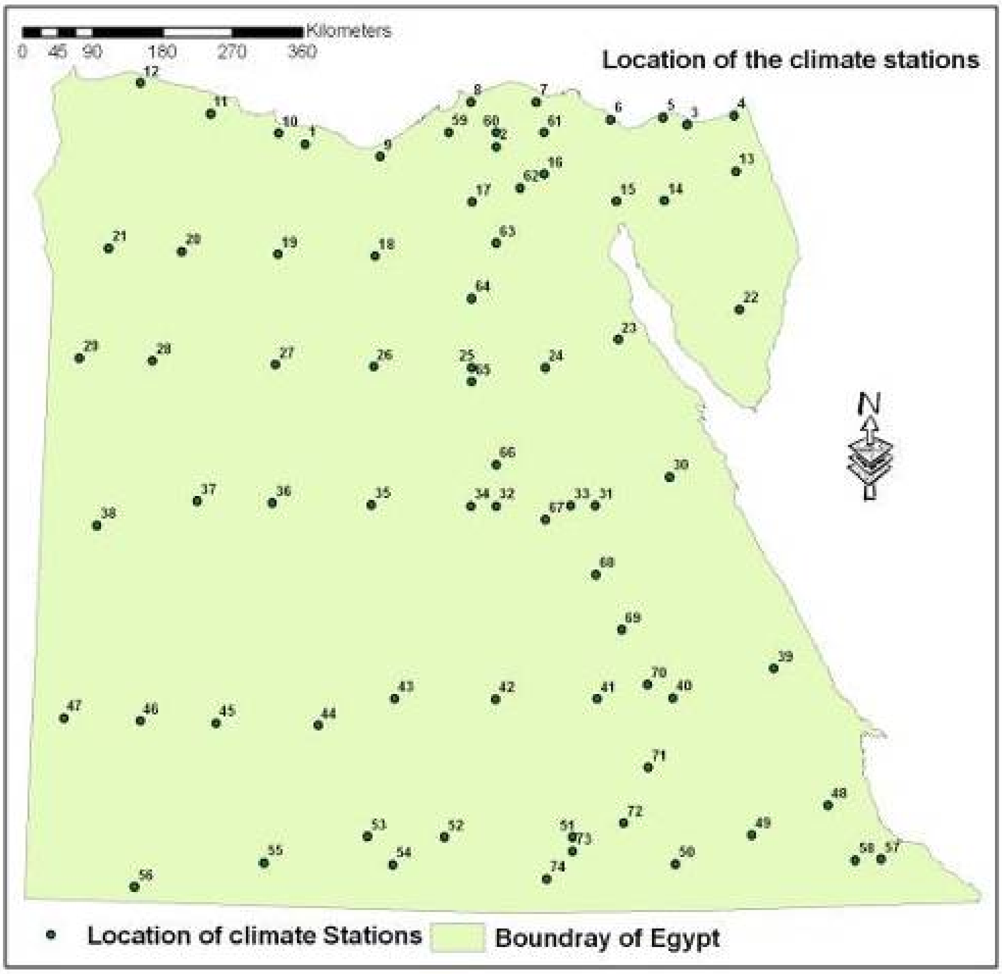

Figure (3) : Location of the selected ETo mean value points over Egypt

3. Land cover map

Land cover maps produced in 1991 by SWERI (Remote Sensing and Geographic Information System unit) were scanned, cropped, and rectified using ETM grid projection. TM satellite images in 2007 were rectified using the geo-referencing ETM grid projection. The classification unit's system design was contained main classes which classified to sub classes. Extract features classes from satellite data and geocoded depending on the Heracles classification with its description depended on the land cover maps of 1991 were developed. Topographic maps in scale 1:250000 produced by Egyptian survey authority (ESA) in 1986 were used to delineate roads, canals, and villages. Field truth was done to emphasis the correct classes. Land cover maps were created at the level of main and sub classes. The classification system represents 11 main classes (Figure 4). Each main class was classified into number of subclasses (Table 3).

