

## **4. RESULTS AND DISCUSSIONS**

### **4.1 Assessment of the present conditions of soil according to the current investigation:**

The current investigation deals with soil and water analyses with regard to:

1. Physical properties of the soils (particle size distribution, soil bulk density and total porosity and pore size distribution).
2. Calcium carbonate.
3. Gypsum.
4. Organic matter content.
5. Soil pH values.
6. Soluble salts.
7. Distribution of soluble cations and anions.
8. Ground water
9. The sodium adsorption ratio SAR of soil extract.

#### **4.1.1 Physical properties of the degraded soils:**

Soil productivity is considered as a function of different soil properties. Any improvement or reclamation of the soils under investigation, especially the saline ones would be met with some difficulties. Soil structure is closely related to moisture retention and total porosity, and it should be considered in the improvement and reclamation of soils.

#### **4.1.1.1 Particle size distribution:**

Soils are the product of the environmental factors which act upon their parent materials. The alluvial soils of Egypt had been formed mainly from the suspended matter carried within the Nile water and transformed from the Abyssian plateau in Ethiopia. The deposition of the suspended materials and formation of the Nile flood plains and Delta is governed by many factors such as grain size, water current speed in the lateral and longitudinal directions, (i.e. encroachment zones), and the admixing by sea formations in the northern part. Accordingly large areas around the lakes in the northern parts of the Delta were considered deteriorated soils particularly and the country lies in the arid zone.

Data on particle size distribution of soil profiles are presented in Table (1) and the soil texture triangle is presented in Fig. (1). The investigated soils are mainly of a clay texture. Seven profiles (Nos. 1, 2, 3, 4, 5, 8 and 9) were clay down to their deepest layer, one profile (No. 7) was a clay, in its upper 60 cm overlying a silty clay loam; another (No. 6) was a clay in its uppermost and deepest horizons and a silty clay in its middle horizon; a third horizon (No. 10) was a silty clay loam in its uppermost horizon, a silty loam in its deepest horizon and a clay in its middle.

Also, there was a wide variation in the sand fraction among the studied soil profiles. This fraction ranged between 1.7 and 35.0%.

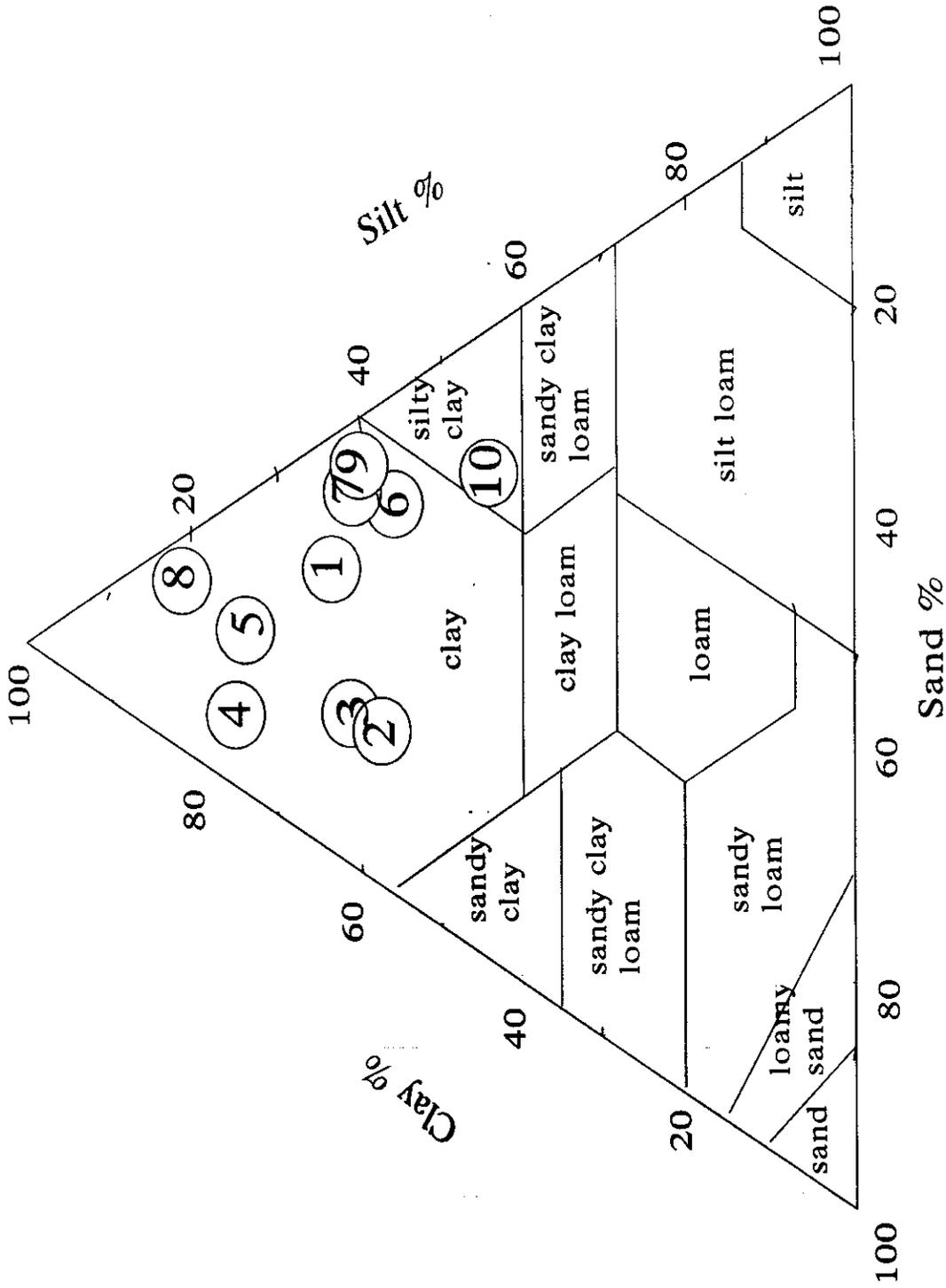
The silt fraction covers a wide range of 10.1 to 43.8%. The higher value

Table (1) : Particle size distribution, calcium carbonate and organic matter of selected soil profiles.

Prof. No.	Location	Depth	Particle size distribution %				Texture grade	Gypsum %	CaCO <sub>3</sub> %	O.M
			Coarse sand	Fine sand	Silt	Clay				
1	Al-Bosrat (a)	0 - 20	4.6	8.0	26.7	60.8	Clay	0.7	3.2	3.7
		20 - 35	2.4	18.9	11.4	67.3	Clay	0.1	3.4	1.4
		35 - 70	3.6	7.8	22.0	66.6	Clay	0.5	1.3	0.5
		Mean	3.6	10.2	21.1	65.1		0.5	2.3	1.6
2	Al-Aziza	0 - 20	1.1	9.8	30.0	59.2	Clay	0.3	0.9	4.0
		20 - 40	2.1	30.1	11.4	56.5	Clay	0.3	1.1	1.3
		40 - 75	0.8	34.2	10.9	54.1	Clay	0.3	1.3	1.6
		75 - 90	1.1	22.4	13.8	62.8	Clay	0.5	0.9	1.0
		Mean	1.2	25.9	15.7	57.2		0.3	1.1	1.9
3	Al-Bosrat (b)	0 - 20	3.2	32.1	15.3	49.5	Clay	0.4	2.8	1.2
		20 - 60	1.2	25.8	7.2	66.0	Clay	0.5	0.9	1.1
		60 - 100	1.4	13.1	18.2	67.3	Clay	0.7	1.5	1.2
		100-150	1.7	16.5	30.2	51.7	Clay	1.1	3.2	0.9
		Mean	1.7	20.1	18.9	59.3		0.7	2.0	1.1
4	Al-Bosrat (c)	0 - 20	0.1	8.1	16.0	75.9	Clay	0.1	3.2	1.0
		20 - 40	0.3	17.1	6.1	76.6	Clay	0.0	1.9	1.5
		40 - 55	1.0	17.1	7.7	74.2	Clay	0.0	3.0	0.2
		Mean	0.4	13.8	10.1	75.7		0.0	2.7	1.0
5	Meat Marag Salsel	0 - 30	2.2	8.3	27.2	62.3	Clay	0.0	2.1	3.1
		30 - 65	2.4	2.8	21.5	73.3	Clay	0.9	0.6	0.7
		65 - 100	1.8	13.4	10.4	74.5	Clay	0.7	0.9	1.3
		100-150	1.7	1.0	21.8	75.6	Clay	0.8	1.1	1.4
		Mean	1.9	5.8	20.1	72.2		0.7	1.1	1.6

Table (1). Cont.

Prof. No.	Location	Depth	Particle size distribution %				Texture grade	Gypsum %	CaCO <sub>3</sub> %	O.M
			Coarse sand	Fine sand	Silt	Clay				
6	Al-Bosrat (d)	0 - 25	2.9	13.2	34.0	50.0	Clay	0.3	3.2	1.1
		25 - 40	0.5	1.7	41.8	56.1	Silty clay	0.0	1.5	1.4
		40 - 65	1.8	5.2	29.3	63.7	Clay	0.0	0.4	1.8
		Mean	1.9	7.5	34.0	56.7		0.1	1.7	1.5
7	Al-Gawaber (a)	0 - 20	1.0	3.5	25.1	70.5	Clay	2.9	5.9	2.4
		20 - 60	0.6	1.1	24.8	73.6	Clay	0.4	4.2	1.0
		60 - 80	0.9	16.4	57.9	24.9	Silty clay loam	0.6	3.2	1.1
		Mean	0.8	5.5	33.1	60.6		1.1	4.4	1.4
8	Al-Gawaber (b)	0 - 20	2.2	1.5	17.7	78.6	Clay	0.3	7.0	1.8
		20 - 60	3.2	1.9	20.8	74.1	Clay	0.5	3.0	1.0
		60 - 100	1.9	0.7	3.8	93.6	Clay	0.0	2.1	1.1
		100-150	1.3	0.9	16.3	81.5	Clay	0.0	3.4	1.0
		Mean	2.1	1.2	14.4	82.4		0.2	3.4	1.2
9	Meet Salsel	0 - 20	2.3	5.3	31.0	61.4	Clay	0.1	2.1	2.4
		20 - 35	1.8	16.9	26.1	55.2	Clay	0.3	0.9	1.0
		35 - 70	1.7	1.4	38.1	58.8	Clay	0.1	1.7	1.1
		70 - 110	1.6	1.4	33.4	63.7	Clay	0.1	0.6	1.4
		Mean	1.7	4.2	33.5	60.6		0.1	1.3	1.5
10	Al-Hosinia	0 - 15	11.9	4.8	50.9	32.4	Silty clay loam	0.4	0.6	3.1
		15 - 50	6.8	14.2	22.6	56.4	Clay	0.4	0.6	1.4
		50 - 100	3.1	12.2	28.6	56.1	Clay	0.6	1.5	1.8
		100-150	4.3	8.4	71.6	15.7	Silty loam	0.2	1.1	0.7
		Mean	5.2	10.7	43.7	40.3		0.4	1.1	1.5



**Fig. (1): Triangle of the particle size distribution and soil texture; and texture designation of the 10 soil profiles (according to the mean of each horizon) taken in the current study (profile No. in circles).**

is associated with the soils profiles 6, 7, 9 and 10, while the lower value is recorded in profiles 2, 3, 4 and 8.

The clay fraction ranged between 40.3 and 82.4%. High values were in profiles 4, 5 and 8, while low values were in profiles 3, 6 and 10.

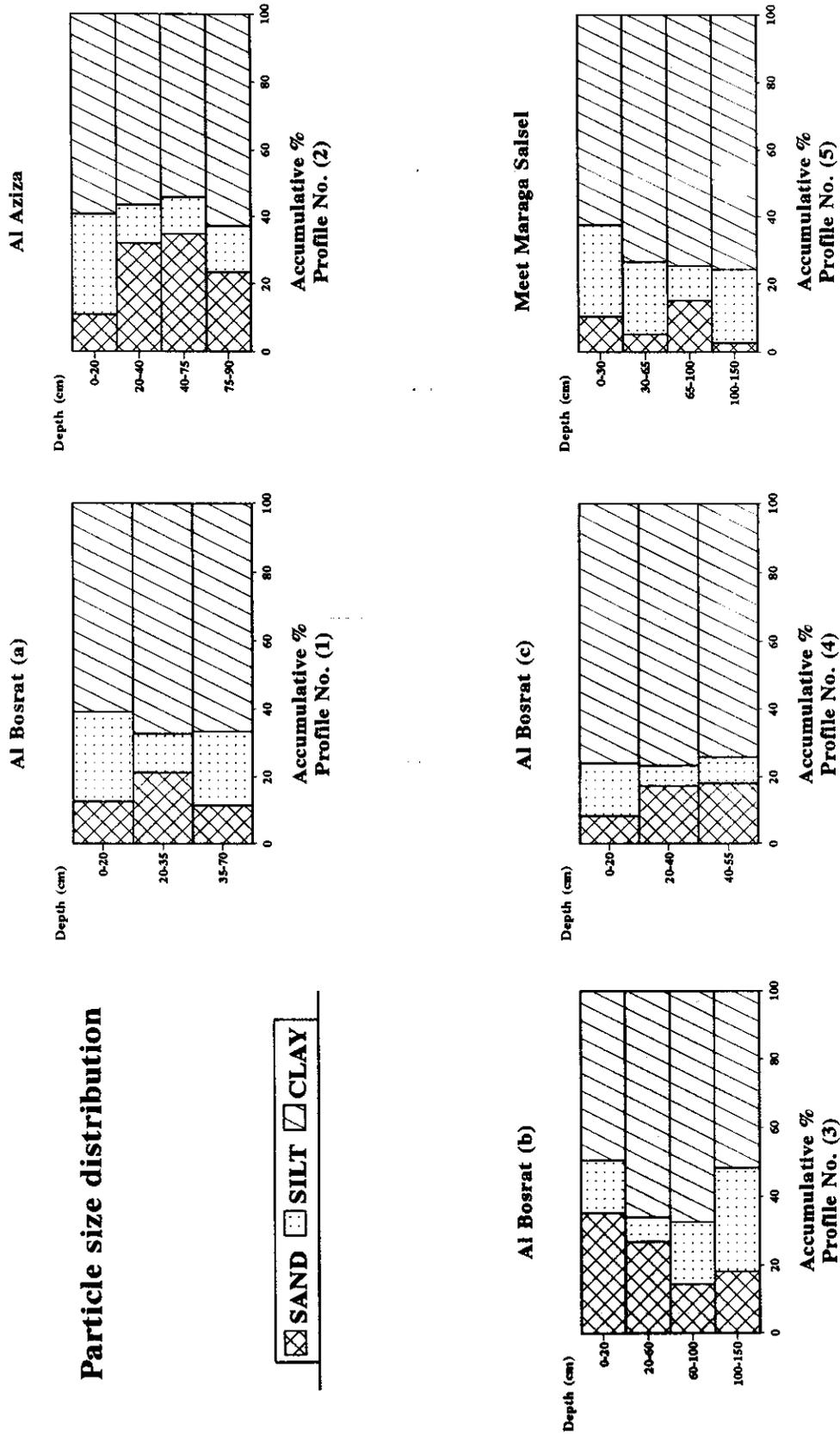
Regarding the pattern of change of sand content with depth [Fig. (2)], this fraction had no particular trend, although it may be stated that in profile 3, 6, 8 and 10 it tended to decrease with depth.

Regarding the pattern of change of silt with this fraction also had no particular trend, though it may be stated that in profiles 1, 2, 4, and 5 it tended to decrease with depth; in profile 7 it tended to increase.

Clay content also showed no regular trend; though it may be stated that in profiles 1, 3, 5, 6 and 9 it tended to increase with depth, whereas in profiles 2 and 7, it tended to decrease with depth. In profile 8, in particular that was a very high clay content of 93.6% in its deep layer (60-100 cm) i.e., the layer is nearly of clay particles. This shows the significant influence of the activity of water current during ancient periods of flood.

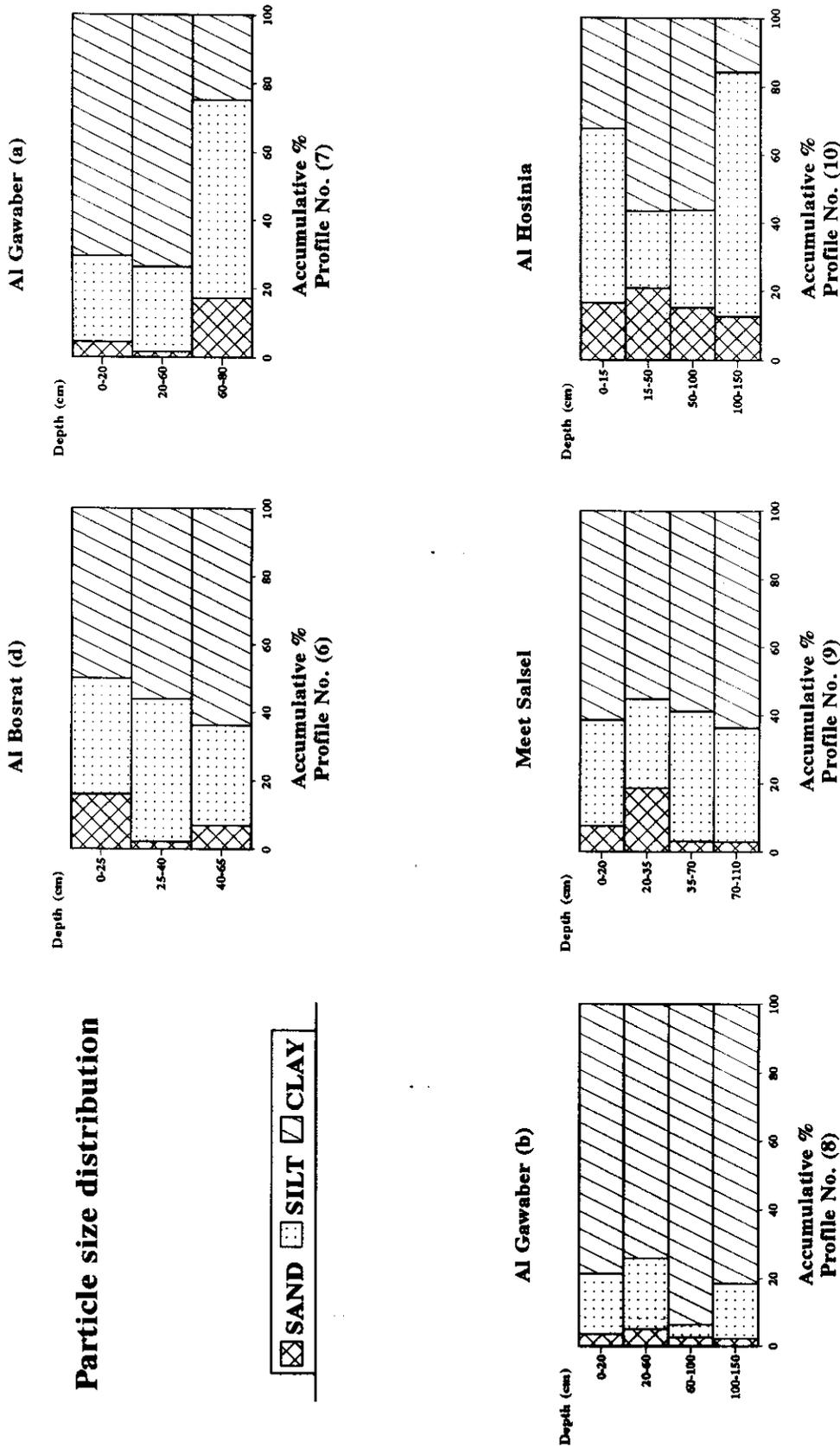
Therefore, it may be stated that soils of the current study were mainly formed from the Nile alluvium probably admixed in some cases with marine formations. In this connection, water either from Nile River or from the sea

## Particle size distribution



**Fig. (2): Particle size distribution in relation to soil depth for the studied soil profiles.**

**Particle size distribution**



**Fig. (2): Cont.**

were most certainly the main important factors affecting the deposition of the studied soils.

#### **4.1.1.2 Soil bulk density:**

The soil bulk density is one of the criteria used as an indicator for the evaluation of soil structure, as well as soil water retention in different sizes of pores. Also, bulk density is a dynamic value which changes in the soil according to several factors, (such as soil texture, structure, organic matter content, soluble and exchangeable salts, human activity and depth of soil layer).

The data given in Table (2) show that bulk density values fluctuate from one site to another as they cover a wide range from 0.87 g/cm<sup>3</sup> (profile 4, layer 40-55 cm) to 1.42 g/cm<sup>3</sup> (profile 10, layer 15-50 cm), the lowest values are associated with the higher moisture and to the relatively heavy texture materials which have a relative high content of organic matter, i.e., the surface layer of the Nile alluvial soils (profiles 1,5,7,9 and 10). While the highest values are found in the relatively light texture materials which are usually poor in organic content and moisture content in profiles 9 and 10.

With regard to the depthwise distribution, Table (2) shows that bulk density values tend to increase with depth, this behaviour is expected, [Baver 1961 and El-Khattib 1983], due to soil compaction and the decrease in organic matter content.

Table (2): Soil moisture characteristics of the studied soil profiles.

Profile No.	Location	Depth cm	Soil moisture percentage different tension (atm). v/v						B.D.	Total porosity % on volume basis	Pore size distribution of total porosity					Porosity %
			0	0.1	0.33	0.66	1	15			>28.8	28.8-8.62	>8.62	>8.62-0.19	<0.19	
1	Al-Bosrat (a)	0 - 20	67.77	58.49	56.30	54.23	51.10	23.52	1.00	67.77	9.27	2.19	11.46	32.78	23.52	62.10
		20 - 35	60.25	54.53	52.01	50.57	48.33	21.94	1.19	60.25	5.71	2.52	8.24	30.07	21.94	55.26
		35 - 70	60.80	52.69	49.90	48.21	45.85	21.20	1.19	60.80	8.12	2.79	10.91	28.70	21.20	55.16
2	Al-Aziza	0 - 20	61.36	50.84	47.78	45.85	43.36	20.46	1.19	61.36	10.52	3.06	13.58	27.32	20.46	55.06
		20 - 40	59.49	49.61	47.71	46.40	44.54	19.97	1.26	59.49	9.87	1.90	11.78	27.74	19.97	52.38
		40 - 75	59.81	51.27	49.22	47.67	46.07	20.63	1.16	59.81	8.53	2.06	10.59	28.58	20.63	56.04
		75 - 90	60.99	53.19	51.46	49.80	47.77	21.40	1.16	60.99	7.80	1.73	9.53	30.06	21.40	56.09
3	Al-Bosrat (b)	0 - 20	65.56	44.69	40.69	38.98	36.92	18.00	0.90	65.56	20.87	4.00	24.86	22.70	18.00	66.06
		20 - 60	59.88	55.18	53.60	51.95	49.96	22.20	1.23	59.88	4.70	1.58	6.29	31.40	22.20	53.50
		60 - 100	59.61	50.21	47.84	46.16	44.45	20.21	1.15	59.61	9.40	2.37	11.77	27.63	20.21	56.69
		100-150	63.27	50.44	48.54	26.76	45.85	20.30	1.23	63.27	12.83	1.91	14.73	28.24	20.30	53.72
4	Al-Bosrat (c)	0 - 20	67.97	55.09	51.58	49.56	46.95	22.16	1.11	67.97	12.88	3.50	16.38	29.43	22.16	57.98
		20 - 40	69.18	61.86	60.35	58.16	55.01	24.87	1.08	69.18	7.32	1.51	8.83	35.48	24.87	59.34
		40 - 55	73.74	69.58	67.73	65.71	62.85	27.96	0.87	73.74	4.15	1.85	6.01	39.77	27.96	67.00
5	Meat Mirag Salsel	0 - 30	60.22	41.29	38.26	37.68	35.20	16.64	0.93	60.22	18.93	3.03	21.96	21.62	16.64	65.04
		30 - 65	62.05	55.68	53.42	51.58	49.50	22.40	1.19	62.05	6.37	2.26	8.63	31.03	22.40	54.94
		65 - 100	64.38	58.68	56.70	54.48	52.27	23.60	1.22	64.38	5.70	1.98	7.68	33.10	23.60	54.02
		100-150	65.65	57.74	55.53	54.09	51.39	23.22	1.22	65.65	7.90	2.21	10.12	32.31	23.22	53.99

Table (2): cont.

Profile No.	Location	Depth cm	Soil moisture percentage defferent tension (atm).						B.D.	Total porosity % on volume basis	Pore size distribution of total porosity					Porosity %
			0	0.1	0.33	0.66	1	15			>28.8	28.8-8.62	>8.62	>8.62-0.19	<0.19	
6	Al-Bosrat (d)	0 - 25	58.06	42.73	40.54	39.23	35.77	17.22	1.00	58.06	15.33	2.19	17.53	23.32	17.22	62.37
		25 - 40	61.06	48.98	46.79	44.17	44.66	19.72	1.14	61.06	12.08	2.19	14.27	27.07	19.72	57.03
		40 - 65	63.61	53.10	51.03	50.90	44.66	21.36	1.24	63.61	10.51	2.07	12.58	29.66	21.36	53.25
7	Al-Gawaber (a)	0 - 20	65.38	55.24	51.68	49.31	46.43	22.22	0.98	65.38	10.14	3.56	13.69	29.46	22.22	62.98
		20 - 60	63.56	56.64	54.61	52.37	50.36	22.78	1.17	63.56	6.92	2.03	8.95	31.83	22.78	55.98
		60 - 80	61.74	55.00	53.18	51.67	48.92	22.13	1.11	61.74	6.73	1.82	8.56	31.06	22.13	57.93
8	Al-Gawaber (b)	0 - 20	71.12	58.08	55.18	54.81	47.93	23.36	1.10	71.12	13.03	2.91	15.94	31.82	23.36	58.32
		20 - 60	67.36	56.79	53.94	51.75	49.64	22.84	1.13	67.36	10.57	2.85	13.42	31.10	22.84	57.24
		60 - 100	70.91	65.42	62.21	59.19	56.68	26.29	1.18	70.91	5.49	3.21	8.70	35.92	26.29	55.58
9	Meer Salsel	100-150	74.57	61.24	57.51	54.85	52.24	24.62	1.21	74.57	13.33	3.73	17.06	32.89	24.62	54.24
		0 - 20	64.45	41.99	39.55	39.10	35.89	16.92	0.99	64.45	22.46	2.45	24.90	22.63	16.92	62.53
		20 - 35	57.22	46.76	45.05	43.81	42.10	18.83	1.25	57.22	10.47	1.71	12.18	26.22	18.83	52.76
10	Al-Hosinia	35 - 70	60.79	53.63	51.78	50.65	48.40	21.58	1.32	60.79	7.15	1.85	9.00	30.21	21.58	50.23
		70 - 110	64.56	54.30	51.95	50.97	48.43	21.84	1.35	64.56	10.26	2.34	12.61	30.11	21.84	49.02
		0 - 15	62.35	47.66	44.01	41.68	39.68	19.19	1.25	62.35	14.68	3.66	18.34	24.82	19.19	53.00
		15 - 50	59.33	49.19	46.92	45.61	43.49	19.80	1.42	59.33	10.14	2.27	12.41	27.12	19.80	46.30
		50 - 100	54.51	45.54	43.33	41.96	40.05	18.34	1.41	54.51	8.97	2.21	11.18	24.99	18.34	46.68
		100-150	60.99	48.02	42.33	38.88	36.58	19.33	1.23	60.99	12.96	5.70	18.66	22.99	19.33	53.66

This layer of the lowest bulk density is characterised by having the highest saturation percentage (164%), a very high total porosity (69%), high sodicity (SAR of 55), high clay content (74%) rather high pH (7.8), this may refer to the soil as being saline-sodic.

The layer of highest density is characterized by its rather low saturation percent 77%, low total porosity 59%, low organic matter and medium clay content 56%.

#### **4.1.1.3 Total porosity and pore size distribution:**

Total porosity is an index of the relative volume of pores in the soil. Data presented in Table (2) reveal that the values of total soil porosity for soils under study ranged between 54.51 and 74.57%. The porosity is classified according to De Leenheer and De Boodt (1965) into the following four main classes:

1. Quickly drainable pores (Q.D.P) of  $> 28.8 \mu\text{m}$ .
2. Slowly drainable pores (S.D.P) of 8.62 to  $28.8 \mu\text{m}$ .
3. Water holding pores (W.H.P) of 0.19 to  $8.62 \mu\text{m}$ .
4. Fine capillary pores (F.C.P)  $< 0.19 \mu\text{m}$ .

The highest total porosity of the soils in Al-Gawaber (profile 8) was 74.57% as well as fine capillary pores. This is the layer which contained the highest percent of fine particles (81.5% clay).

The trend of profiles (4, 5 and 6) tends to increase porosity with depth

while profile 7 tends to decrease with depth, whereas the other profiles were no clear trend obtained.

Statistical analysis shows a highly significant positive correlation between total soil porosity and clay and significant with clay plus silt, with  $r$  values 0.54 and 0.37, respectively. There was a significant negative correlation between total porosity and sand content, with  $r$  value -0.37.

The statistical analysis shows a significant positive correlation between slowly drainable pores (S.D.P) and silt, with  $r$  0.37.

The correlation between water holding pores (W.H.P) and clay was highly positively significant ( $r = 0.61$ ); and highly negatively significant with silt ( $r = -0.50$ ).

The correlation between fine capillary pores (F.C.P) and clay was highly positively significant ( $r = 0.59$ ); and highly negatively significant with silt ( $r = -0.45$ ).

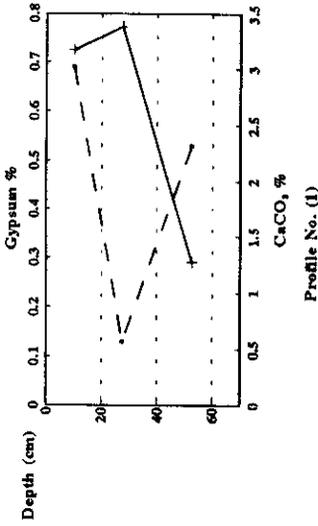
#### **4.1.2 CaCO<sub>3</sub>:**

With regard to data presented in Table (1) and illustrated by Fig. (3), the total CaCO<sub>3</sub> content ranged between 1.06 and 4.39% (expressed as profiles mean). The comparatively low values (1.06 - 1.27%) are associated with the soils of profiles 2, 5, 9 and 10, while the relatively high ones (2.65-4.39%) are

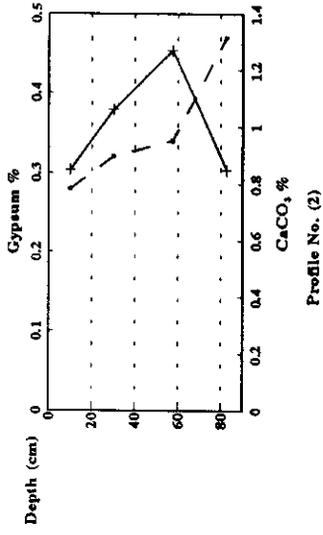
**CaCO<sub>3</sub>  
and  
Gypsum**

**-- Gypsum + CaCO<sub>3</sub> .**

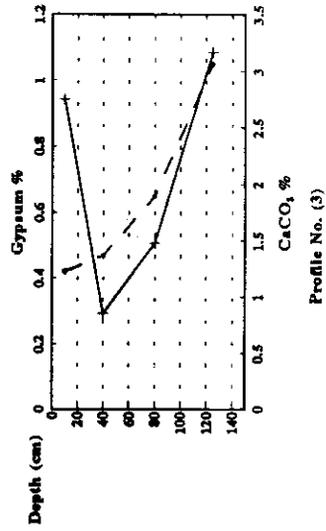
**Al Bosrat (a)**



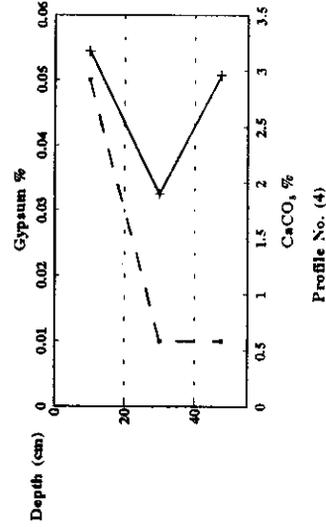
**Al Aziza**



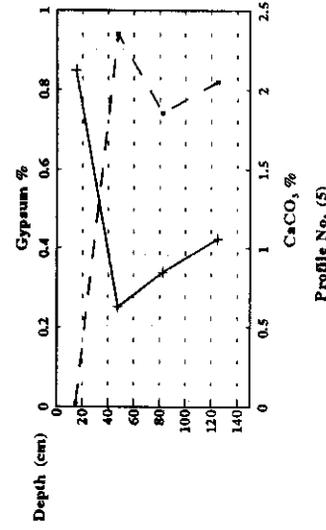
**Al Bosrat (b)**



**Al Bosrat (c)**



**Meet Maraga Salsel**

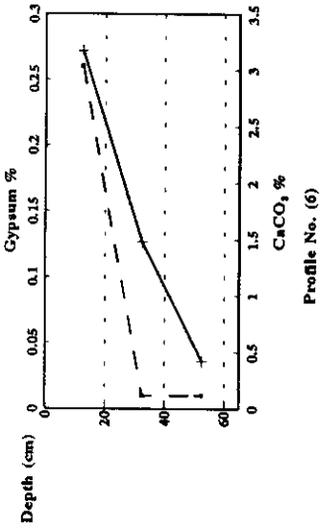


**Fig. (3): CaCO<sub>3</sub> and gypsum distribution through soil depth for the studied soil profiles.**

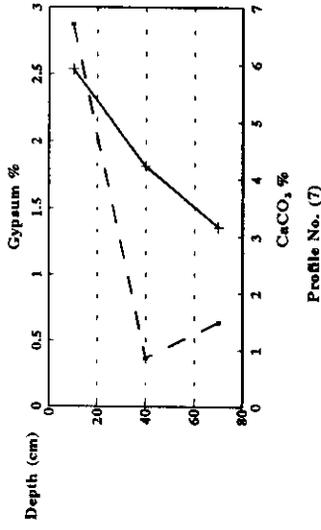
**CaCO<sub>3</sub>  
and  
Gypsum**

--- Gypsum + CaCO<sub>3</sub> .

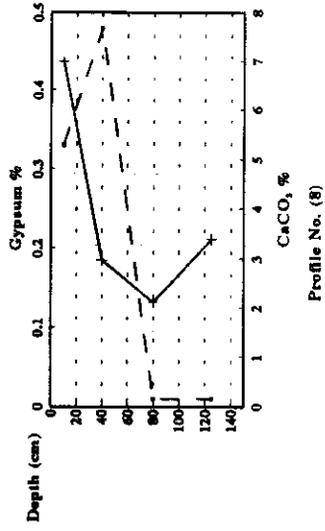
**Al Bosrat (d)**



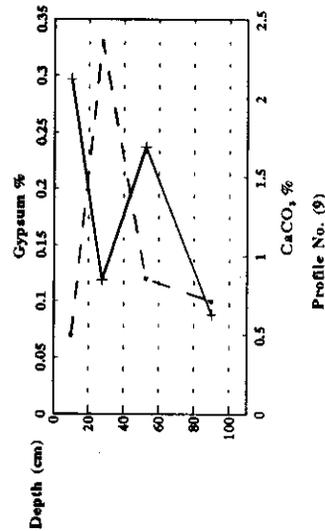
**Al Gawaber (a)**



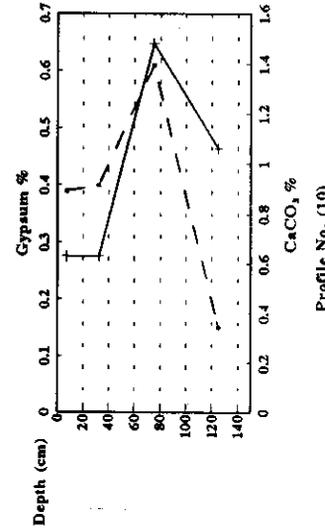
**Al Gawaber (b)**



**Meet Salsel**



**Al Hosinia**



**Fig. (3): Cont**

found in soils of profiles 4,7 and 8. Differences in  $\text{CaCO}_3$  content in profiles are mainly due to the differences in its sources and origin. As the origin of  $\text{CaCO}_3$  in the locations of low contents may have been mainly of chemical precipitation of  $\text{Ca}(\text{HCO}_3)_2$  from the Nile water during soil formation whereas in locations of relatively high contents may be inclusion of  $\text{CaCO}_3$  from different sources.

The highest contents of  $\text{CaCO}_3$  found in soil horizons were those of the upper layers of profiles 7 and 8.

The distribution of  $\text{CaCO}_3$  with profile depth reveals different patterns. The majority of profiles (1, 5, 6, 7, 8, 9 and 10) showed a decrease with depth. Profile 2 showed an increase of  $\text{CaCO}_3$  with depth down to 75 cm followed by a decrease. Profiles 3 and 4 show a decrease in  $\text{CaCO}_3$  with depth (down to the depth of 40 cm) followed by an increase.

#### **4.1.3 Gypsum:**

Gypsum contents in soil profiles are presented in Table (1) and illustrated by Fig. (3). Values ranged from 0.01 to 2.87 in different layers, and 0.03 to 1.06 as profile means. Low values are particularly found in profiles 4, 6, 8 and 10. High values are particularly found in profiles 3, 5 and 7. Top soil of profile 7 (where the highest gypsum content was found), is characterized by its extremely high salinity; it has the highest salinity of all layers in the study ( $\text{EC} = 52 \text{ dS/m}$ ). Profiles 1, 2, and 10 contained intermediate contents.

Regarding the vertical distribution of the gypsum. Profiles 1, 6, 7 and 10 showed (gypsum) enrichment in the two uppermost horizons in particular. Profiles 2, 3, and 10 showed an increase with depth. Other profiles showed no definite pattern of distribution.

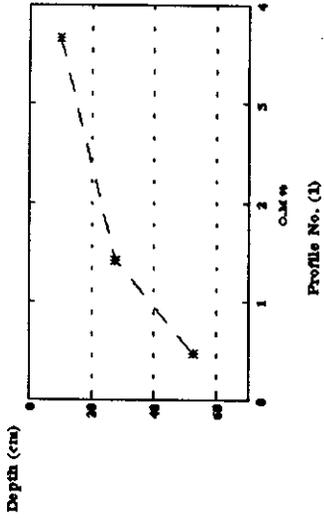
The soils of arid and semi arid regions usually have calcium carbonate and often gypsum in pronounced contents. The depth of precipitation in the profile of such substances depends on the water movement, capillarity, depth of ground water and salt content. Solubility of  $\text{CaSO}_4$  in water is 3.5 me/L and may be several folds in presence of soluble NaCl (De Sigmond, 1938). Solubility of  $\text{CaCO}_3$  could be enhanced in presence of  $\text{Na}_2\text{SO}_4$  (Cameron and Seidell, 1901). Concerning forms of these salts in the alluvial soils in the Nile Delta. Fathi et al. (1972) stated that  $\text{CaSO}_4$  and  $\text{CaCO}_3$  may be precipitated as small crystals in the soil pores, or as coatings on the soil particles or as veins in root channels.

Examination of Fig. (3) concerning  $\text{CaCO}_3$  and gypsum distribution patterns, indicates an accumulation of gypsum in the top layers followed by an accumulation of lime as shown in profiles 1, 3, 4, 8 and 10.