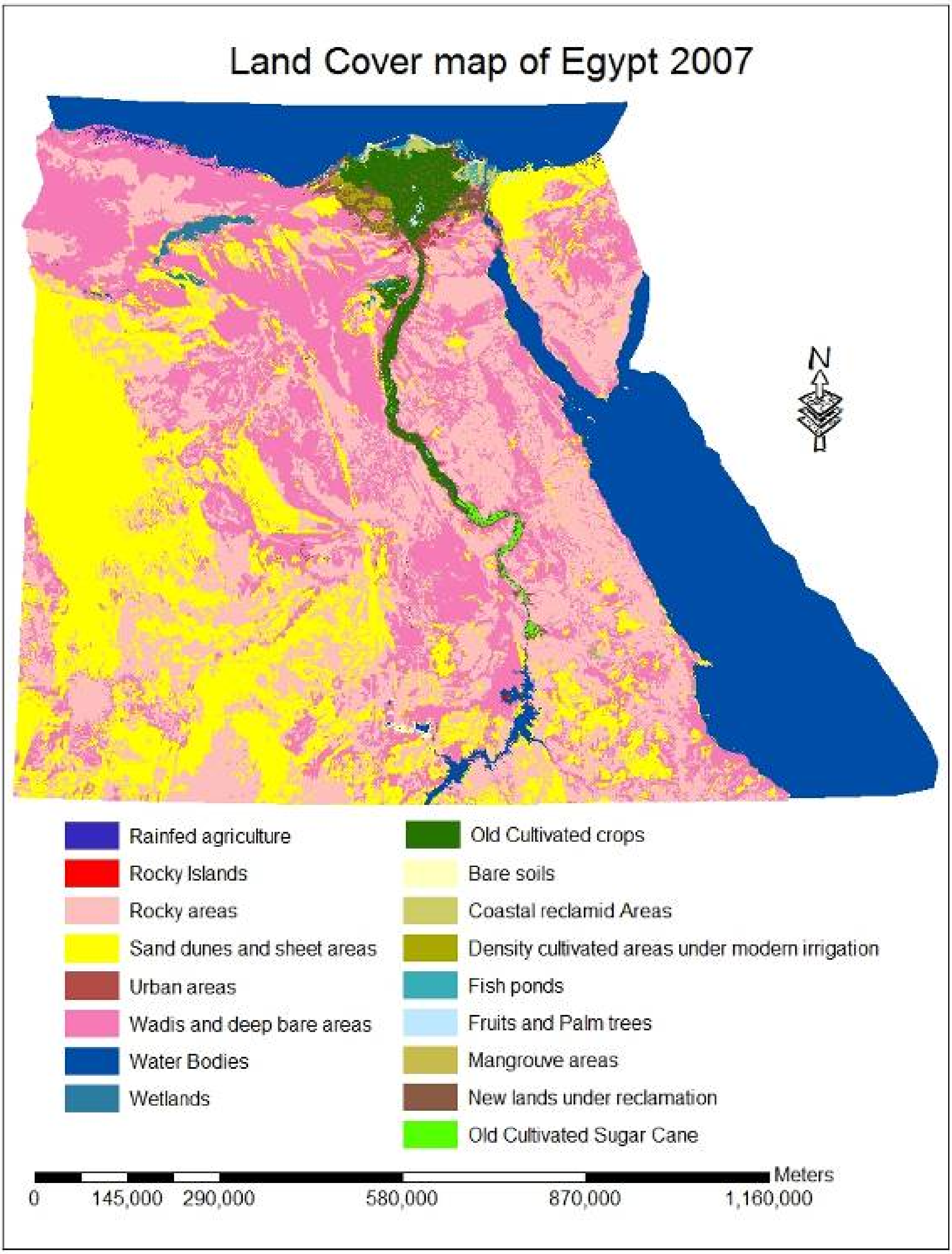

Figure (4) : Main classes of land cover units of Egypt 2007

Table (3): Land cover and land use classes of Egypt

Land use or Landcover Description of sub Classes	Land cover of Main classes	Area in Feddan	Area %
Rice, Cotton, Maize (S), Wheat, Clover (W), Fruits, Vegetables (SEC)	Old Cultivated Crops areas	937782	0.315
Rice, Cotton, Maize (S), Clover, Wheat (W), Fruits, Vegetables (SEC)		781663	0.262
Rice , Cotton , Maize (S), Clover , Wheat (W) ,Sugar beet		589645	0.198
Maize , Cotton(S) , Clover , Wheat , Feba bean (W), Rice , Fruits , Vegetables , Soya (SEC)		465282	0.156
Maize, Cotton(S), Wheat, Clover, Feba bean (W), Vegetables (SEC)		269787	0.090
Maize , Cotton(S) , Wheat , Clover , Feba bean (W), Fruits , Vegetables (SEC)		826038	0.277
Maize , Cotton(S) , Wheat , Clover , Feba bean (W),Fruits, Sugar cane, Veget (SEC)		1021853	0.343
Fruits + Veg. Maize (S) , Clover (SEC)		287241	0.096
Sugar cane (S), Sugar cane (W)	Old Cultivated Sugar cane areas	502778	0.169
New lands under reclamation (infrastructure under progress)	New lands under reclamation	161156	0.054
Low - density cultivated areas (very recent extension)		390210	0.131
Medium -density cultivated areas (recent extension)		626793	0.210
Density cultivated areas (old extension)		779305	0.261
Density cultivated areas under modern irrigation (geometrical shape)	Density cultivated areas under modern irrigation	606876	0.204
Density cultivated areas under pivot irrigation		77663	0.026
Areas in the very early stages of reclamation	Coastal Reclaimed areas	50866	0.017
Areas in the early stages of reclamation (leaching , installation of irrigation and drainage networks, no cultivation)		34854	0.012
Reclaimed areas with starting cultivation		126069	0.042
Reclaimed areas fully cultivated		461044	0.155
Rained agriculture (western coast)	Rained agriculture	365101	0.122
Bare soils	Bare soils	51039	0.017
Sub deltaic hilly sediments		3431	0.001
Inland sandy areas		30905	0.010
Beach , sand , dunes		142716	0.048
Weeds		225633	0.076
Wetlands	Wetlands	20340	0.007
Inland water		838258	0.281
Inland salted water		197445	0.066
Urban areas	Urban areas	1123517	0.377
Area on the way of urbanisation		140095	0.047
Scattered urbanisation		31417	0.011
Industrial zones		54273	0.018
Artificial , non - agricultural vegetated areas (Parks)		15523	0.005
Airport , harbour		69775	0.023
Mediterranean Sea	Water Bodies	16765517	5.624
Nile River		181864	0.061
Lakes		1755900	0.589
Suez canal		13044	0.004
Red Sea		42515337	14.262
Fruits (S), Fruits (W)	Fruits and Palm trees	83761	0.028