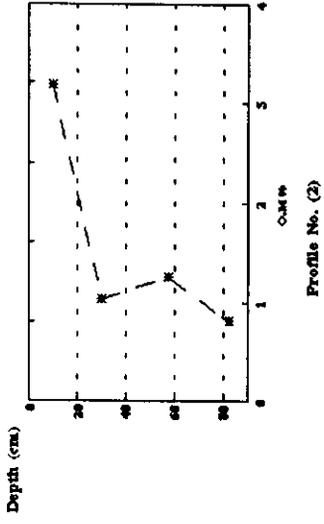
#### **4.1.4 Organic matter content:**

Organic matter is one of the main constituents of the soil system which plays an important role in soil property. The organic matter content of the investigated soil profiles are presented in Table (1) and Fig. (4). The organic matter content, covered a range of 0.20 to 3.97% in layers of horizons (or 0.90

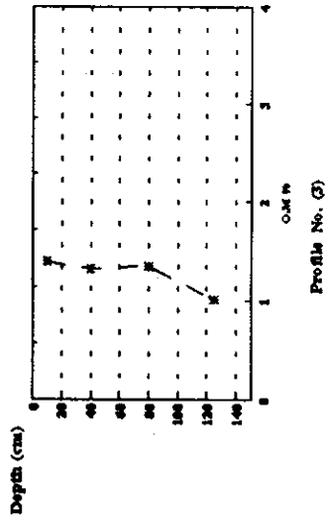
**Al Bosrat (a)**



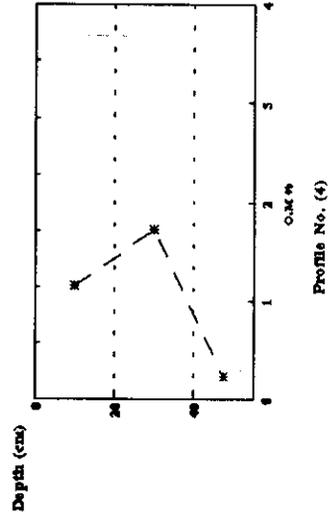
**Al Aziza**



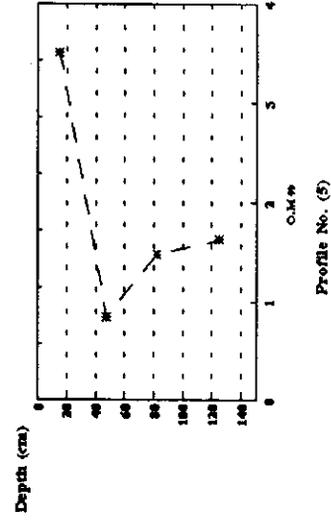
**Al Bosrat (b)**



**Al Bosrat (c)**



**Meet Maraga Salsel**



**Fig. (4): Distribution of organic matter (O.M) through soil depth for the studied soil profiles.**

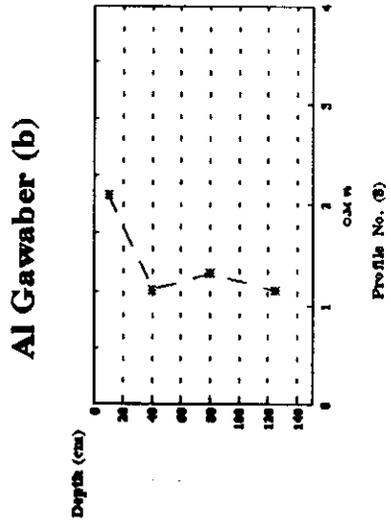
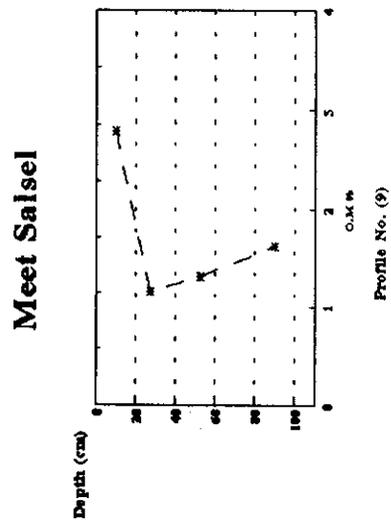
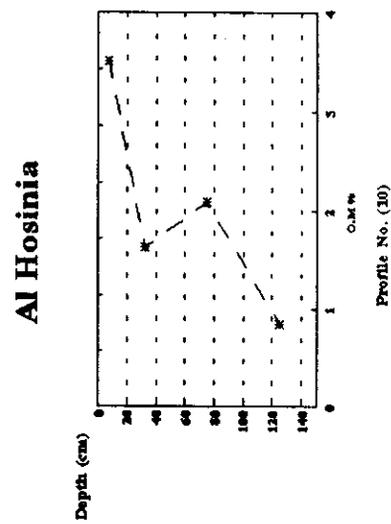
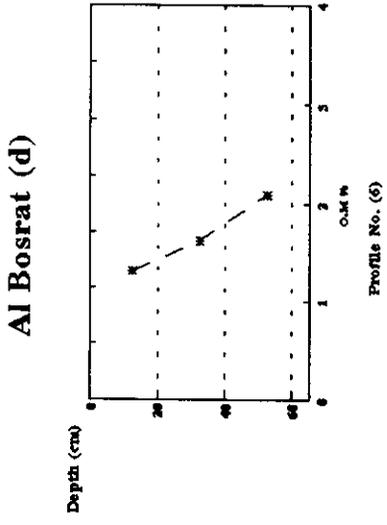
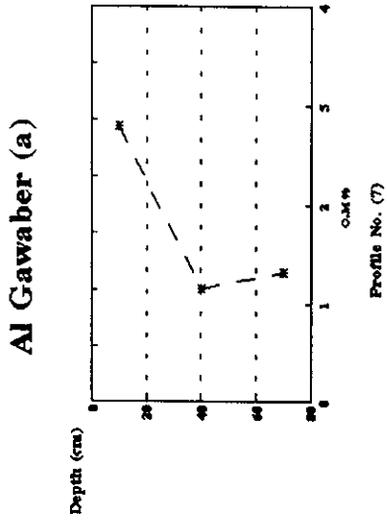


Fig. (4): Cont.

to 1.58 as means of profiles), the higher values were in the six profiles Nos. 1, 2, 5, 7, 9 and 10. High contents of organic matter in arable lands are especially found in the uppermost layers, which is most certainly mainly due to the enrichment of the profile by the organic matter residues of plant cover, as well as to a continuous addition of organic manure to the soil.

For organic matter decomposition enough supplies of oxygen, moisture, and temperature are important. Under the prevailing conditions of soils of the aforementioned six profiles (where most of them particularly No. 5 and 7 have highly saline top soils), one or more of the requisites for oxidation may have been missing. High water table and conditions of saturation produce anaerobic conditions. A decrease in soil temperature which may have occurred due to raising the specific heat of saline soils, (beside occurrence of high salt contents) may have slowed down the activity of microorganisms in these soils. All such reasons would decrease the rate of organic matter decomposition, and thus would lead to its accumulation in the soil. Shallow ground water and high salinity were characteristics of profiles 1 and 7, which contained high organic matter contents. All the examined soils showed a similar pattern of organic matter distribution throughout the soil profiles i.e., decreasing downwards.

#### **4.1.5 Soil pH:**

The soil pH values [presented in Table (3)] ranged from 7.28 to 8.32, and were irregular from the surface downwards. Soils of the top layers of Al-Aziza (profile 2), Al-Bosrat (profile 3), Meet Marage Salsel (Profile 5), Al-Gawaber

Table (3): Saturation percent (SP), soil pH, salinity and sodicity of soils of the studied area of North East Delta, Egypt.

Prof. No.	Location	Depth	SP %	pH	EC dS/m	Soluble cations meq/L				Soluble anions meq/L				Sodicity parameters		
						Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>-</sup>	CO <sub>3</sub> <sup>-</sup>	HCO <sub>3</sub> <sup>-</sup>	SSP	ESP*	SAR
1	Al-Bosrat (a) G.W. at 70 cm	0 - 20	98	7.80	7.58	19.2	27.0	61.0	1.3	37.0	59.4	0.0	12.0	56.3	14.9	12.7
		20 - 35	99	8.04	5.09	9.1	15.0	35.0	0.6	24.5	30.7	0.0	4.5	58.7	12.0	10.1
		35 - 70	99	8.08	3.07	5.6	3.1	22.5	0.3	13.5	14.3	Tr.	3.5	71.6	12.8	10.8
		Mean	99	7.99	4.79	10.2	12.5	36.2	0.6	22.6	30.7		6.1	60.8	12.7	10.7
2	Al-Aziza G.W. at 90 cm	0 - 20	90	7.53	4.32	16.7	13.2	23.0	0.4	25.0	20.2	0.0	8.0	43.2	7.0	6.0
		20 - 40	82	7.60	3.36	12.1	10.0	22.5	0.2	15.0	26.3	0.0	3.5	50.2	8.0	6.8
		40 - 75	82	7.50	2.40	8.1	5.4	9.0	0.2	10.0	9.2	0.0	3.5	39.7	3.7	3.5
		75 - 90	94	7.51	2.21	7.6	5.4	9.0	0.2	9.5	8.7	0.0	4.0	40.5	3.8	3.5
		Mean	86	7.53	3.01	10.8	8.1	15.1	0.2	14.4	15.4		4.6	44.1	5.6	4.9
3	Al-Bosrat (b)	0 - 20	77	7.83	4.03	21.2	12.0	15.0	2.8	12.5	27.4	0.0	11.0	29.4	4.0	3.7
		20 - 60	90	7.79	1.20	3.5	1.3	9.0	0.6	3.5	7.9	0.0	3.0	62.3	6.8	5.8
		60 - 100	99	7.75	1.68	4.0	2.7	8.0	0.5	6.5	5.7	0.0	3.0	52.6	4.9	4.4
		100-150	81	8.06	1.34	2.0	2.3	13.4	0.2	4.0	10.9	0.0	3.0	74.8	10.9	9.1
		Mean	88	7.87	1.75	5.5	3.4	11.0	0.7	5.7	10.9		4.1	53.2	6.0	5.2
4	Al-Bosrat (c) G.W. at 55 cm	0 - 20	147	8.23	6.91	2.5	8.1	62.0	1.5	47.0	23.1	0.0	4.0	83.7	27.8	27.0
		20 - 40	150	7.88	14.40	6.1	19.4	155.0	3.0	108.0	72.5	0.0	3.0	84.5	38.6	43.4
		40 - 55	164	7.77	24.10	14.1	41.2	290.0	5.9	220.0	126.2	0.0	5.0	82.6	44.5	55.1
		Mean	153	7.98	14.32	7.0	21.2	158.0	3.2	116.4	69.2		3.9	83.4	37.8	42.1
		Meet Marag	98	7.44	13.63	29.3	37.1	124.0	0.8	114.0	72.2	0.0	5.0	64.8	23.4	21.5
5	Salsel	30 - 65	135	8.01	3.46	4.5	2.2	34.5	0.3	22.0	15.4	Tr.	4.0	83.2	20.9	18.8
		65 - 100	128	7.88	2.78	4.0	2.2	18.6	0.3	14.0	7.1	0.0	4.0	74.0	12.5	10.5
		100-150	127	7.88	2.40	4.0	1.7	13.5	0.2	12.5	3.5	0.0	3.5	69.3	9.5	7.9
		Mean	123	7.82	4.98	9.2	9.0	41.7	0.4	35.4	20.9		4.0	69.2	16.0	13.8

SP : saturation percent (w/w). G.W. : Ground water. ESP\* : Calculated exchange sodium percent after (USDA, 1954).  
 Na me/L  
 SSP : Soluble sodium % (Na as a fraction of total soluble cations = \_\_\_\_\_ X 100  
 Soluble cation me/L

Table (3): cont.

Prof. No.	Location	Depth	SP %	pH	EC dS/m	Soluble cations meq/L				Soluble anions meq/L				Sodicity parameters		
						Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>=</sup>	CO <sub>3</sub> <sup>=</sup>	HCO <sub>3</sub> <sup>=</sup>	SSP	ESP*	SAR
6	Al-Bosrat (d) G.W. at 65 cm	0 - 25	85	8.15	21.81	2.0	31.2	290.0	5.5	179.0	134.2	Tr.	15.0	88.2	50.9	71.2
		25 - 40	112	8.32	15.79	2.0	11.4	205.0	2.3	115.5	88.9	Tr.	16.0	92.9	53.5	79.0
		40 - 65	113	7.67	19.27	6.1	20.9	240.0	2.5	157.0	109.4	0.0	3.0	89.1	48.8	65.4
		Mean	102	8.00	19.44	3.6	22.7	251.2	3.6	155.9	114.2		10.6	89.4	50.3	69.3
7	Al-Gawaber (a) G.W. at 80 cm	0 - 20	90	7.91	52.80	114.1	259.1	240.0	2.0	508.0	102.3	0.0	5.0	39.0	19.8	17.6
		20 - 60	124	7.57	11.71	27.8	42.0	65.0	1.2	82.0	50.4	0.0	3.5	47.8	13.0	11.0
		60 - 80	107	7.52	17.86	48.5	65.5	62.0	1.8	146.0	26.2	0.0	5.5	34.9	9.8	8.2
		Mean	111	7.64	23.52	54.5	102.1	108.0	1.5	204.5	57.3		4.4	40.6	14.3	12.2
8	Al-Gawaber (b)	0 - 20	104	7.88	7.52	10.6	16.8	63.6	1.0	47.5	40.0	0.0	4.5	69.1	19.4	17.2
		20 - 60	110	7.73	8.46	12.6	22.5	80.0	1.3	59.0	54.4	0.0	3.0	68.8	21.2	19.1
		60 - 100	125	7.67	8.55	10.1	15.4	51.0	1.3	61.5	12.7	0.0	3.5	65.6	16.5	14.3
		100-150	130	7.70	7.80	7.6	14.6	70.0	1.1	55.0	35.8	0.0	2.5	75.1	22.9	21.0
Mean	120	7.72	8.14	10.0	17.2	66.7	1.2	56.8	35.1		3.2	70.2	20.3	18.1		
9	Meer Salsel	0 - 20	83	7.32	4.23	14.1	13.8	25.0	0.4	26.5	21.3	0.0	5.5	46.9	7.9	6.7
		20 - 35	80	7.82	2.73	5.1	6.5	22.5	0.2	12.0	18.7	0.0	3.5	65.8	11.2	9.4
		35 - 70	86	8.19	6.49	2.5	3.7	89.0	0.4	20.0	47.9	Tr.	27.5	93.1	42.2	50.3
		70 - 110	100	8.32	3.10	4.2	3.9	25.5	0.4	13.5	14.2	Tr.	6.0	74.9	14.8	12.6
Mean	90	8.03	4.33	5.6	6.0	45.2	0.3	17.7	26.8		12.4	79.1	20.9	18.8		
10	Al-Hosinia	0 - 15	77	7.28	2.82	27.8	15.0	19.5	0.4	24.5	33.2	0.0	5.0	31.1	4.7	4.2
		15 - 50	77	7.85	3.38	1.5	4.3	32.5	0.2	7.5	16.0	0.0	15.0	84.4	21.2	19.1
		50 - 100	75	7.43	6.77	12.6	19.1	61.0	0.4	25.0	56.2	0.0	12.0	65.5	17.6	15.3
		100-150	86	7.50	3.29	16.7	13.2	18.5	0.3	7.0	38.6	0.0	3.0	38.1	5.5	4.8
Mean	79	7.54	4.42	12.9	13.3	36.0	0.3	14.9	38.7		9.0	57.6	11.8	10.0		

SP : saturation percent (w/w). G.W. : Ground water. ESP\* : Calculated exchange sodium percent after (USDA, 1954).

SSP : Soluble sodium % (Na as a fraction of total soluble cations =  $\frac{\text{Na me/L}}{\text{Soluble cation me/L}} \times 100$ )

(profiles 7 and 8), Meet Salsel (profile 9) and Al-Hosinia (profile 10) may be designated as mildly to moderately alkaline (pH 7.28 to 7.91), while those of profiles 1, 4 and 6 would be moderately alkaline (pH 7.80 to 8.23). None of the soils had pH exceeding 8.5, a level which indicates soil sodicity, particularly where soils are non-saline. However, profiles 1, 4, 6, and 7 have a high level of sodium adsorption rates (SAR) which indicates high sodicity. The same profiles have high levels of salinity.

#### **4.1.6 Soluble salts:** (Table 3).

Salinity of the soil profiles varied. EC values ranged between 2.82 and 52.8 dS/m in the uppermost layer. The 3 Al-Bosrat locations a, c, and d (profiles 1, 4, and 6, respectively), Meet Maraga Salsel location (profile 5), and the 2 Al-Gawaber locations (profiles 7 and 8) were characterized by their very high salinity. In these locations, symptom of poor drainage system were observed; such lands have low elevation and their ground-water table was shallow (profiles 1, 2, 6, 4 and 7) with the soils being adjacent to the Manzala lake. On the other hand, locations of Al-Aziza (profile 2), Al-Bosrat b (profile 3), Meet Salsel (profile 9) and Al-Hosinia (profile 10) showed low values of salinity. In these locations there was no symptoms of poor drainage, and -in Al-Bosrat and Hosinia- the level of ground-water was deeper than 150 cm from the surface.

Vertical distribution of EC is presented in Table (3) and Fig. (5). At locations of Al-Bosrat a, b, and d (profiles 1, 3, and 6), Al-Aziza (profile 2), and Meet Maraga Salsel (profile 5) the EC tended to increase towards the soil surface

thus reflecting an active upward movement causing salt accumulation on the soil surface. This was particularly apparent where shallow saline ground water existed such as at Al-Gawaber "a" (profile 7), with the water EC=6.1 dS/m and at Al-Bosrat "d" (profile 6) with the water EC=47.9 dS/m, Table (4). The depth of ground water at Al-Gwaber was 80 cm and Al-Bosrate it was 65 cm. Therefore soil degradation in those locations is obvious. Accumulation of salts in the deep layers (60 to 100 cm) was shown at Al-Gawaber (profiles 8), Meet Salsel (profile 9) and Al-Hosinia (profile 10).

#### **4.1.7 Distribution of soluble cations and anions:**

Data presented in Table (3) & Fig. (5) indicate that cations distribution in the studied soil profiles follows a trend similar to that of the total soluble salts. In most of the soil profiles the obtained data reveal that soluble sodium is the dominant cation followed by magnesium or calcium at Al-Bosrat (profiles 1, 4, and 6), Al-Aziza (profile 2), Meet Maraga Salsel (profile 5), Al-Gawaber (profile 8) and Meet Salsel (profile 9). In Al-Bosrat (profiles 3) and Al-Hosinia (profile 10), calcium was the dominant cation followed by sodium then magnesium. Soils of Al-Bosrat and Al-Hosiniya showed relatively lower values of soluble salts and their ground-water table was deeper than 150 cm. In the soil of Al-Gawaber (profiles 7), The dominant cation was magnesium followed by sodium then calcium this pattern are due to the adjacent of these soils for Manzala salty lake.

Concerning soluble anions concentration and their distribution, the data of Table (3) and Fig. (5) show that in profiles No. 2 to 9 chloride was the dominant

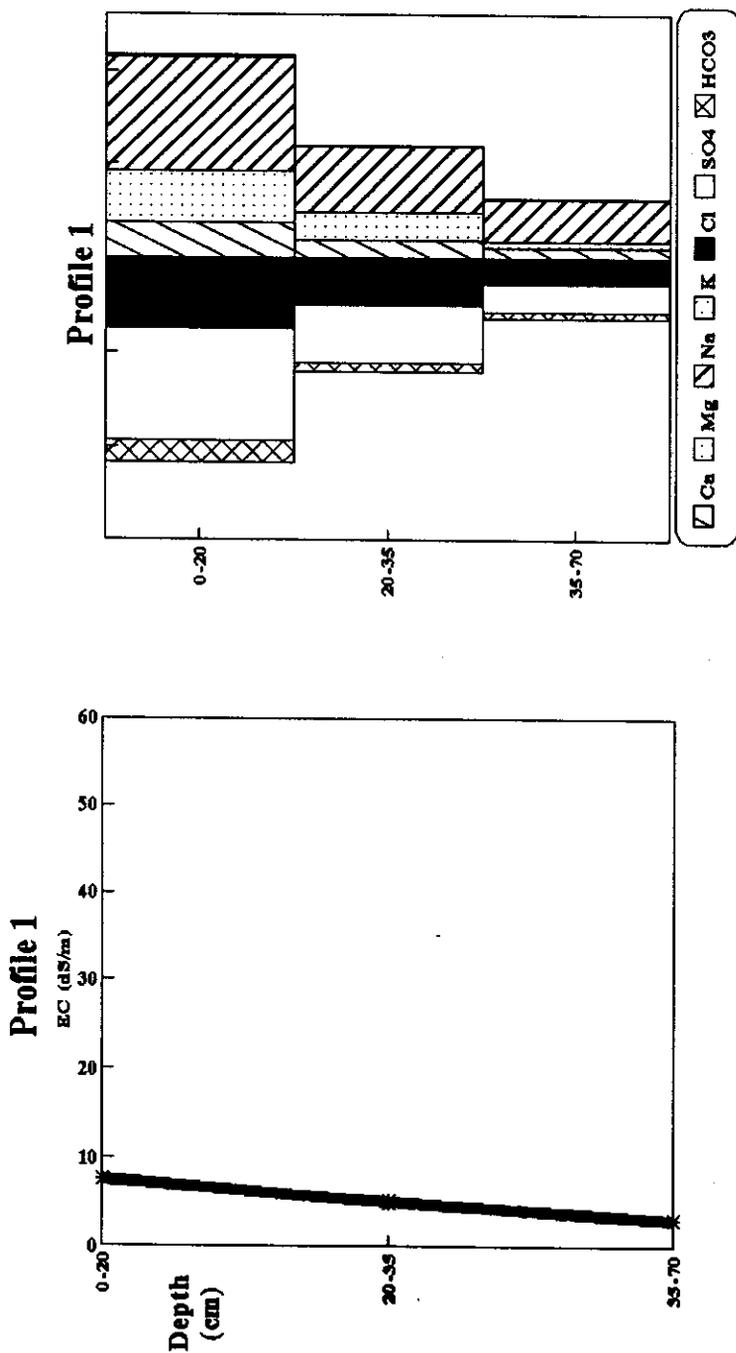


Fig.(5) : Cations, anions and electrical conductivity of Al-Bosrat (a).

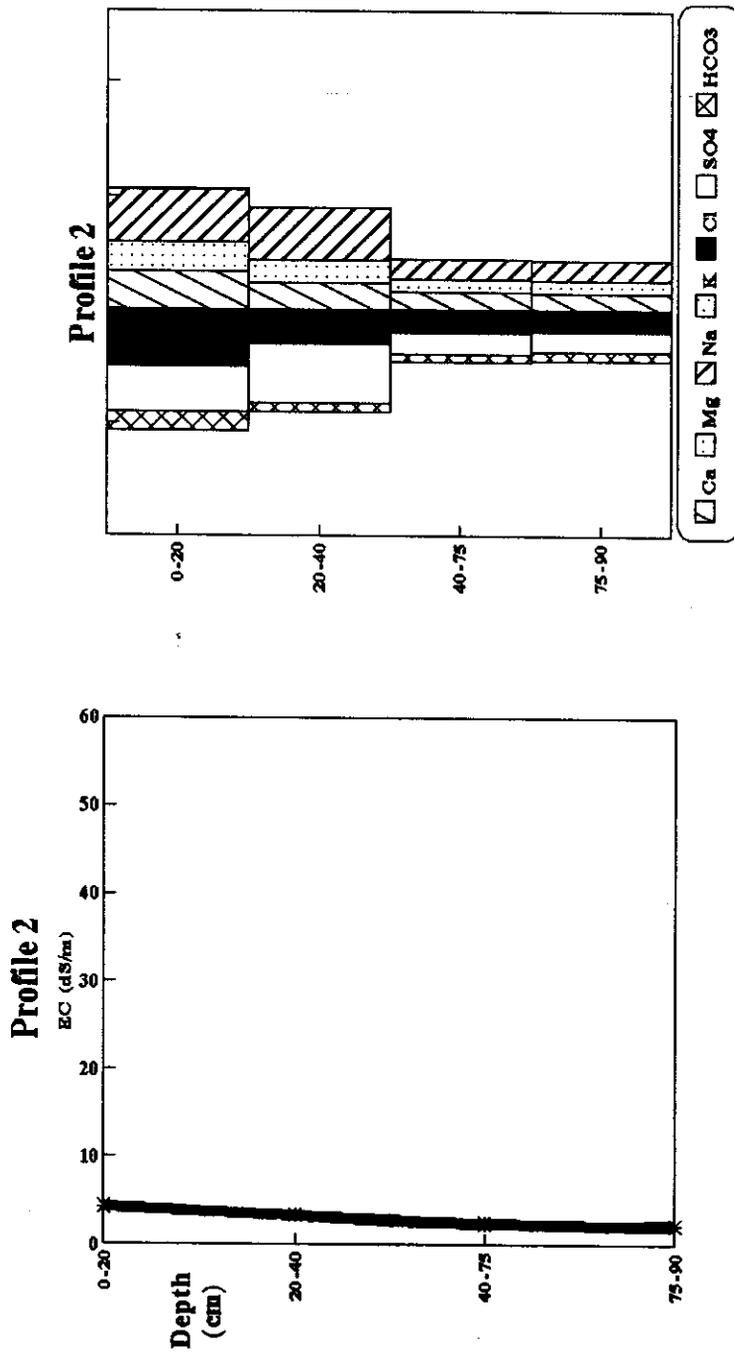


Fig.(5) : Cations, anions and electrical conductivity of Al-Aziza.

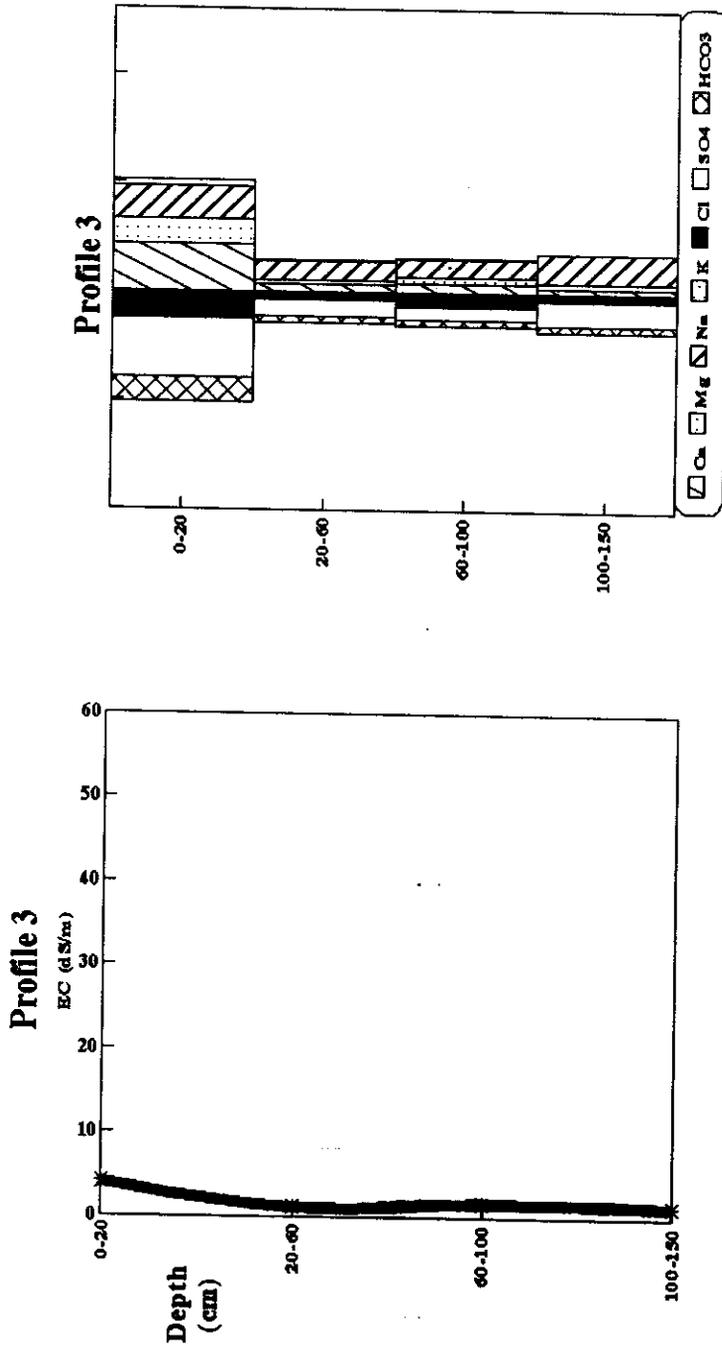


Fig.(5) : Cations, anions and electrical conductivity of Al-Bosrat (b).

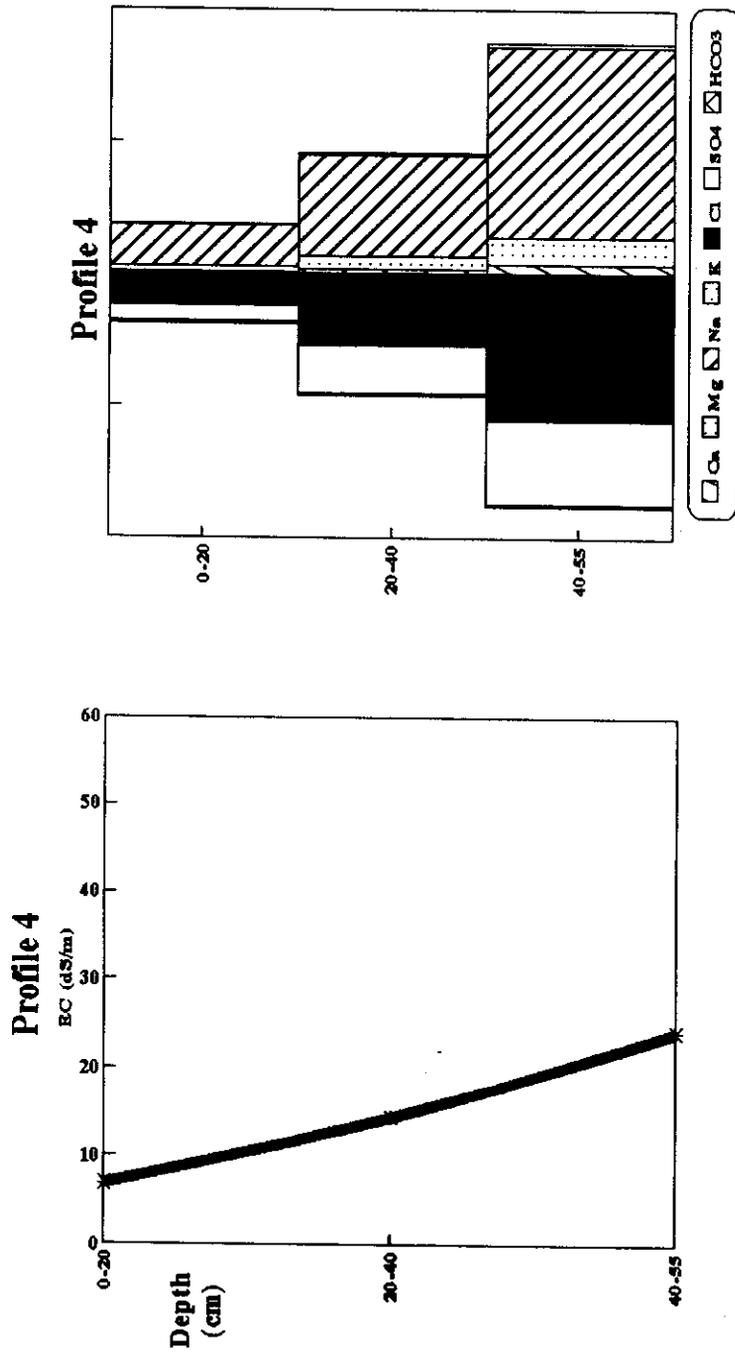


Fig.(5) : Cations, anions and electrical conductivity of Al-Bosrat (c).

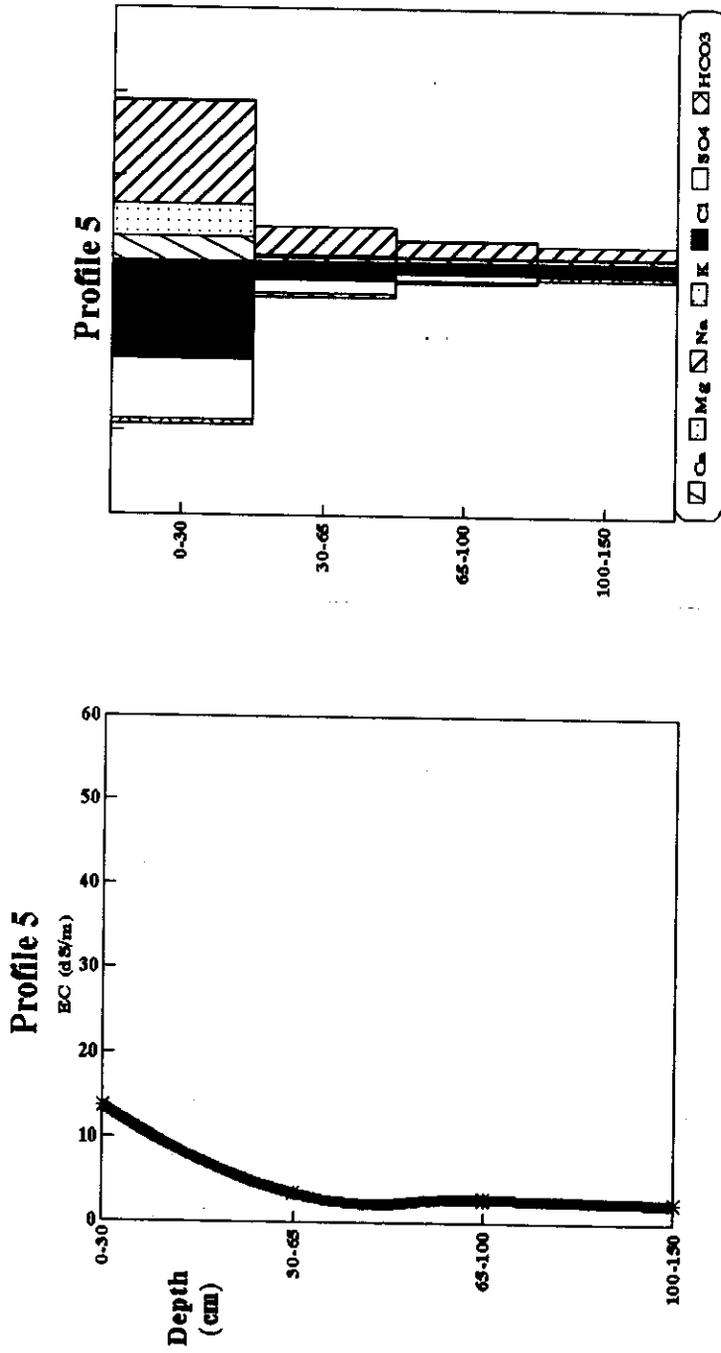


Fig.(5) : Cations, anions and electrical conductivity of Meet Maraga Salsel.

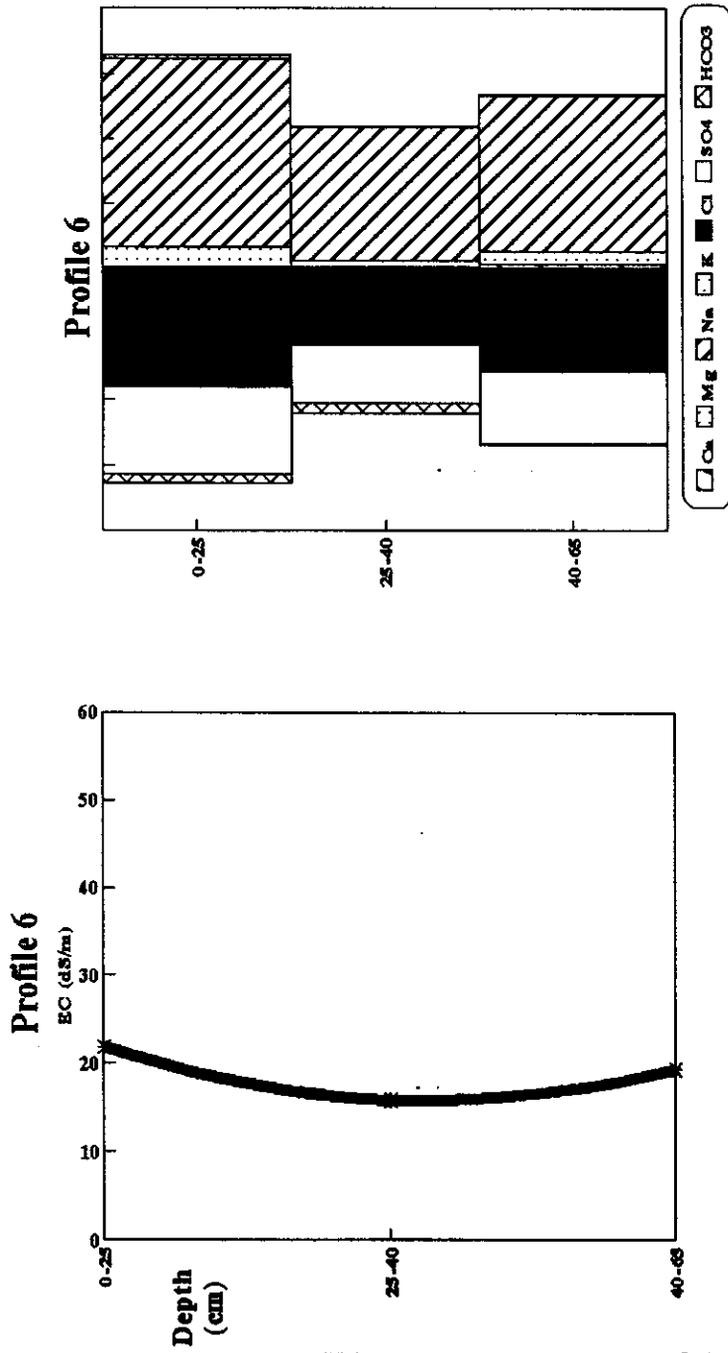


Fig.(5) : Cations, anions and electrical conductivity of Al-Bosrat (d).

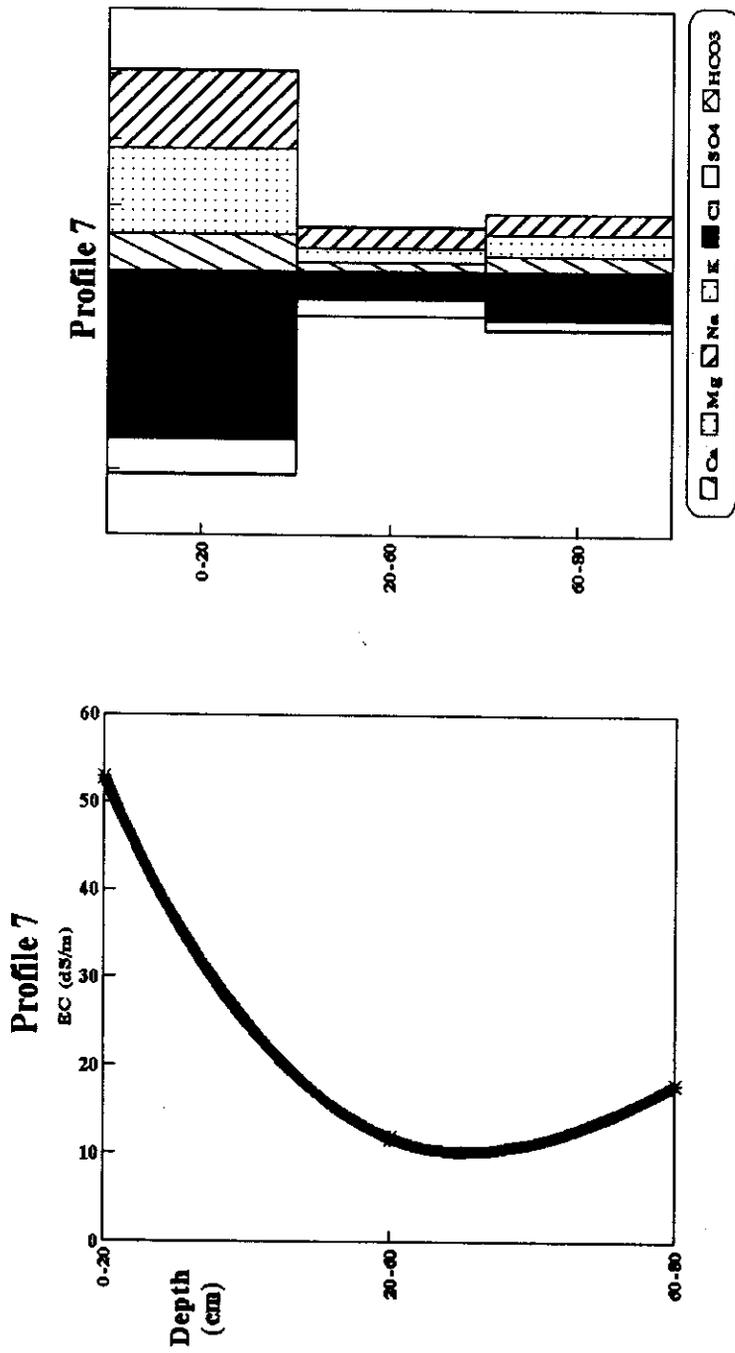


Fig.(5) : Cations, anions and electrical conductivity of Al-Gawaber (a).