Palm grows		75783	0.025
Salted marches	Fish ponds	30805	0.010
Marine waters (coastal lagoons , estuaries)		1563	0.001
Salt evaporation basin		17058	0.006
Fish ponds		225324	0.076
Rocky Islands	Rocky Islands	42062	0.014
Rocky Islands		1660	0.001
Wadi areas	Wadis and Deep bare areas	4658372	1.563
Deep bare areas		54702090	18.350
Deep bare areas with gravels		11911774	3.996
Sand dune areas	Sand dune and Sand sheet areas	25116758	8.425
Sand sheet areas		39837973	13.363
Rocky areas	Rocky areas	34733627	11.651
Rocky areas covered with shallow soils		53080292	17.806
Mangrove areas	Mangrove areas	53764	0.018
Total		298110699	100.000

S: Summer season, W: Winter season, SEC: Secondary crops

4. Statistical analysis of ETo values

Descriptive statistics of the ETo values was done to calculate the standard deviation which is used to create the ETo zones of Egypt. The 74 ETo values were divided according to the value of longitude to three groups. Each group contains 26 values of ETo and represents a part of Egypt from north to south. Furthermore, each group was considered as a replicate. Therefore, each replicate contains temperature values prevailed in Egypt. Analysis of variance was done using one factor randomize complete block design with three replicates. The means of the 74 ETo values was separated and ranked in ascending order using least significant difference test ($LSD_{0.05}$).

Geostatistical analysis was carried out at a two step procedure: (a) calculation of the experimental semi-variogram and fitting a model; and (b) interpolation through ordinary Kriging, which uses the semi-variogram parameters (Stein, 1998). From the semi-variogram operation it could define which model fits the experimental semi-variogram values. The most fitted model parameters were used by calculating the Goodness of fit (R^2) to apply Kriging method.

5. Creation of ETo values map

The point's map of the calculated means of 74 ETo values was used to create the Agro-Ecological Zones. The parameters of the semi-variogram of the ETo points map were calculated using spatial correlation operation.

RESULTS AND DISCUSSIONS

1. Statistical analysis

The descriptive statistics of 74 ETo values indicated that the mean value was 5.48 mm/day and the standard error was 0.14. Furthermore, the standard deviation was 1.22 and the range between the highest and the lowest values of ETo was 4.75 mm/day (Table 4). This indicates the variations of Egyptain weather conditions. It could be reflect the water requirements for crops grown in different locations in Egypt.