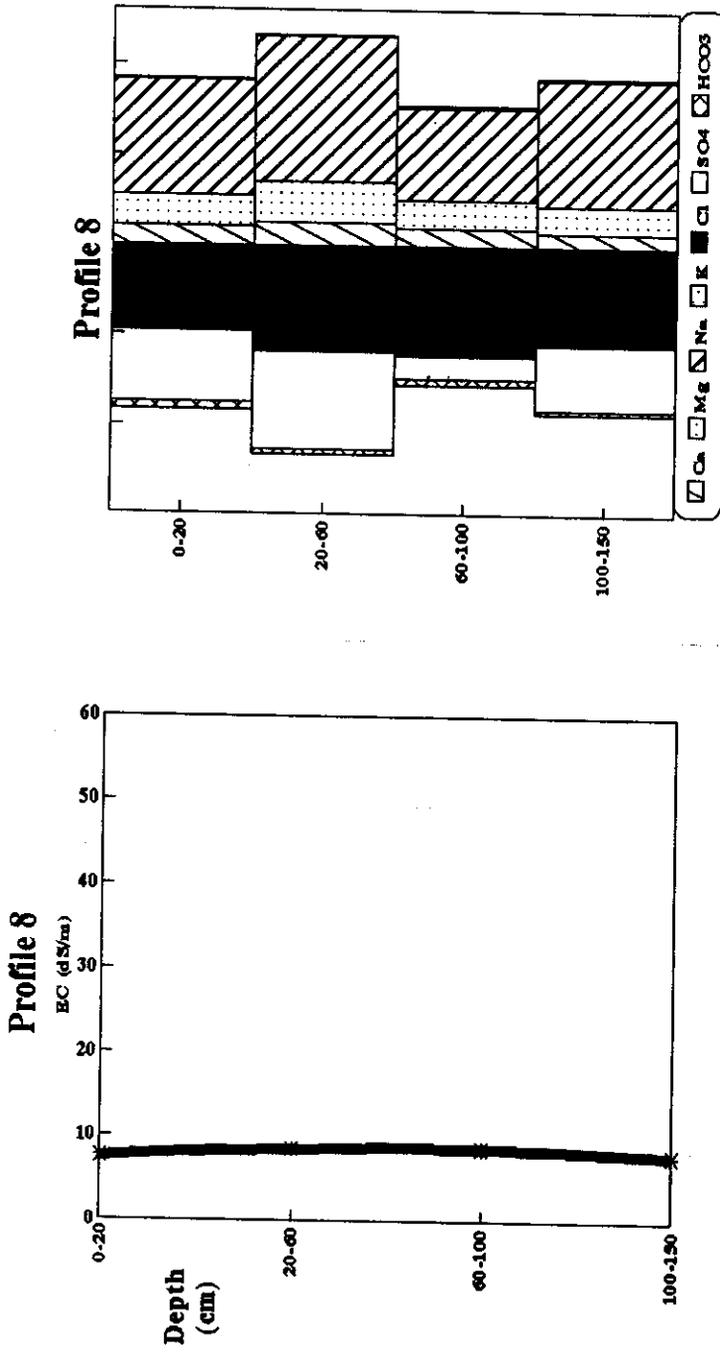


Fig.(5) : Cations, anions and electrical conductivity of Al-Gawaber (b).

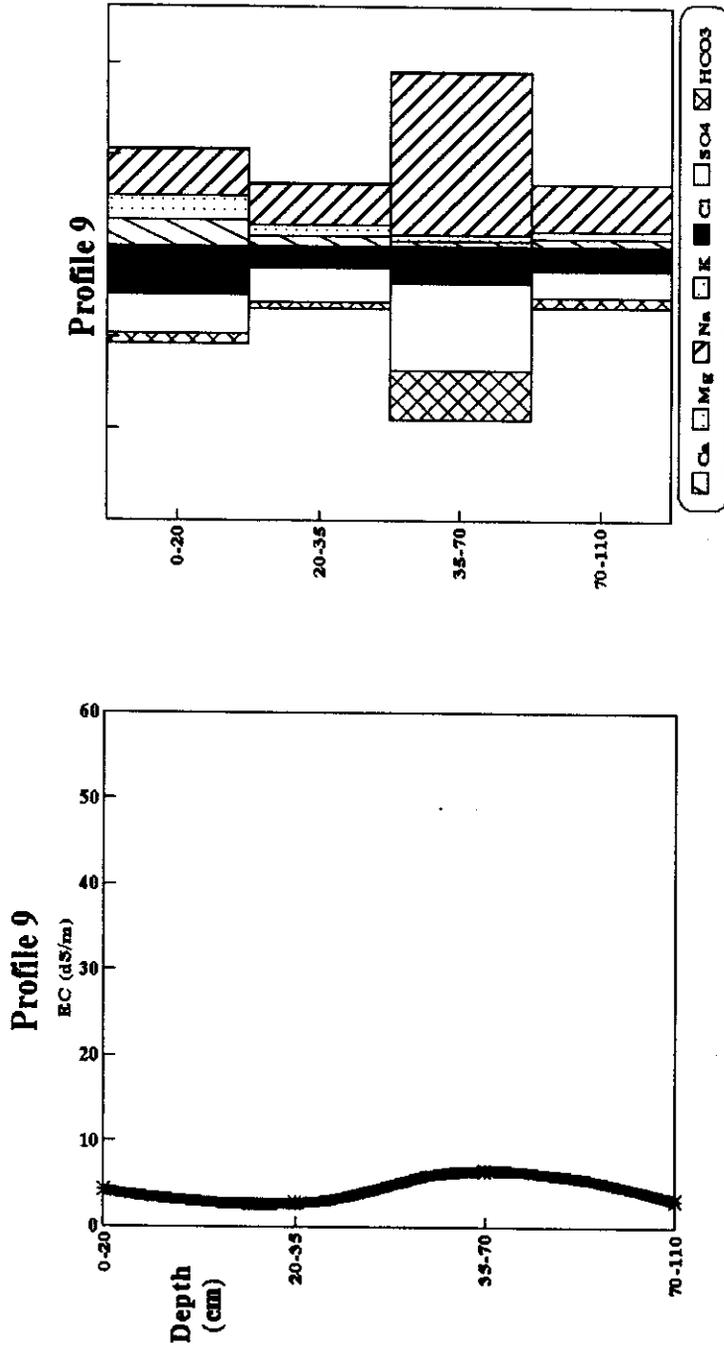


Fig.(5) : Cations, anions and electrical conductivity of Meet Salsel.

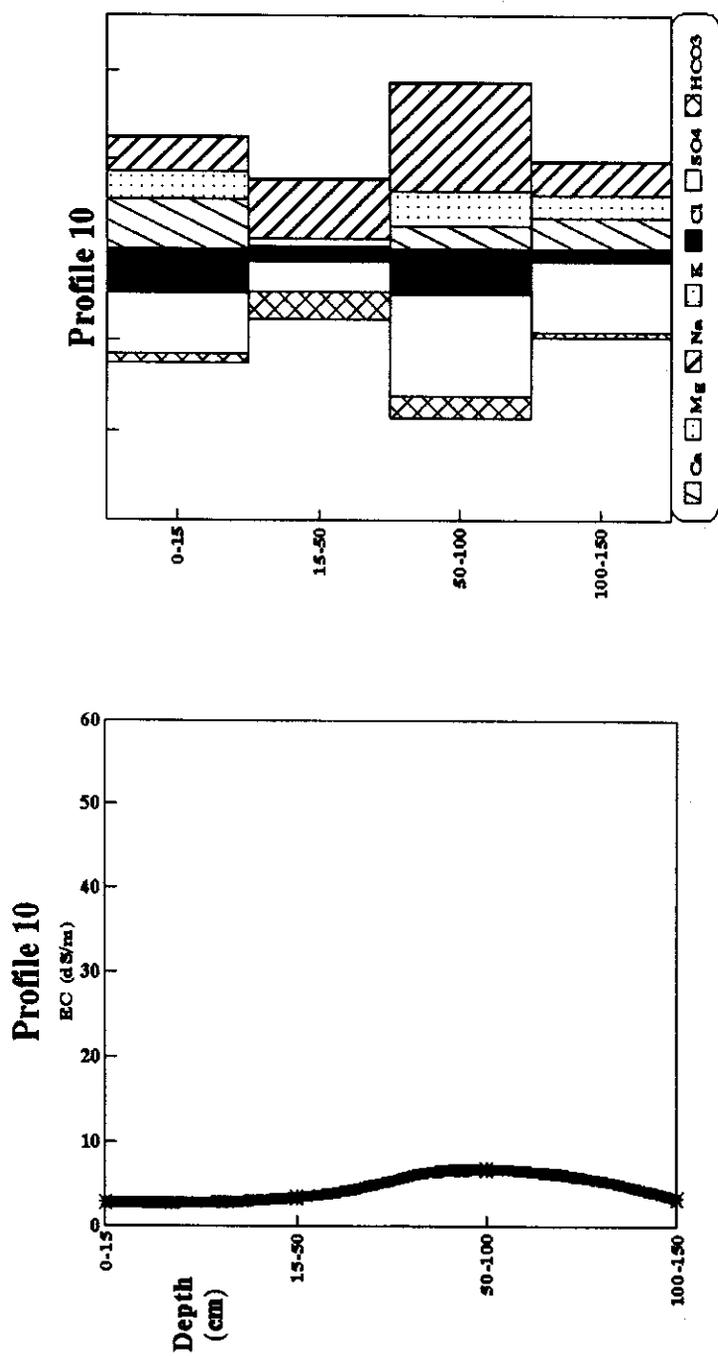


Fig.(5) : Cations, anions and electrical conductivity of Al-Hosinia.

anion followed by sulphate, with carbonate and bicarbonates being in very small concentrations. In profiles Nos. 1 and 10 sulphate was the dominant anion followed by chloride.

#### **4.1.8 Ground-water:**

The ground-water table levels ranged between 55 and 90 cm in depth (Table (4) and Fig. (6)). The lower values were in locations of profiles 1, 4 and 6 and the higher values were in locations of profiles 2 and 7. Water intrusion from Manzala lake may have been the main factor behind shallow water table of profiles 1,4 and 6, in view of their nearness to the lake. Occurrence of water table of profiles 2 and 7 indicate insufficient drainage. Electric conductivity of the ground-water ranged between 2.76 dS/m (profile 2) and 47.94 dS/m (profile 6) which in extremely saline.

The cationic sequence in water of the ground-water was similar to that of the soil water extract: sodium was dominant followed by magnesium then calcium, with potassium being present in very small content; chloride was dominant followed by sulphate; carbonate and bicarbonate were in small content.

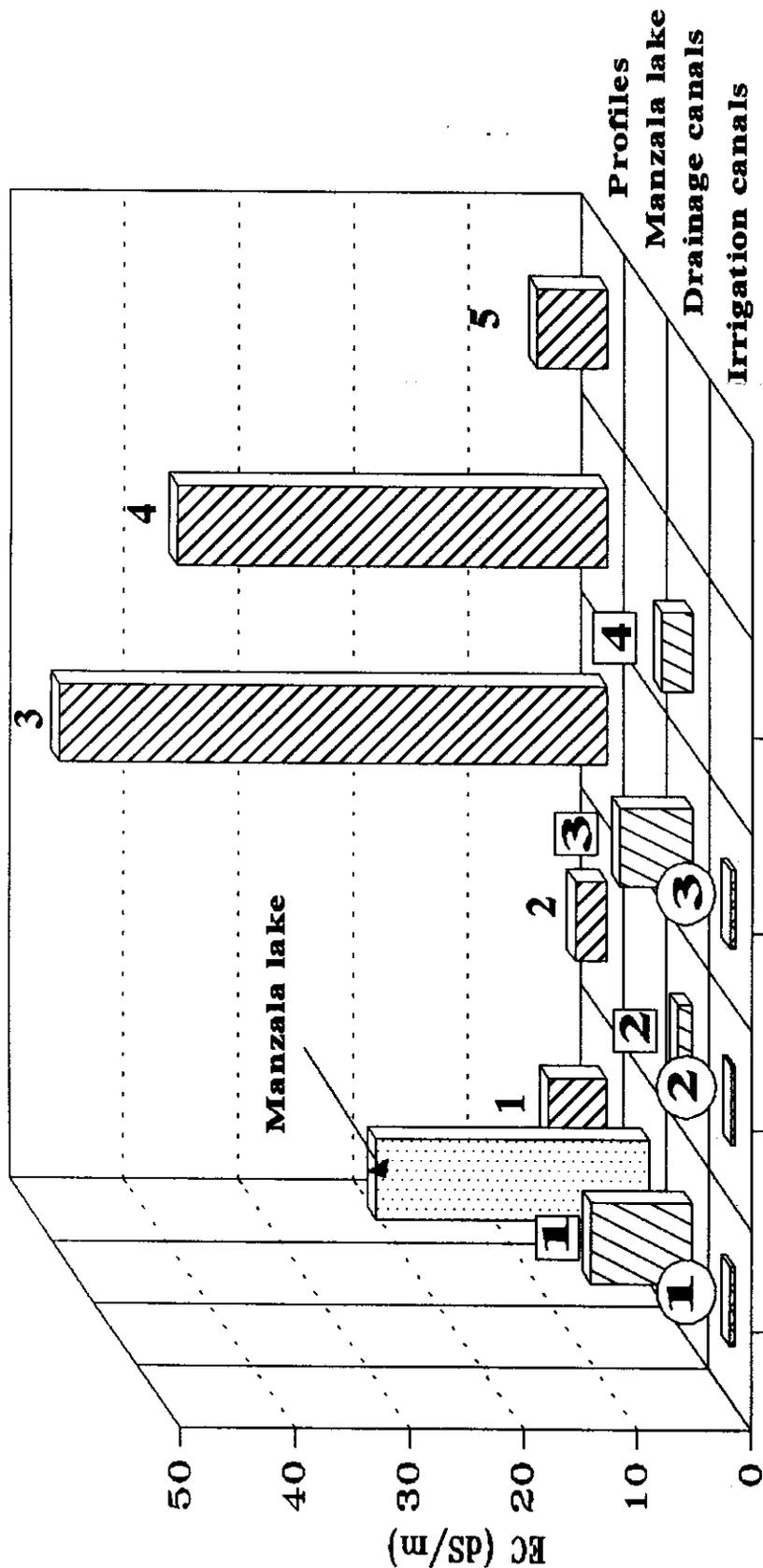
#### **4.1.9 The sodium adsorption ratio SAR and electrical conductivity:**

The correlation between electrical conductivity and sodium adsorption ratio SAR is illustrated in Fig (7). It was positive and highly significant  $r=0.47062^{**}$  for all the studied soil profiles.

Table (4): Irrigation, drainage, Manzala lake and ground water of the studied soil profiles.

Source of water	E.C dS/m	pH	CO <sub>3</sub> <sup>=</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	me/L				Na <sup>+</sup>	SAR
						<-----	-----	-----	----->		
Alshapor canal	0.37	7.75	0.30	2.70	1.00	0.25	2.06	0.94	0.28	0.98	0.80
Albahr Elsaghir canal	0.32	7.65	0.40	2.10	1.00	0.15	1.55	0.95	0.28	0.88	0.79
Alsamana canal	0.44	7.65	0.50	2.40	1.00	0.69	2.58	0.42	0.35	1.24	1.01
Almaqtaa drain	8.83	8.04	0.50	5.30	83.00	3.80	10.31	39.69	2.60	40.00	8.00
Alitrad drain	1.22	7.90	0.40	2.90	6.00	1.77	4.12	2.88	0.39	3.68	1.97
Abd Elrahman drain	6.37	7.82	0.80	4.00	56.50	1.19	11.34	16.66	0.98	33.52	8.96
Abo Elsood drain	2.69	8.15	1.00	3.90	23.50	1.53	5.16	10.85	1.63	12.30	4.35
Manzala lake	24.00	8.10	0.60	2.90	248.00	44.80	2.10	52.20	4.50	237.50	45.58
G.W. of Prof. (1).	5.13	7.96	1.20	7.60	51.00	1.87	8.25	19.75	0.67	33.00	8.82
G.W. of Prof. (2).	2.76	7.91	0.80	6.50	20.00	0.17	5.67	10.83	0.23	10.75	3.74
G.W. of Prof. (6).	47.94	8.06	2.80	8.40	459.00	9.05	15.47	111.54	14.25	338.00	42.42
G.W. of Prof. (4).	37.55	7.78	1.80	12.70	378.00	12.50	14.43	107.57	11.00	272.00	34.83
G.W. of Prof. (7).	6.18	8.29	1.20	4.90	60.00	1.75	15.47	24.04	0.75	27.60	6.21

G.W. : Ground water.



**Fig. (6): EC of waters of irrigation canals, drainage canals, Manzala lake and ground water at locations of soil profiles.**

Profiles: 1 (Al-Bosrat a), 2 (Al-Aziza), 3 (Al-Bosrat d), 4 (Al-Bosrat c), 5 (Meet Maraga Salsel).  
 Drainage canals: 1 (Almaqtaa), 2 (Alirad), 3 (Abd Elrahman), 4 (Abo Elsood).  
 Irrigation canals: 1 (Alshapor), 2 (Albahr Elsaghir), 3 (Alsamana).

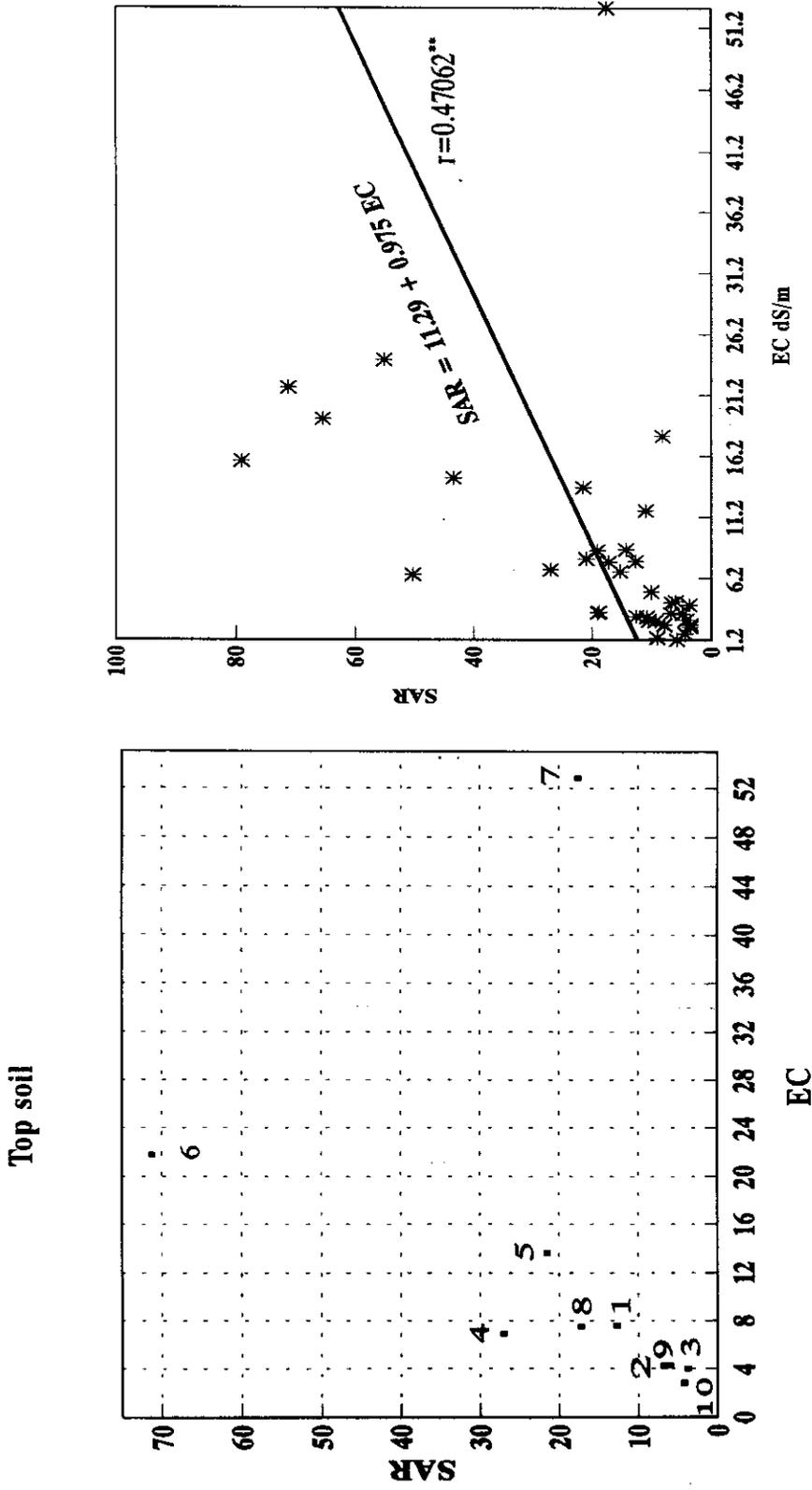


Fig.(7) : SAR and EC Relationship.

#### **4.2 Assessment of the change in soil characteristics during the 1963-1992 and urbanization during 1952-1992:**

Assessment was carried out comparing data obtained by the current study with data which were formerly obtained by the (SWRI, 1963) on the same locations.

##### **4.2.1 Desertification of the investigated areas:**

One of the greatest threats to agricultural production in Egypt is the desertification of agricultural land. Several processes contribute to the removal of land from agricultural production. They include:

1. The salinization of soils.
2. Changes in land use such as urbanization.
3. The covering of fertile soils by wind-blown sand.
4. Loss of agricultural land to urban expansion and for building purposes.

Within the Nile Delta, agricultural lands of reduced productivity and lands which went out of agricultural production due to urban expansion were identified. In the current study, data of soils analysis of profiles taken during 1995 were compared with similar data on soils taken in the same region during 1963. (Soils of the 1995 study were in locations rather similar to those of the 1963, in order for comparison to be of relevance). Such a comparison may reflect the extent of degradation or change. Besides areal photographs and areal remote sensing during 1952 to 1995 were used in order to give indications of urbanization

growth.

#### **4.2.1.1 Degradation due to salinization:**

Table (5) and Fig. (8) give the EC of soil in profiles taken by the 1963, Ministry of Agriculture during their work in the same areas and those of the profiles take in the current 1995 study (Maps 2 to 7 for salinity and Maps 8 to 13 for productivity). From the presented data, it seemed that in many cases, increases in the EC values occurred between 1963 and 1995, particularly for the uppermost layer as well as the deep layers of the soil profiles.

Under arid and semiarid conditions as well as under conditions of poor natural drainage, there exists a real hazard of salt accumulation in soils. Most of the studied soil profiles of these locations have shallow as well as saline ground water. Ground water table in Al-Bosrat (profiles 1,4 and 6) and Al-Gawaber (profile 7) for the 1995 data was shallow and extremely saline than that of 1963 data, (Table, 5). Al-Bosrat and Al-Gawaber are both near El-Manzala lake. Since the construction of High Dam, considerable changes have occurred to arable soils in Egypt. Some of these changes affected by irrigation systems, water hydrostatic pressure against sea water intrusion, crop rotation, drainage systems, and soil management practices. These changes must have contributed to the to the salinization of the soils. The increase in soil salinity during these 33 years reflects land degradation.

#### **4.2.1.2 Degradation due to sodicity:**

Soluble salts in soil system govern the equilibrium ions in soil solution and

**Table ( 5 ): Soil salinity (expressed as electrical conductivity\* of saturated paste extract) as shown by the current study of 1995 in comparison with similar data in the same area conducted in 1963 by (SWRI, 1963).**

EC in 1995				EC in 1963*		
				in areas near or around locations of the current study		
Prof. No.	Locations	Depth	EC dS/m	Locations	Depth	EC dS/m
1	Al-Bosrat (a)	0 - 20	7.58	Al-Bosrat	0 - 30	1.84
		20 - 35	5.09		30 - 60	2.43
		35 - 70	3.07		60 - 120	2.10
2	Al-Aziza	0 - 20	4.32	Al-Aziza	0 - 30	3.70
		20 - 40	3.36		30 - 60	4.50
		40 - 75	2.40		60 - 90	3.50
		75 - 90	2.21			
3	Al-Bosrat (a)	0 - 20	4.03	Al-Bosrat	0 - 30	1.83
		20 - 60	1.20		30 - 60	2.03
		60 - 100	1.68		60 - 100	1.71
		100 - 150	1.34			
4	Al-Bosrat (c)	0 - 20	6.91	Al-Bosrat	0 - 30	4.40
		20 - 40	14.40		30 - 60	5.80
		40 - 55	24.10			
5	Meet Maraga Salsel	0 - 30	13.63	Meet Maraga Salsel	0 - 30	2.60
		30 - 65	3.46		30 - 60	3.40
		65 - 100	2.78		60 - 100	3.50
		100 - 150	2.40			

\* Data of 1963, was carried out on soil water extract, by the Soil Survey Department, Soil water Res. Inst., Agriculture Res. Center. (see, SWRI 1963).

Table ( 5 ): cont.

EC in 1995				EC in 1963*		
Prof. No.	Locations	Depth	EC dS/m	Locations	Depth	EC dS/m
6	Al-Bosrat (d)	0 - 25	21.81	Al-Bosrat	0 - 30	2.26
		25 - 40	15.79		30 - 60	5.50
		40 - 65	19.27		60 - 100	5.90
7	Al-Gawaber (a)	0 - 20	52.80	Al-Gawaber	0 - 30	8.00
		20 - 60	11.71		30 - 60	7.40
		60 - 80	17.86		60 - 90	6.60
8	Al-Gawaber (b)	0 - 20	7.52	Al-Gawaber	0 - 30	6.00
		20 - 60	8.46		30 - 60	7.00
		60 -100	8.55		60 - 100	8.00
		100-150	7.80			
9	Meet Salsel	0 - 20	4.23	Meet Salsel	0 - 30	1.60
		20 - 35	2.73		30 - 60	1.50
		35 - 70	6.49		60 - 90	2.00
		70 -110	3.10		90 -120	4.25
10	Al-Hosinia	0 - 15	2.82	Al-Hosinia	0 - 30	3.50
		15 - 50	3.38		30 - 60	4.60
		50 -100	6.77		60 -100	5.70
		100-150	3.29		100-150	3.70

\* Data of 1963, was carried out on soil water extract, by the Soil Survey Department, Soil water Res. Inst., Agriculture Res. Center. (see, SWRI 1963).

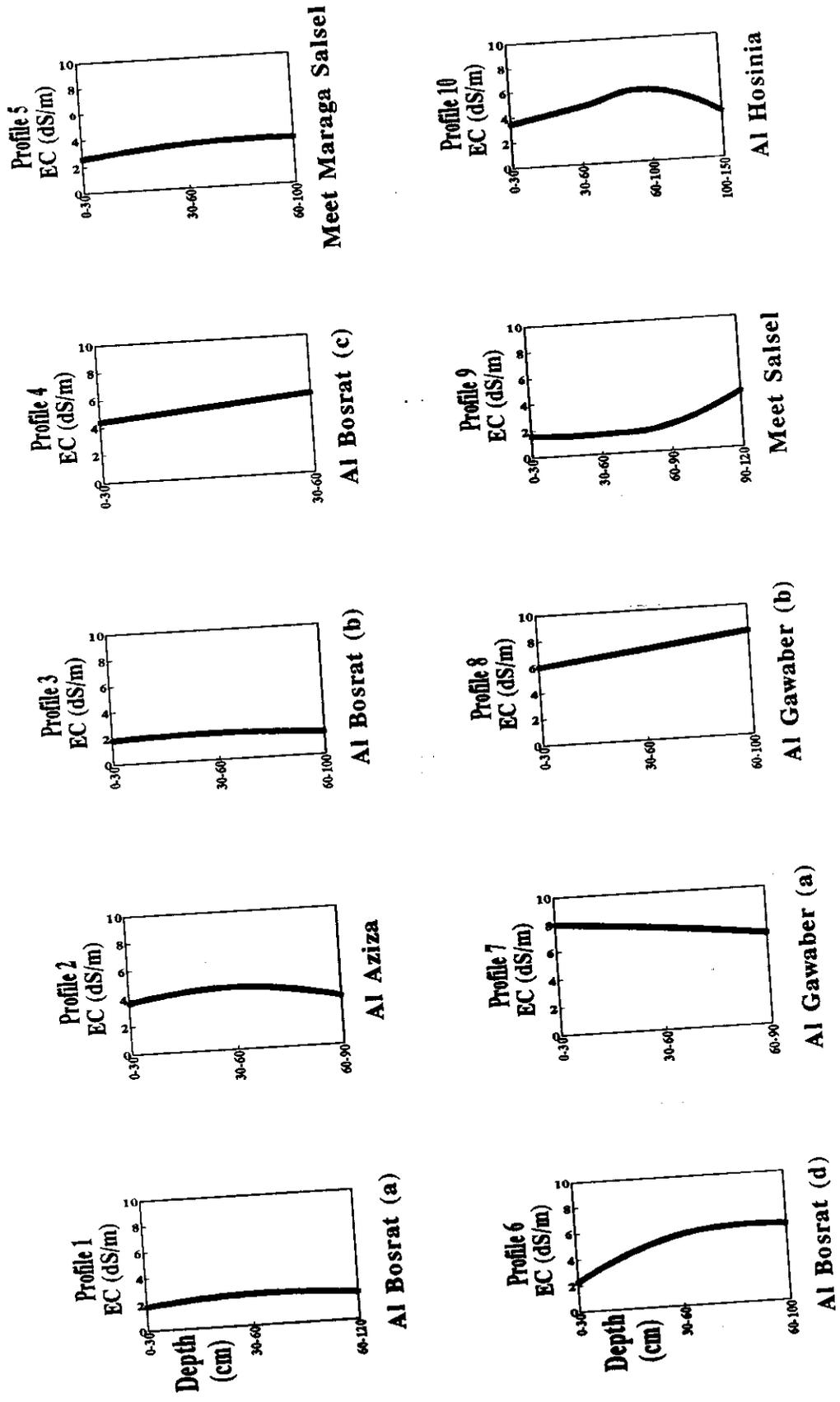
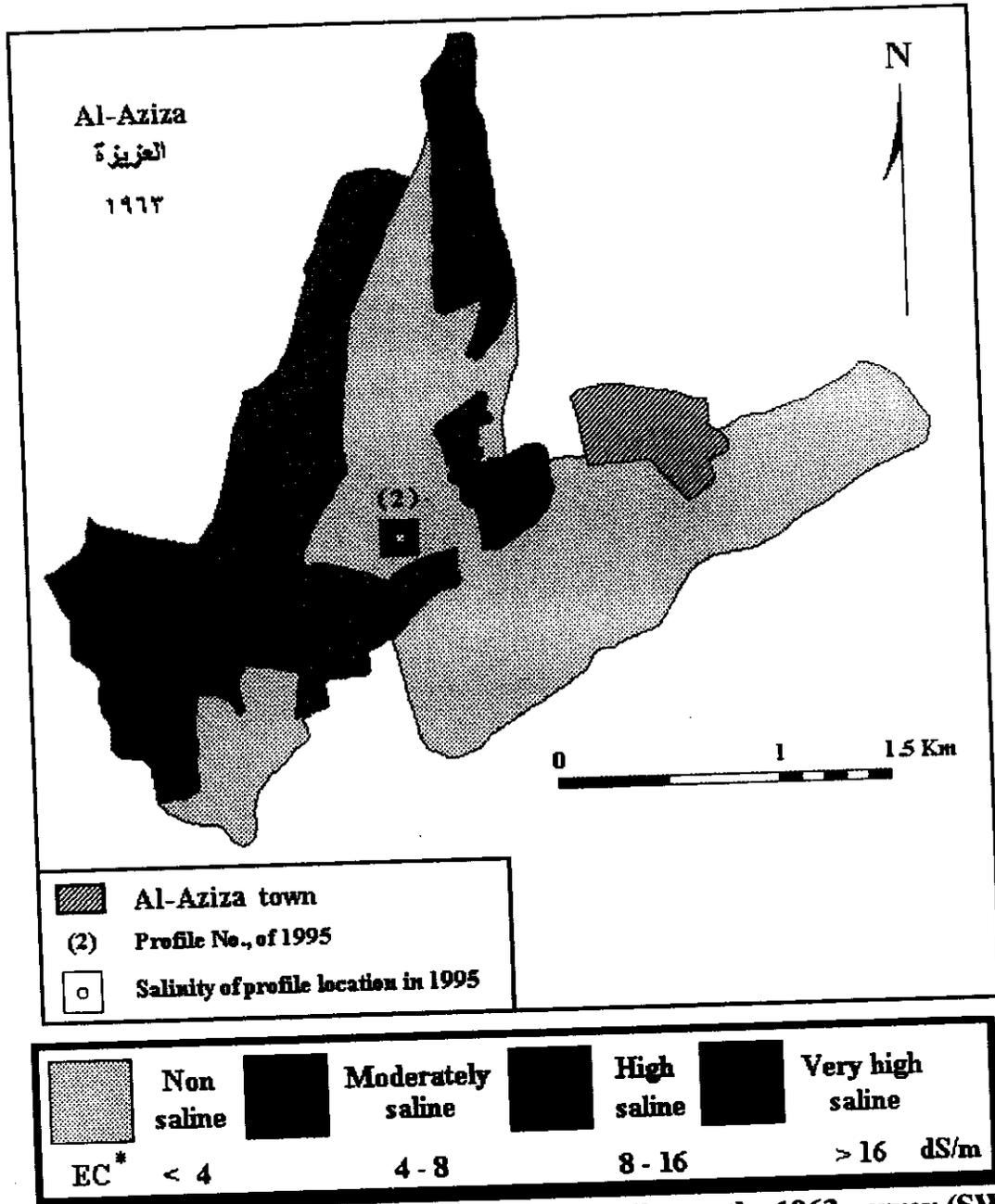


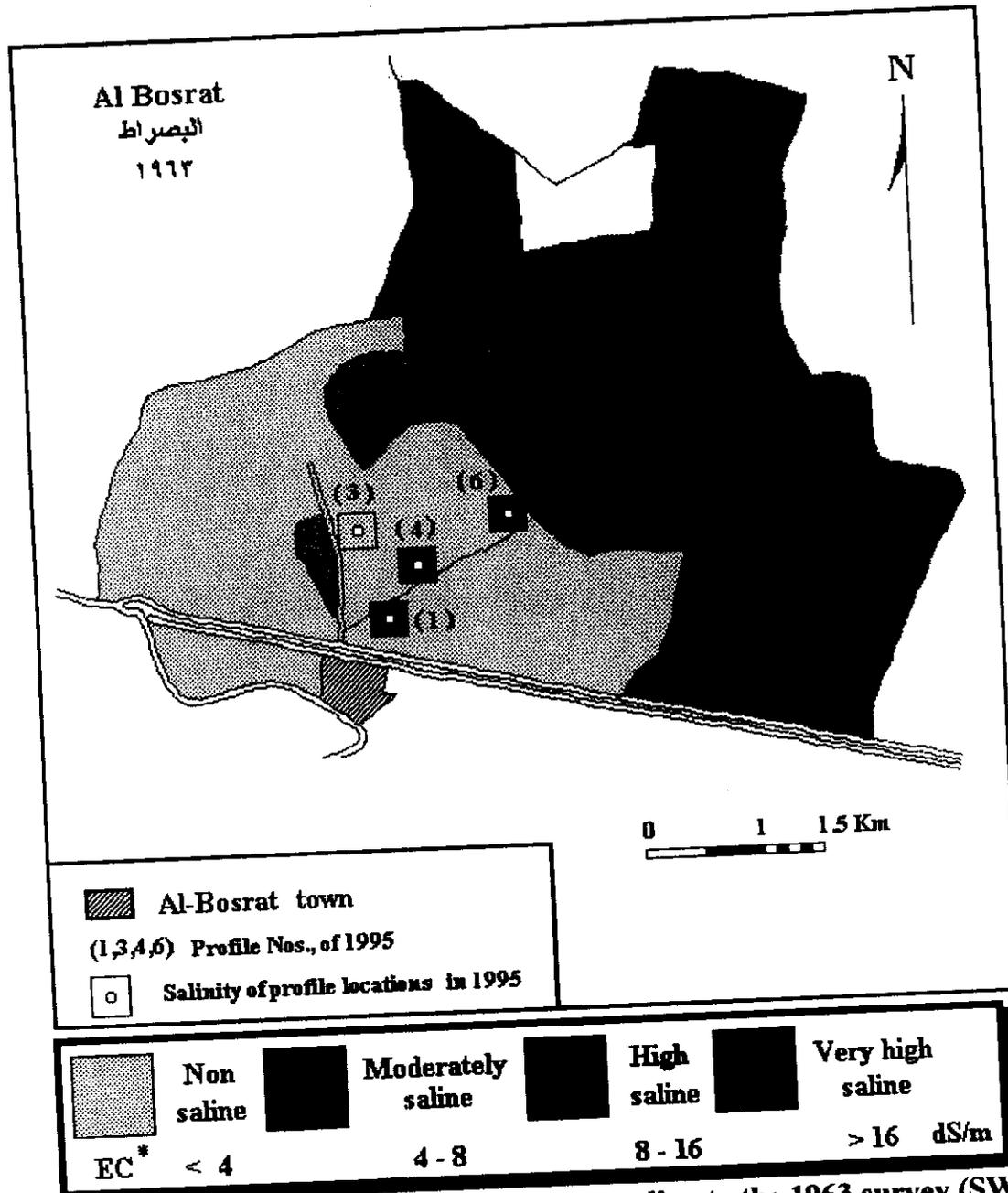
Fig. (8): Electrical conductivity of the studied area in 1963.



Map ( 2 ): Salinity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995 indicating the profiles current salinity status.

(e.g., Location area of profile 2 of the current study was non saline in 1963, but was found to be moderately saline in 1995).

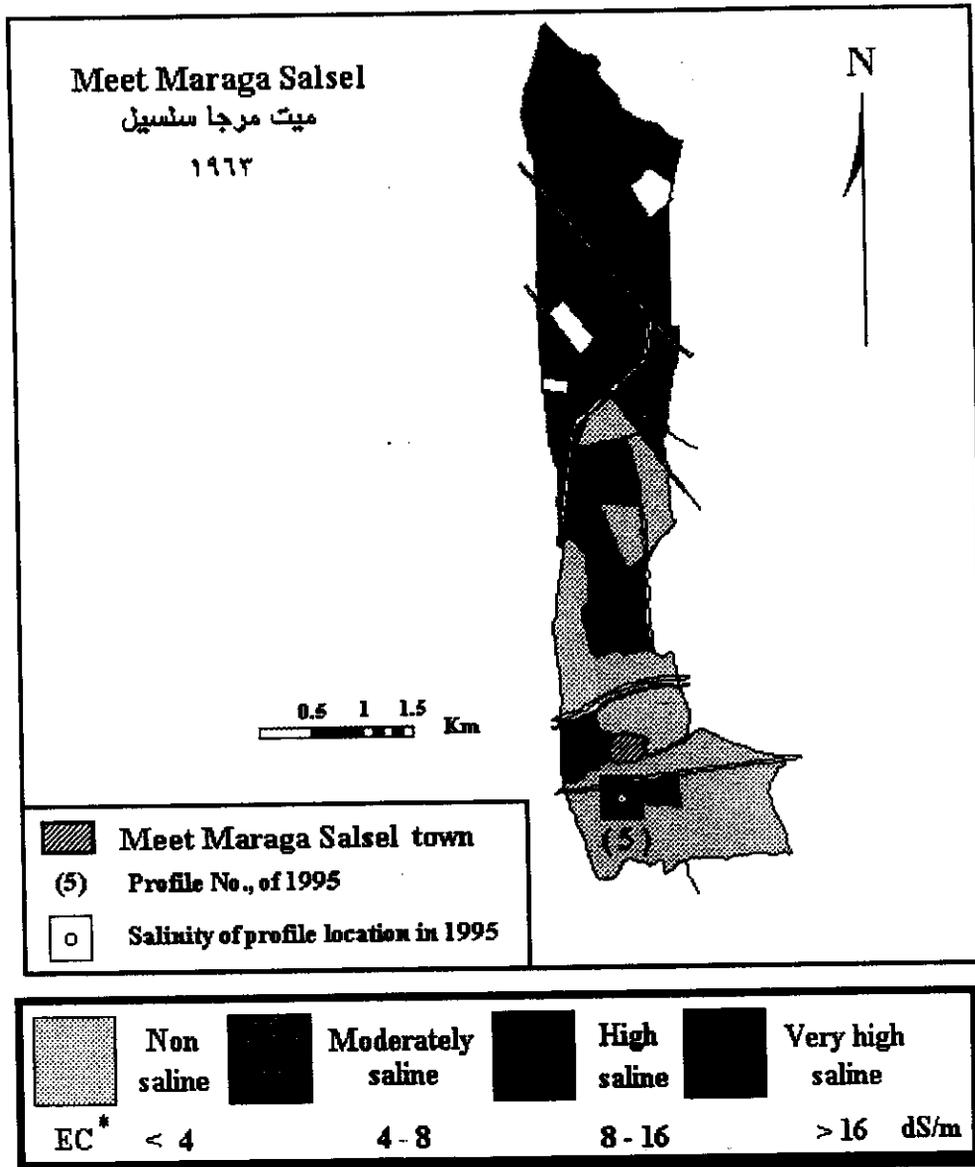
\* : EC of paste extract.



Map ( 3 ): Salinity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995 indicating the profiles current salinity status.

(e.g., Location area of profiles 1, 4 and 6 of the current study was non saline in 1963, but was found between highly saline (profiles 1 and 4); and very highly saline (profile 6) in 1995.