2. Creation of ETo values map

The kriging method was applied using the parameters of the semi-variogram of the ETo points map to create the ETo value map (Figure 5). This method resulted in 32 ranges of ETo values spread all over Egypt area. The slicing operation was used to group the ETo values in seven zones based on the standard deviation of the ETo points map (Figure 6).

Table (4): Descriptive statistics of ETo values

Statistical analysis	Value
Mean	5.478137
Standard Error	0.141307
Medium	5.675
Mode	6.7.58333
Standard deviation	1.215566
Sample Variance	1.477601
Kurtosis	-0.296377
Skewnees	-063027
Range	4.747619
Minimum	2.885714
Maximum	7.633333
Sum	405.3821
Count	74
Confidence level (95.0%)	0.281624

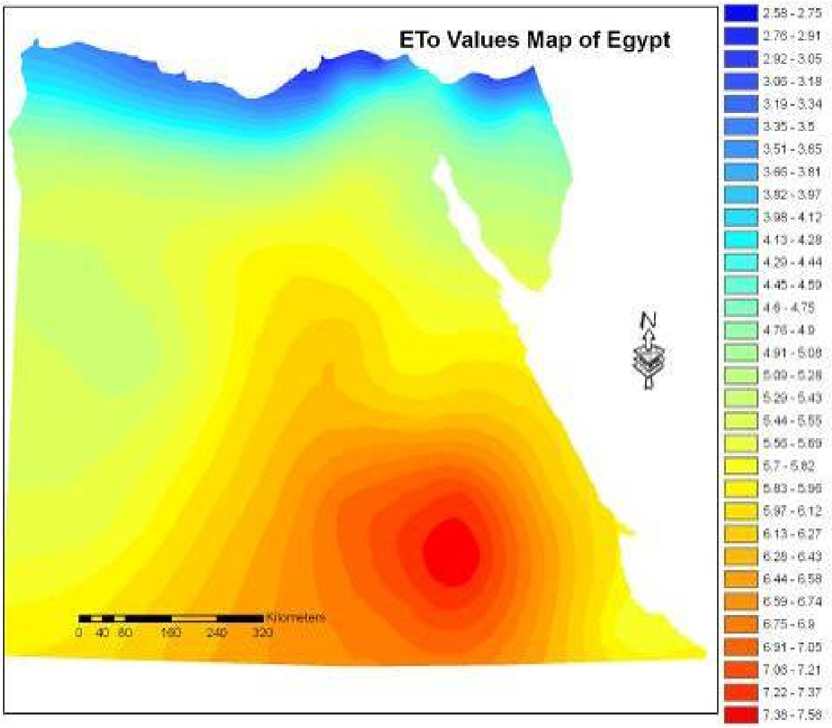

Figure (5) : ETo values map of Egypt

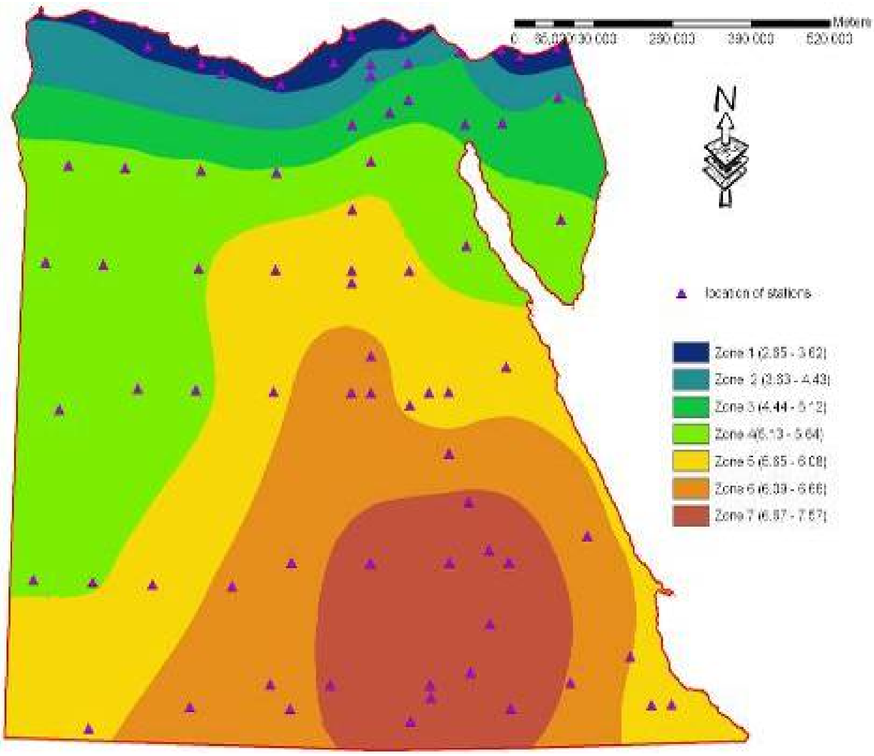

Figure (6): ETo Zones map of Egypt

3. Description of the Agro-ecological Zones

Seven Agro-Ecological Zones were obtained using the layering operation between the land cover, soil and ETo maps. The description of these seven zones is included in Table (5). Zone 1 is represented by a narrow strip on the northern of Egypt. Furthermore, its area is the lowest. Rain-fed irrigation is prevailed in this zone, in addition to surface irrigation in the Nile Delta. The governorates included in this zone are North Sinai, Bort Said, Demiatte, El-Dakahlia, Kafr El-Sheikh, Alexandria and Marsa matrouh. All these governorates existed in the Nile Delta, except North Sinai and Marsa matrouh. The rice and sugar beat are the main cultivated crops, in addition to fruits and vegetables. Zone 2 includes all the above governorates, in addition to Ismalia and El-Sharkia. Zone 3 includs North Sinai, Ismalia and El-Sharkia, El-Monofia, El-Behira, El-Kalubia and Marsa Matrouh. The most important cultivated crops in this zone are wheat, clover and faba bean in winter season, in addition to maize and cotton in the summer season. Zone 4 includs South Sinai, El-Suize, El-Giza and El-Wadi El-Gedid. Zone 5 includes Bani Swief, Menia, Assuite and Red Sea governorates. Zone 6 has the largest area and includes Qena, Red Sea and El-Wadi El-Gedid governorates. Zone 7 includes Souhage, El-Luxor, Aswan, Red Sea and El-Wadi El-Gedid governorates. The main cultivated crop in zones 5, 6 and 7 is sugar cane. The most of cultivated lands of these are zones are located mainly at the Nile Delta and Valley.