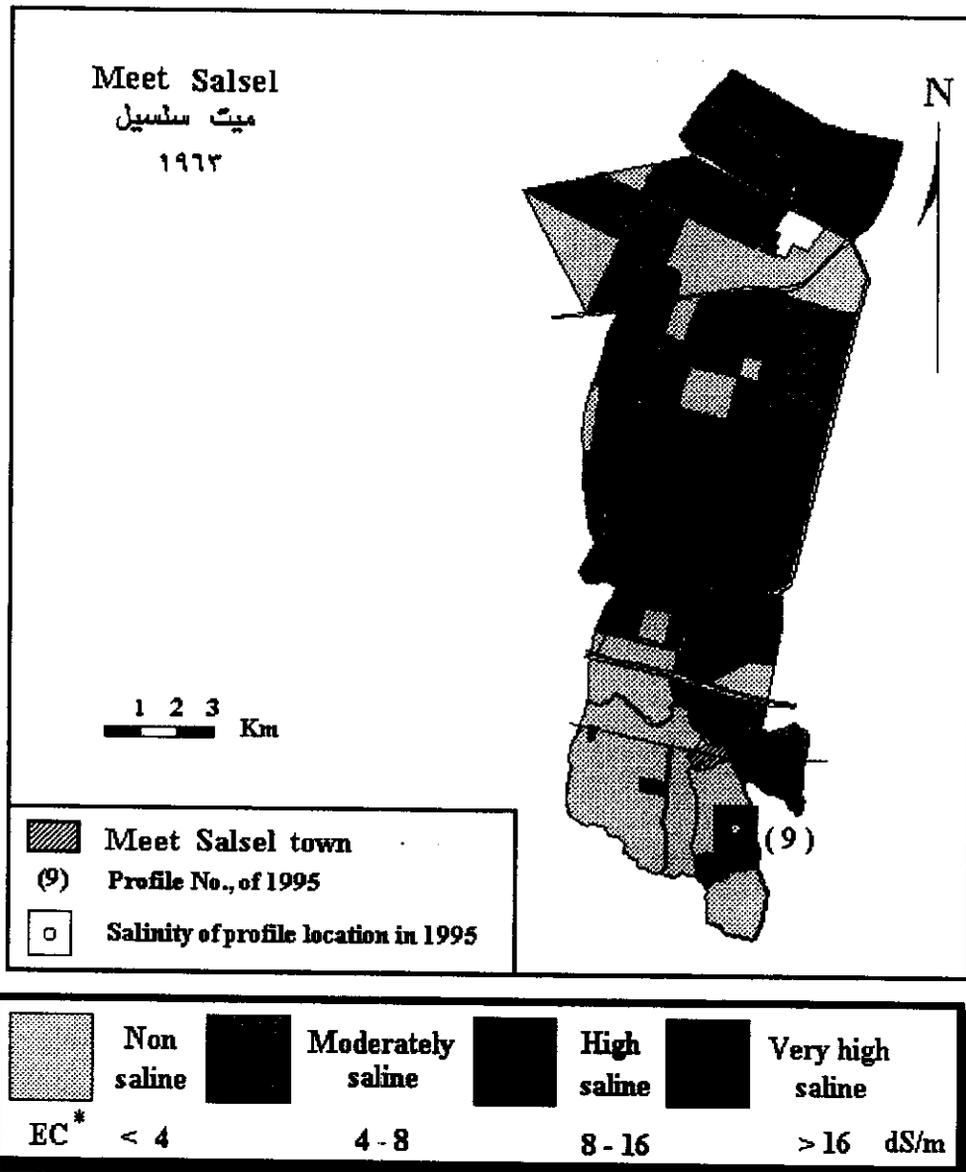
\* : EC of paste extract.



Map ( 4 ): Salinity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995 indicating the profiles current salinity status.

(e.g., Location area of profile 5 of the current study was non saline in 1963, but was found to be highly saline in 1995).

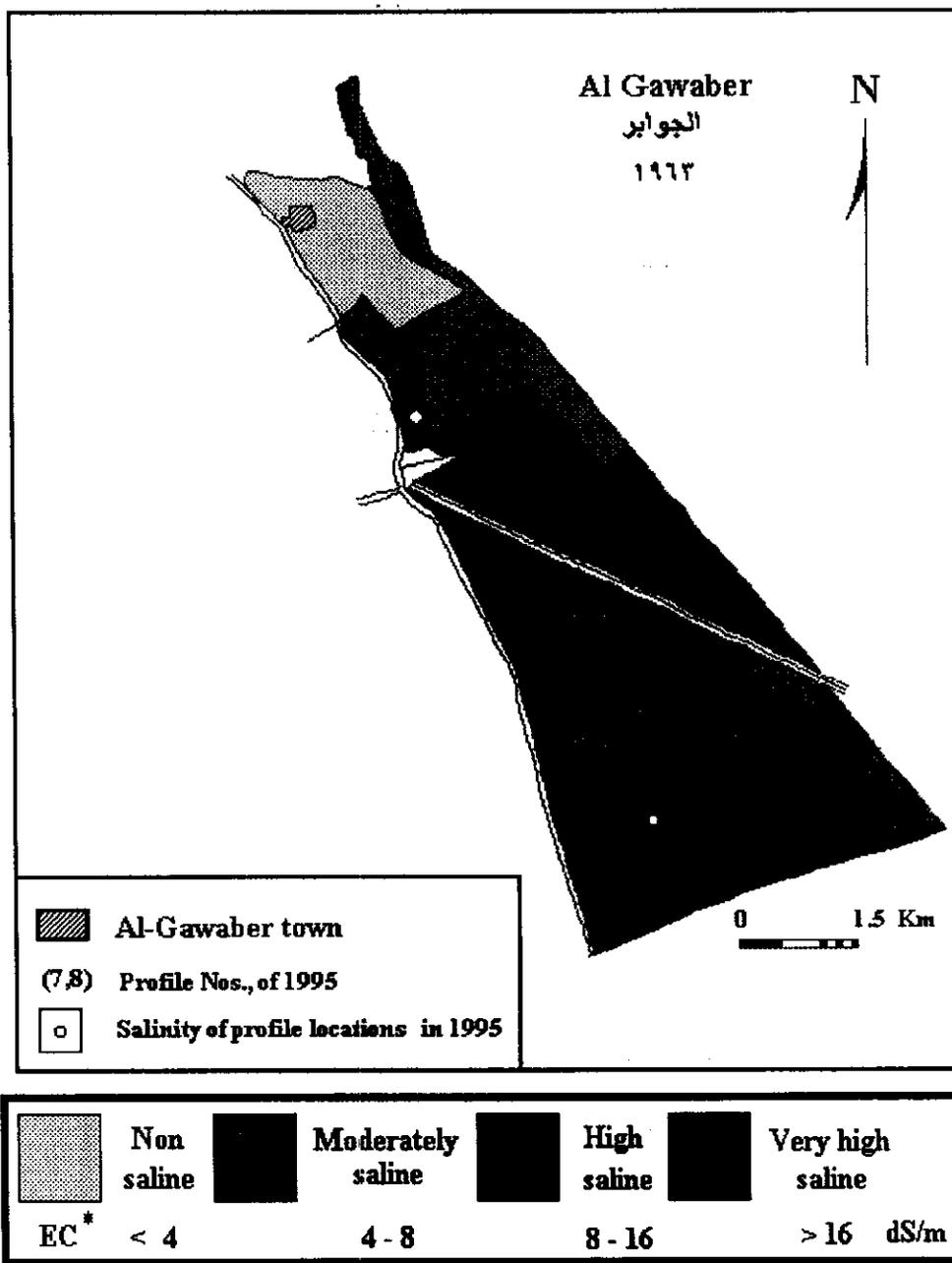
\* : EC of paste extract.



**Map ( 5 ): Salinity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995 indicating the profiles current salinity status.**

**(e.g., Location area of profile 9 of the current study was non saline in 1963, but was found to be moderately saline in 1995).**

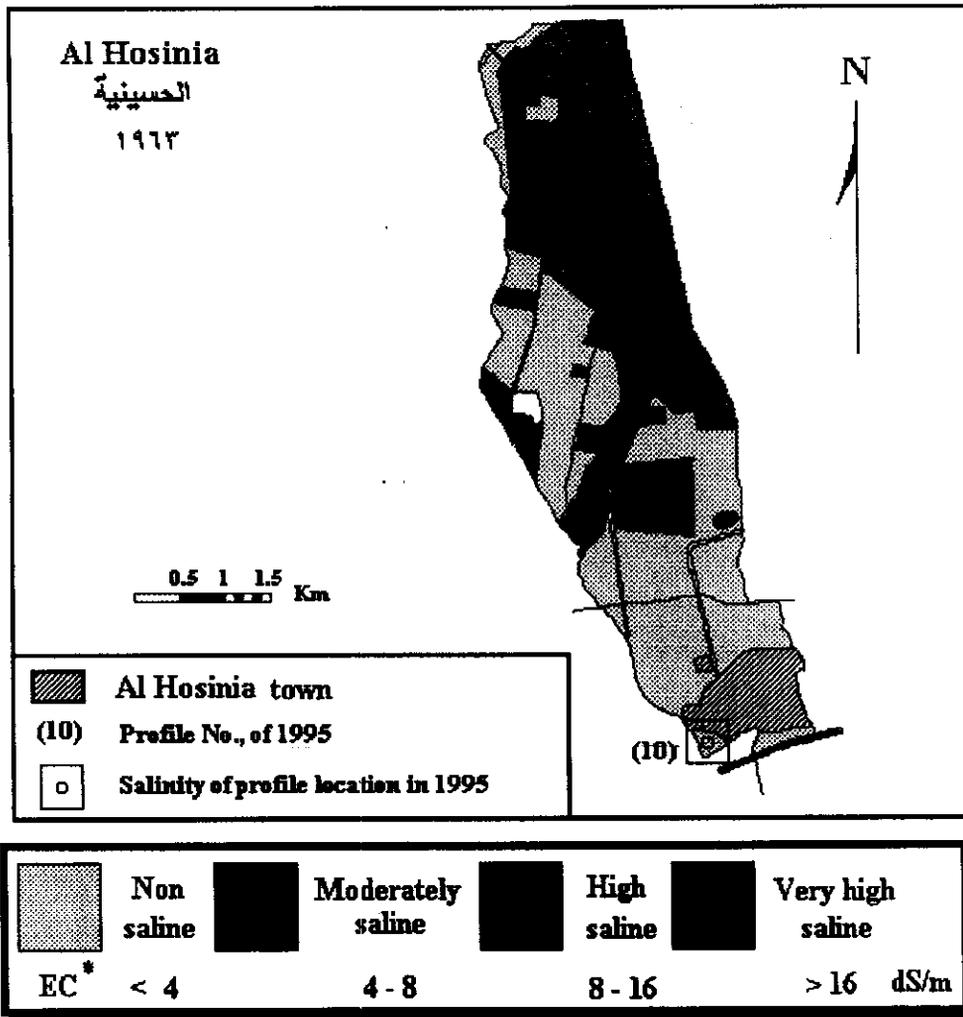
**\* : EC of paste extract.**



**Map ( 6 ): Salinity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995 indicating the profiles current salinity status.**

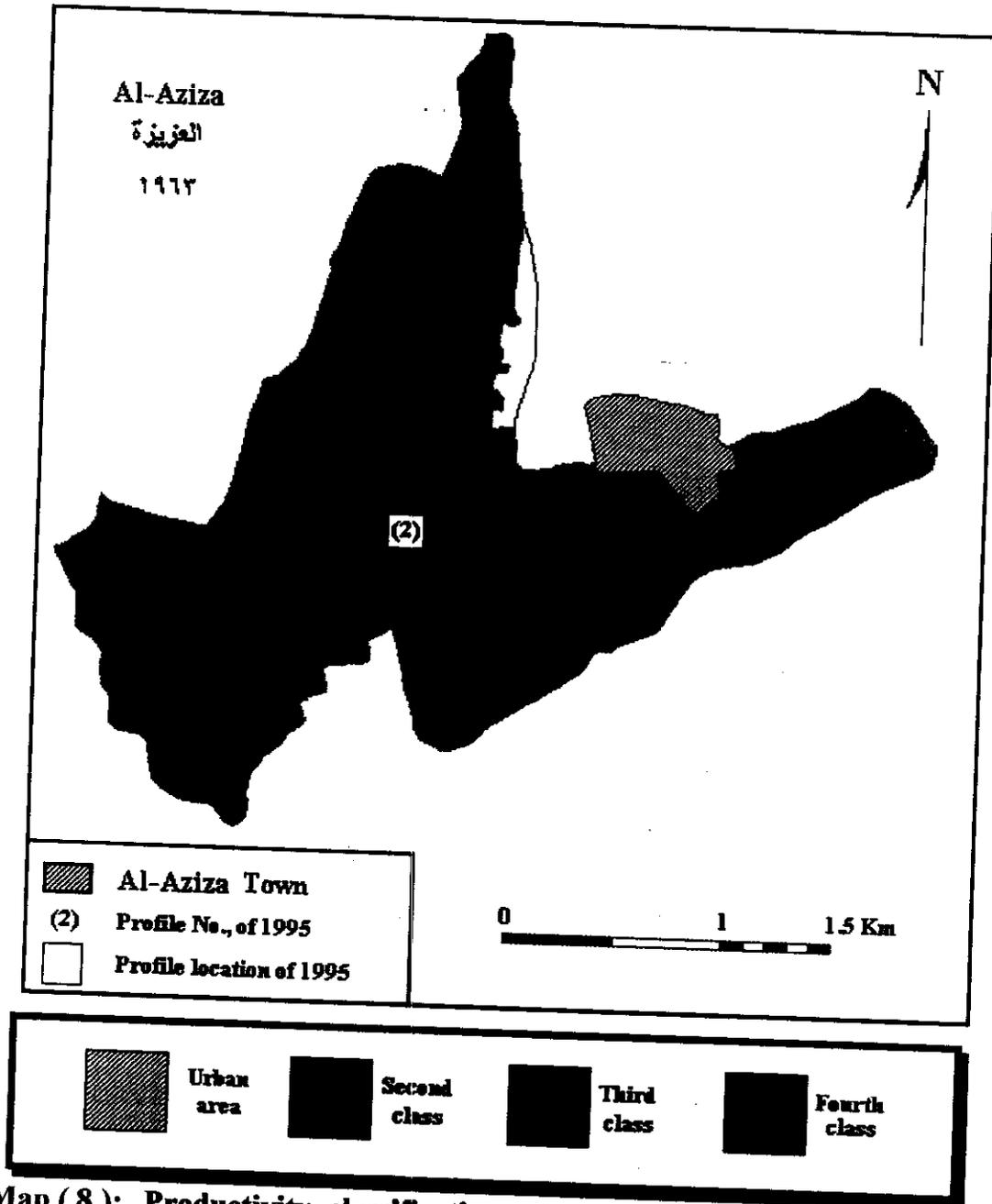
(e.g., Location of profile 7 of the current study was moderately saline in 1963, but was found to be very highly saline in 1995).

\* : EC of paste extract.

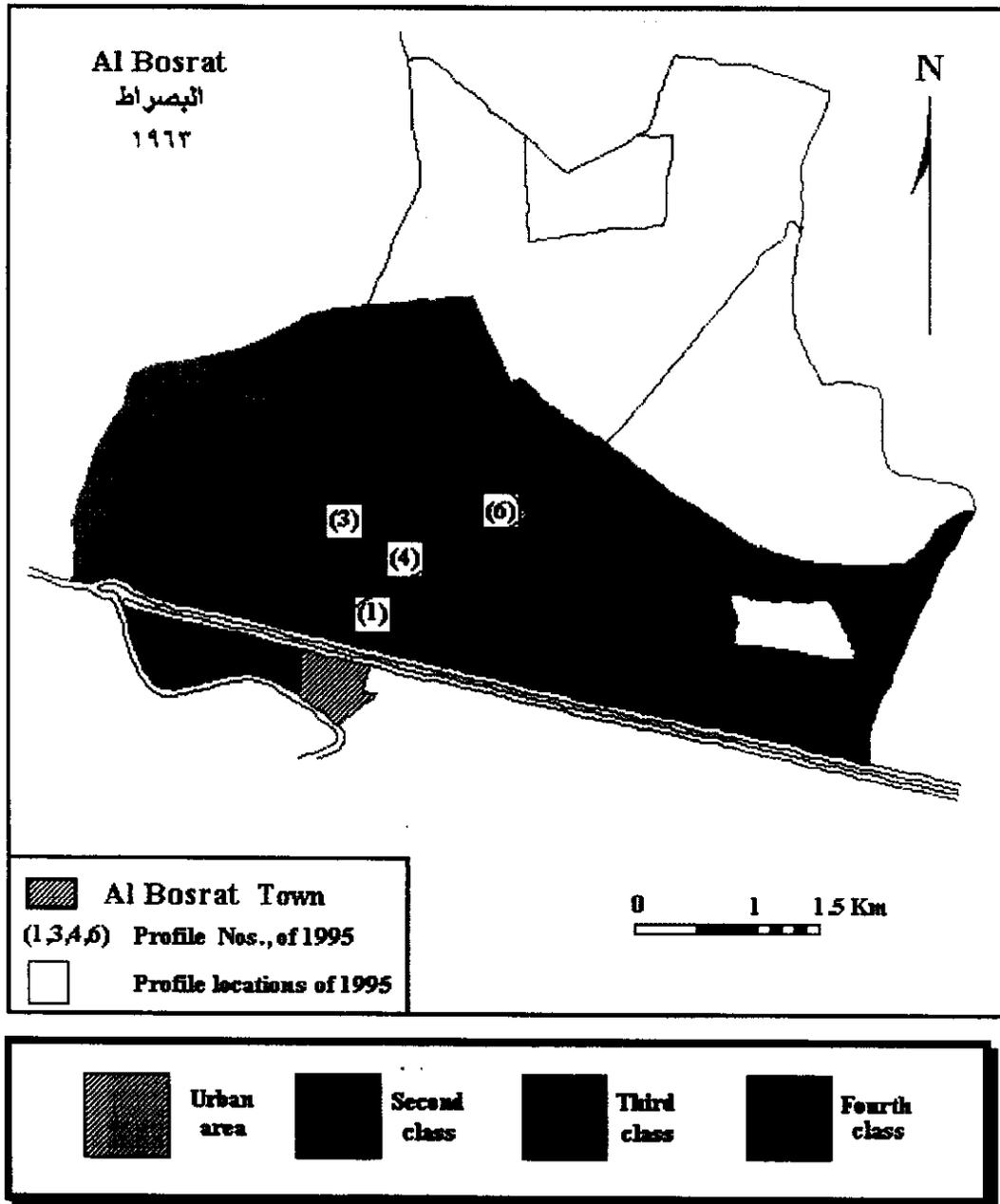


Map ( 7 ): Salinity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995 indicating the profiles current salinity status.

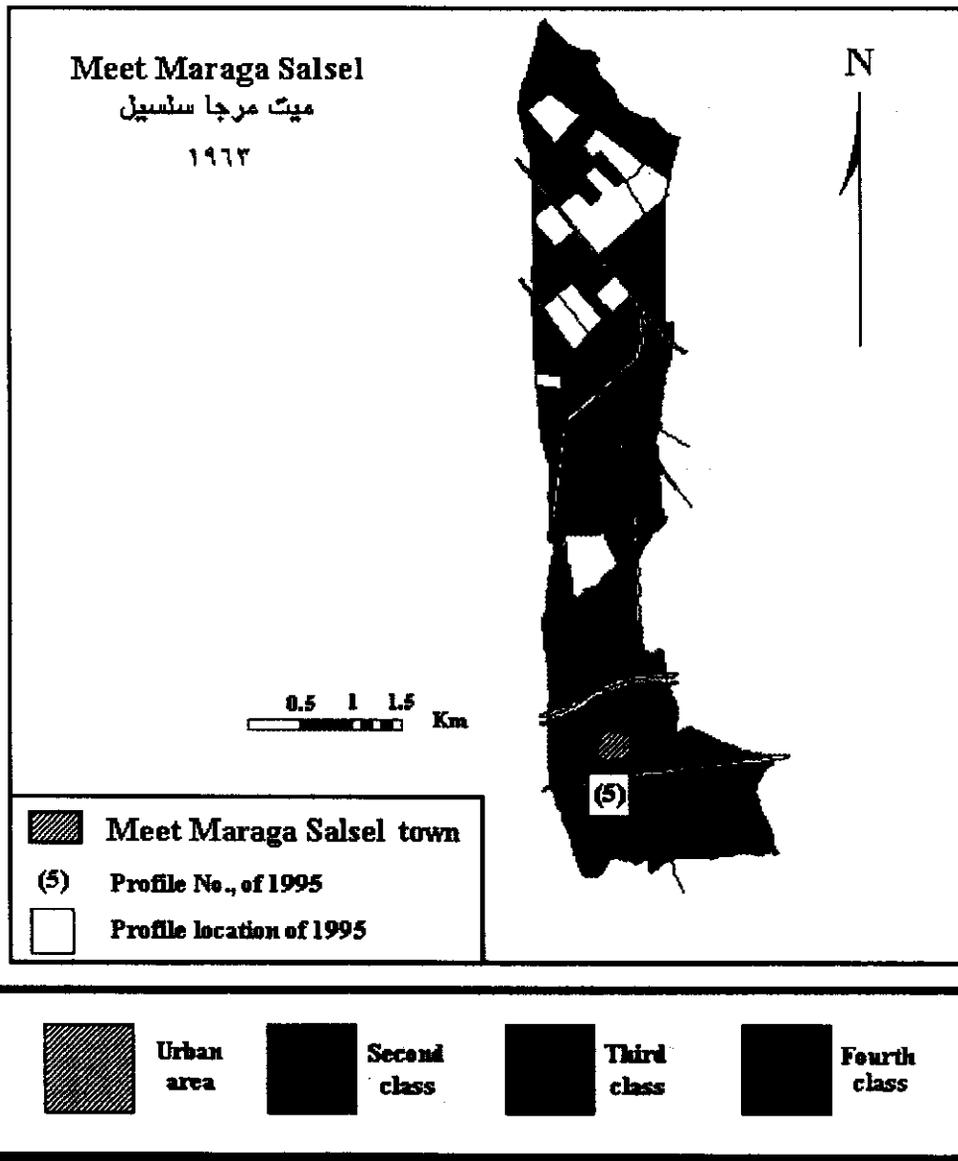
\* : EC of paste extract.