Table (5): Description of agro-ecological zones of the Nile Delta and Valley

Agro-ecological zone	Area in Feddan	ETo Range	Dominant Soils classification	Cultivated Crops
Zone 1	8,275,387	2.65 – 3.62	Typic Torrerts Typic Torrifluvents	Rice, Maize, Wheat, Clover, Sugar Beat, Fruits, Vegetables
Zone 2	42,348,750	3.63 – 4.43	Typic Torrerts Typic Torrifluvents Typic Quortzisanments	Maize, Cotton, Wheat, Clover, Faba bean, Fruits, Vegetables.
Zone 3	25,243,006	4.44 – 5.12	Typic Torrerts Typic Torrifluvents, Typic Quortzisanments & Rocky Land	Maize, Cotton, Wheat, Clover, Faba bean, Fruits, Vegetables.
Zone 4	22,864,256	5.13 – 5.64	Typic Torrerts Typic Torrifluvents, Typic Calciorthids & Rocky Land	Maize, Cotton, Wheat, Clover, Faba bean, Fruits, Vegetables.
Zone 5	35,294,643	5.65 – 6.08	Typic Torrerts Typic Torrifluvents, Typic Calciorthids & Rocky Land	Maize, Cotton, Wheat, Clover, Faba bean, Fruits, Sugar cane Vegetables
Zone 6	72,215,089	6.09 – 6.66	Typic Torrerts , Typic Quortzisanments & Typic Torriorthents	Maize, Cotton, Wheat, Clover, Faba bean, Fruits, Sugar cane Vegetables
Zone 7	33,604,583	6.67 – 7.57	Typic Torrerts , Typic Quortzisanments & Typic Torriorthents	Maize, Cotton, Wheat, Clover, Faba bean, Fruits, Sugar cane Vegetables

Conclusion:

Egypt area (about one million square kilometres) have varied climatic features, geomorphic characteristics and land use patterns, with different socio-economic implications. The land use and or land cover and soil maps of Egypt were converted to the digital format to facilitate the GIS analyses. The ETo values over Egypt were extracted from the available climatic stations by using the spatial analyses techniques. It is found that ETo differ widely from north to south direction, where the values tend to increase towards the south direction. According the variation of ETo values, the total area of Egypt was classified into 7 zones. GIS capabilities can be used to extract the soils and land use and or land cover under each ETo class. The study represents the efficiency of Geostatistical analysis, RS and GIS in setting the correlation between the ETo values and their associated land use and or land cover and soils.

Such zoning will increase the ability of the Egyptian policy makers to prepare the appropriate developmental policies as a result of proper information available about each zone. The zoning will be useful to define suitable crops within each zone to attain its optimum production. Furthermore, the classification of ETo mean values and their associated land use or land cover and soils could assist the developmental planning for sustainable agricultural. This could be determine and improve the actual water requirements for different crops of each zone which is help for save irrigation water for other areas. It could be useful for establishing the strategic crops belts for Egypt. And lastly, it can be help for improving the income of water/soil/crop units.

REFERENCES

Eid, H. M., S. M. El-Marsafawy and S.A. Ouda (2006). Assessing the impact of climate on crop water needs in Egypt: the CropWat analysis of three districts in Egypt. CEEPA Discussion Papers No. 29.

FAO (1981). Agro-ecological Zones. World Soil Resources Report 48, FAO, Rome.

FAO/ IIASA/ UNFPA (1982). Potential Population supporting Capacities of Lands in the Developing World. Technical Report on Project INT/513, FAO, Rome.

FAO. (1983). Land Evaluation of Rain-fed Agriculture. Soil Bull. 52, FAO, Rome, 237p.

FAO (1992). CROPWAT, a computer program for irrigation planning and management by M. Smith. FAO Irrigation and Drainage Paper No. 26. Rome.

FAO (1996). AQUASTAT model of weather data for Egypt, (http://www.fao.org/nr/water/aquastat/main/index.stm).

Gardner, F. P., R. B Pearce, R. L. Mitchell (1985). Physiology of Crop Plants. Iowa State University Press. Ames. USA.

Hamad *et.al.* (1975). “Soils Map of Egypt”, Web site, European digital archive of soil maps, http://eusoils.jrc.ec.ruropa.eu/esdb_archive/EuDASM/Africa/lists/s1_ceg.htm.

Medany, M. (2007). Water Requirement for Crops in Egypt. Central Laboratory of Agricultural Climate.

Pratap, T., P. Pradhan, P.K. Lotta, Mya S. Karim and G. Nakarmi (1992). Geographic Information Systems and Technology application in Agro-ecological zonation of mountain agriculture. Eds. N.S. Jodha, M. Banskota and Tej Pratap, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Patel, N.R., U.K. Mandal and L.M. Pande (2000). Agro-ecological zoning system. A Remote Sensing and GIS Perspective. Journal of Agrometeorology, 2 (1) : 1-13.

Stein, A. (1998). Spatial Statistics for Soil and the Environment. Soil survey course, ITC, lecture note, Enschede, The Netherlands.

استخدام تطبيقات الاستشعار عن بعد ونظم المعلومات الجغرافية فى تقسيم نطاقات البيئية الزراعية لمصر

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وحدة الاستشعار عن بعد ونظم المعلومات الجغرافية معهد بحوث الاراضى والمياه والبيئة – مركز البحوث الزراعية

الملخص العربي

تواجه التنمية الزراعية كثير من التعديات مثل تدهور التربة والتغيرات المناخية والمشاكل التي يسببها الإنسان. ان التغيرات المناخية الكبيرة والجفاف الذي يحدث في أفريقيا له عواقب سيئة علي الزراعة وخصوصاً في الجزء الشمالي من أفريقيا. وفى هذه الدراسة قد تم استخدام تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية لتقسيم مصر إلي مناطق بيئية زراعية وعمل جدول لوصف هذه المناطق.

تم الحصول علي ٧٤ قيمة للبخر نتح المرجعي لجمهورية مصر العربية منتشرة من الشمال إلي الجنوب. هذه النقاط تم الحصول عليها من برنامج FAO-AQUASTAT حيث تم عمل تحليل إحصائي للصور الفضائية من LandSat ETM التي تم الحصول عليها في عام ٢٠٠٧م واستخدمت لتحديد مواقع محطات الأرصاد الجوية الزراعية التي تم الحصول علي هذه القيم منها. وتم عمل تحليل Geostatical وتم استخدام أكبر المتغيرات توافقاً في عمل طريقة Kriging حيث تم الحصول علي (٧) مناطق بيئية زراعية عن طريق دمج خريطة نوع التربة مع خريطة الغطاء النباتي وخريطة توزيع قيم البخر نتح المرجعى.

ترجع أهمية تحديد هذه المناطق إلي أنها سوف تحسن قدرة واضعى السياسات في تحديد سياسات التنمية المناسبة لكل منطقة والتي يمكن الوصول إليها عند توفر المعلومات المناسبة لكل منطقة زراعية.