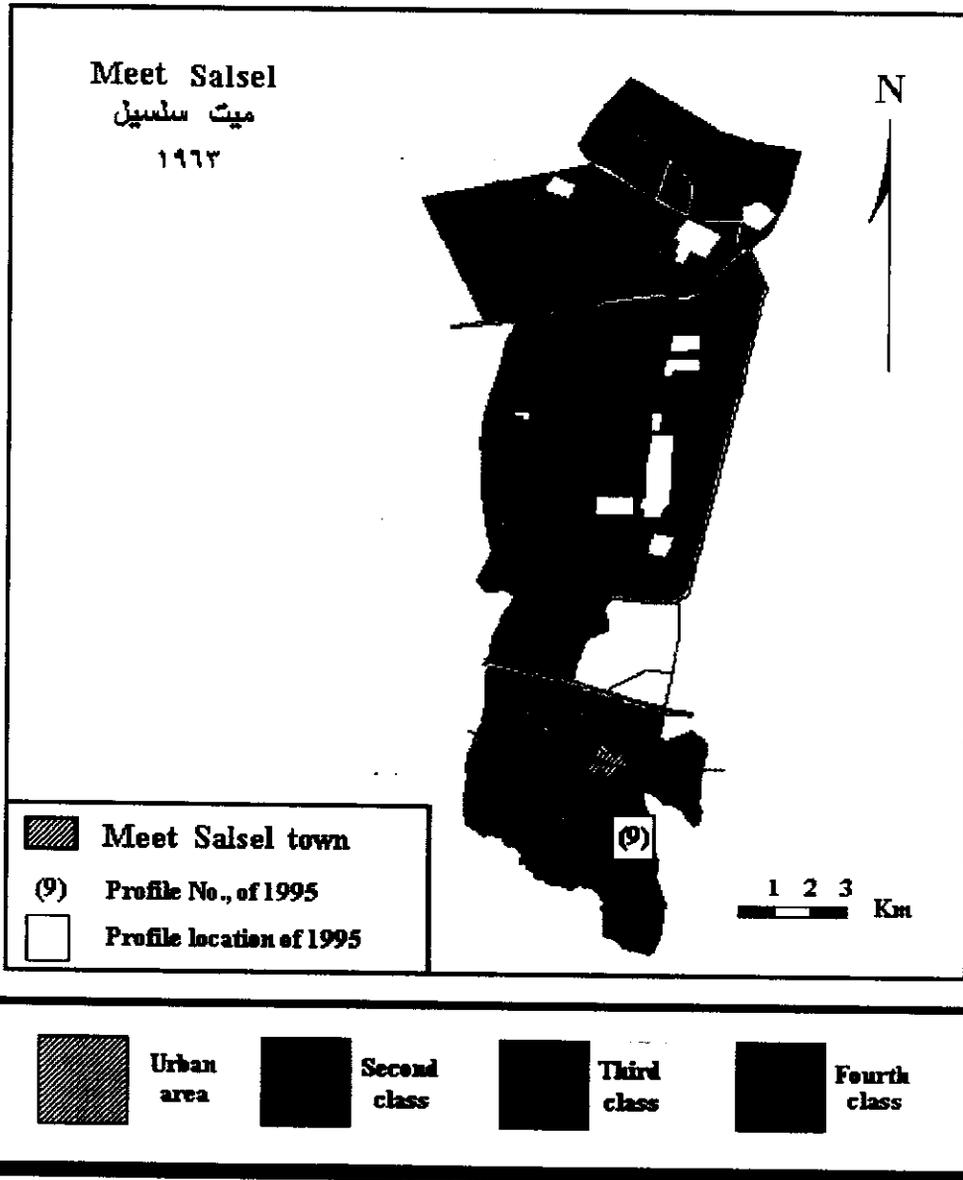
Map (8): Productivity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995.



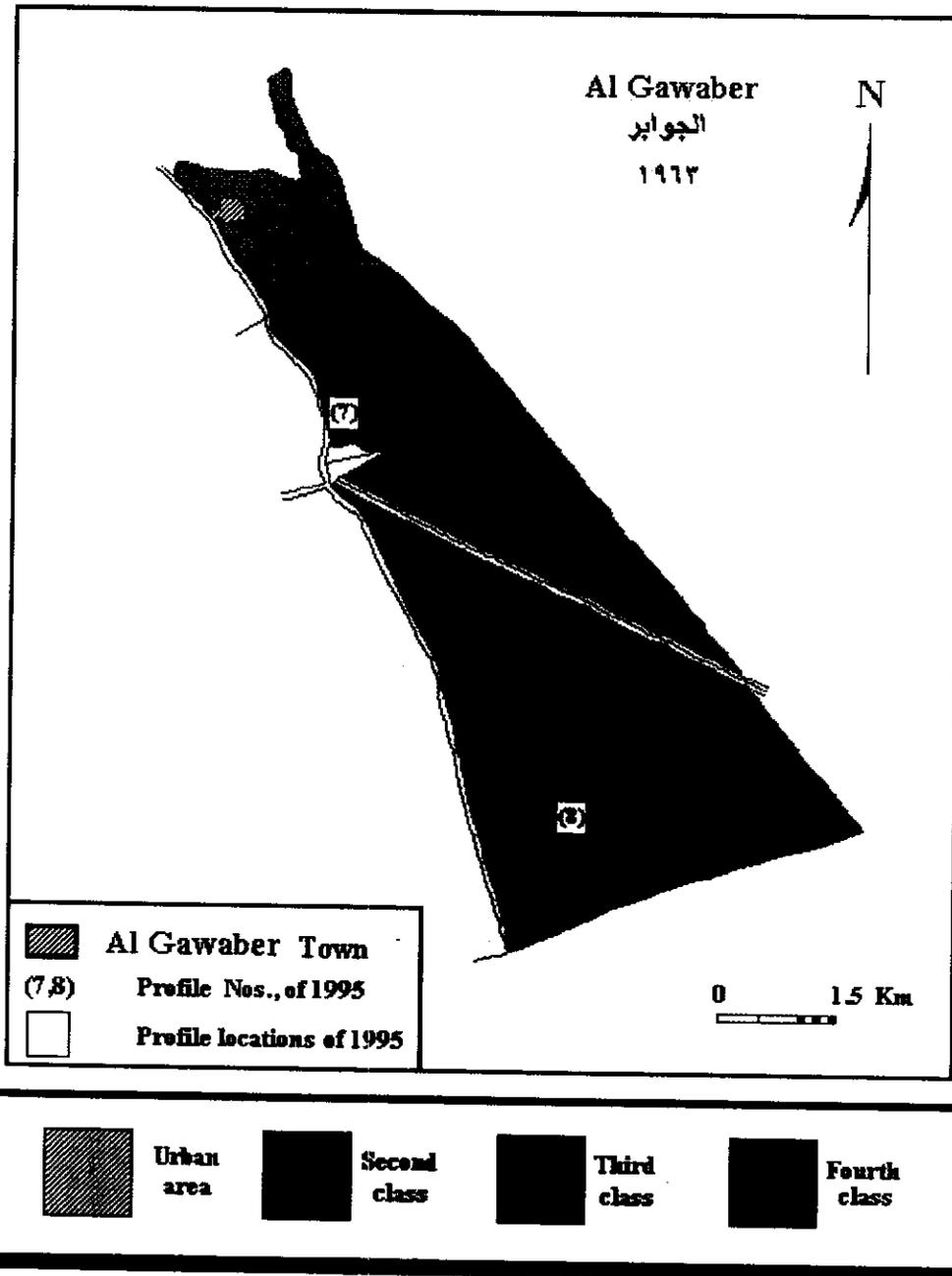
Map (9): Productivity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995.



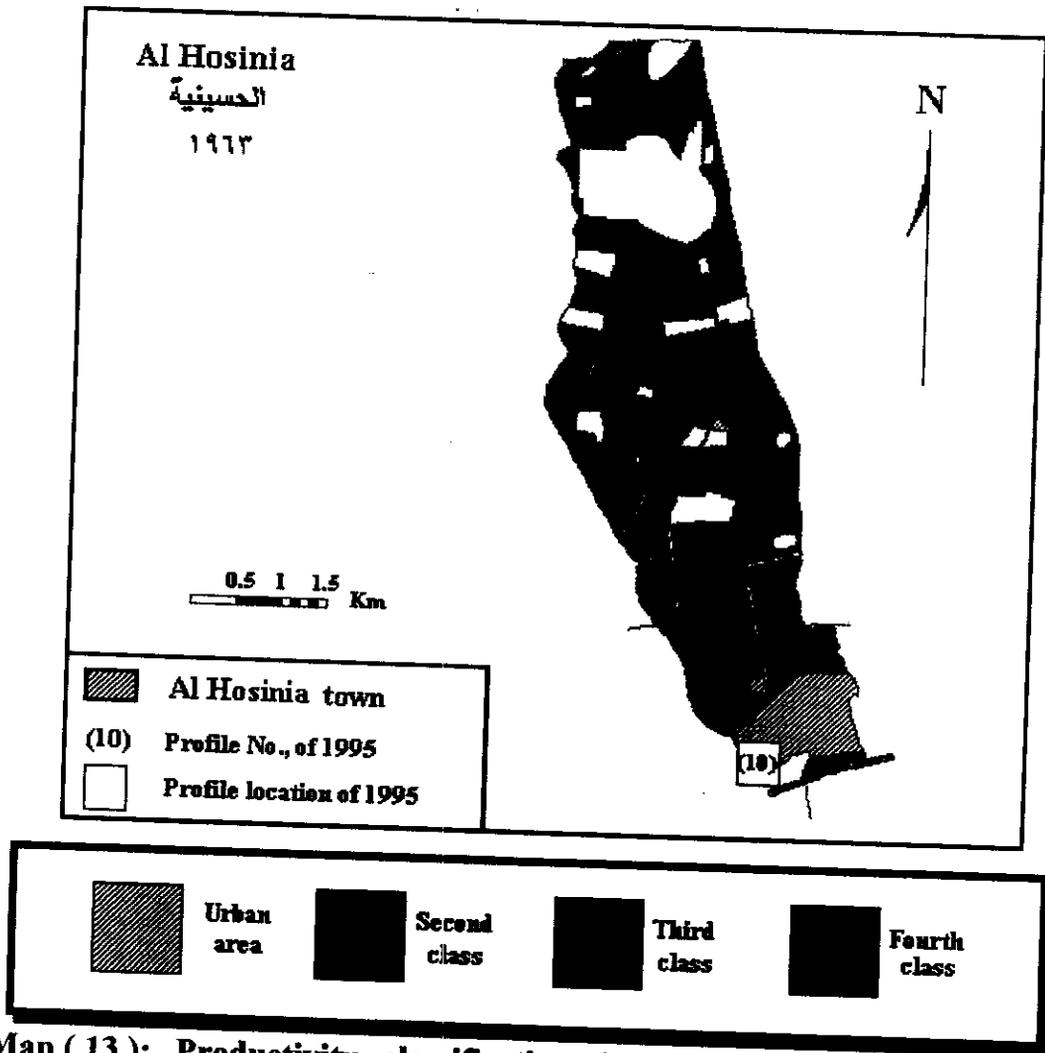
Map ( 10 ): Productivity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995.



Map ( 11 ): Productivity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995.



Map ( 12 ): Productivity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995.



Map ( 13 ): Productivity classification of soil according to the 1963 survey (SWRI 1963), along with profiles taken in the current study 1995.

those on the exchange sites of soil colloids. The environmental condition (temperature, evaporation and humidity) and ground water affect the salt balance of the soil. This is reflected directly on the exchangeable cations.

Sodicity is mainly associated with the excess of exchangeable and soluble Na, Table (6) elucidates the soluble status of Na in the soil solution and a calculated status of exchangeable Na using data of soil solution. The data indicate that soil sodicity expressed as soluble sodium percent (SSP), or sodium adsorption ratio (SAR), or exchangeable sodium percent (ESP) were high for soil profiles 1, 4, 5, 6, 7, 8 and 10 in 1995 than in 1963. This may have been due to a shallow and high saline ground water as well as an increase in soil salinity during the same period.

The SAR of the soil water and the ESP calculated using SAR values illustrate such a sodicity degradation during 1963-1995 period.

#### **4.2.1.3 Change in soil pH:**

Concerning the soil pH of the studied areas, the data presented in Table (6) show the values of pH determined in the current research and those determined at 1963. The data reveal obvious increase (during the period of 1963-1992) in the pH values in soil profiles 1, 4, 6, 7, 8, 9 and 10. A reverse is shown for profiles 2, 3 and 5.

#### **4.2.1.4 Probable sources of salt accumulation in the studied soils:**

Waters of the sea and the lakes in the studied area must have had a

Table (6): Soil pH and sodicity parameters as shown by the current study of 1995 in comparison with similar data in the same area conducted in 1963 by (SWRI, 1963).

Prof. No.	Location	Depth	pH 1995			Sodicity parameters in 1995			Location	Depth	pH 1963			Sodicity parameters in 1963		
			1995	ESP*	SAR	SSP	ESP*	SAR			1963	SSP	ESP*	SAR		
1	Al-Bosrat (a)	0 - 20	7.80	14.9	12.7	56.3	14.9	12.7	Al-Bosrat (a)	0 - 30	8.2	72.0	10.7	9.0		
		20 - 35	8.04	12.0	10.1	58.7	12.0	10.1		30 - 60	8.2	74.6	12.6	10.6		
		35 - 70	8.08	12.8	10.8	71.6	12.8	10.8		60 - 120	7.9	79.4	13.4	11.3		
2	Al-Aziza	0 - 20	7.53	7.0	6.0	43.2	7.0	6.0	Al-Aziza	0 - 30	7.8	49.9	7.4	6.3		
		20 - 40	7.60	8.0	6.8	50.2	8.0	6.8		30 - 60	7.7	52.0	9.0	7.6		
		40 - 75	7.50	3.7	3.5	39.7	3.7	3.5		60 - 90	7.6	59.2	9.4	7.9		
		75 - 90	7.51	3.8	3.5	40.5	3.8	3.5								
3	Al-Bosrat (b)	0 - 20	7.83	4.0	3.7	29.4	4.0	3.7	Al-Bosrat (b)	0 - 30	7.9	61.2	7.5	6.4		
		20 - 60	7.79	6.8	5.8	62.3	6.8	5.8		30 - 60	8.0	71.3	10.9	9.2		
		60 - 100	7.75	4.9	4.4	52.6	4.9	4.4		60 - 100	8.2	87.0	20.6	18.5		
		100-150	8.06	10.9	9.1	74.8	10.9	9.1								
4	Al-Bosrat (c)	0 - 20	8.23	27.8	27.0	83.7	27.8	27.0	Al-Bosrat (c)	0 - 30	8.0	62.4	12.1	10.2		
		20 - 40	7.88	38.6	43.4	84.5	38.6	43.4		30 - 60	8.2	77.9	21.9	19.9		
		40 - 55	7.77	44.5	55.1	82.6	44.5	55.1								
5	Meat Marag Salsel	0 - 30	7.44	23.4	21.5	64.8	23.4	21.5	Meat Marag Salsel	0 - 30	7.9	73.8	13.5	11.4		
		30 - 65	8.01	20.9	18.8	83.2	20.9	18.8		30 - 60	8.1	82.5	20.1	17.9		
		65 - 100	7.88	12.5	10.5	74.0	12.5	10.5		60 - 100	8.1	80.3	18.5	16.2		
		100-150	7.88	9.5	7.9	69.3	9.5	7.9								

ESP\* : Calculated exchange sodium percent after (USDA, 1954).

Na me/L  
Soluble cation me/L

SSP : Soluble sodium % (Na as a fraction of total soluble cations =  $\frac{\text{Na me/L}}{\text{Soluble cation me/L}} \times 100$ )

Table (6): cont.

Prof. No.	Location	Depth	pH	Sodicity parameters in 1995			Location	Depth	pH	Sodicity parameters in 1963		
				SSP	ESP*	SAR				SSP	ESP*	SAR
6	Al-Bosrat (d)	0 - 25	8.15	88.2	50.9	71.2	Al-Bosrat (d)	0 - 30	7.9	74.0	12.2	10.3
		25 - 40	8.32	92.9	53.5	79.0		30 - 60	8.0	74.7	18.5	16.2
		40 - 65	7.67	89.1	48.8	65.4		60 - 100	8.1	79.0	21.9	19.9
7	Al-Gawaber (a)	0 - 20	7.91	39.0	19.8	17.6	Al-Gawaber (a)	0 - 30	7.8	56.9	13.2	11.1
		20 - 60	7.57	47.8	13.0	11.0		30 - 60	8.1	62.1	14.7	12.5
		60 - 80	7.52	34.9	9.8	8.2		60 - 90	7.9	62.0	14.4	12.3
8	Al-Gawaber (b)	0 - 20	7.88	69.1	19.4	17.2	Al-Gawaber (b)	0 - 30	7.9	66.0	14.8	12.6
		20 - 60	7.73	68.8	21.2	19.1		30 - 60	7.5	78.7	23.2	21.3
		60 - 100	7.67	65.6	16.5	14.3		60 - 100	7.5	80.7	26.0	24.7
9	Meet Salsel	0 - 20	7.32	46.9	7.9	6.7	Meet Salsel	0 - 30	7.4	71.4	9.2	7.8
		20 - 35	7.82	65.8	11.2	9.4		30 - 60	7.7	78.6	11.6	9.7
		35 - 70	8.19	93.1	42.2	50.3		60 - 90	7.7	86.6	18.2	16.0
10	Al-Hosinia	70 - 110	8.32	74.9	14.8	12.6	Al-Hosinia	90 - 120	7.6	84.6	22.7	20.8
		0 - 15	7.28	31.1	4.7	4.2		0 - 30	7.5	35.3	5.0	4.4
		15 - 50	7.85	84.4	21.2	19.1		30 - 60	7.2	43.1	8.7	0.5
		50 - 100	7.43	65.5	17.6	15.3	60 - 100	7.3	55.7	13.6	11.5	
		100 - 150	7.50	38.1	5.5	4.8	100 - 150	7.4	82.2	21.0	18.9	

ESP\* : Calculated exchange sodium percent after (USDA, 1954).

SSP : Soluble sodium % (Na as a fraction of total soluble cations =  $\frac{\text{Na me/L}}{\text{Soluble cation me/L}} \times 100$ )

negative affect on soils of the area. In Australia, Hutton and Leslie, (1958) estimated that in lands lying near sea coasts, the zone of ground-water table contaminated by sea water along the coastline of the sea may reach to as far as 50 km from the shore line. In Egypt El-Khattib, (1983) estimated that such a zone in the Delta may be about 80 km from the shoreline inland towards the Nile Delta. In general, accumulation of salts in soils, is due to a number of, climatological and geochemical processes stimulated when ground-water levels become sufficiently shallow. Soil moisture evaporation to the atmosphere and leads to salt accumulation. Water, in Egyptian agriculture, is probably applied in quantities which may be excessive, exceeding the capacity of soil retention as well as the requirements of crops. Although excess irrigation water helps in decreasing the build up of salinity in soils, by percolating deep to drain water, it may raise the level of ground water nearer to the soil surface where drainage is impeded. Rationalized irrigation will save water for expansion of agriculture beside conserving soils from the shallow ground water hazards. Chemical analyses of ground water, irrigation water, lake water, and drainage water of the area are shown in Table (4).

**A. Water seepage as a probable source of salt accumulation:**

In order to visualize the significance of irrigation and drainage activities as a source of salts in ground water table in the investigated soils, the anionic ratios:  $\text{Cl}^-/\text{SO}_4^{2-}$ ;  $\text{Cl}^-/\text{HCO}_3^- + \text{CO}_3^{2-}$  and the cationic ratio:  $\text{Na}^+/\text{Mg}^{2+}$ ,  $\text{Na}^+/\text{Ca}^{2+} + \text{Mg}^{2+}$ ,  $\text{Na}^+/\text{Ca}^+$ ,  $\text{Na}^+ + \text{K}^+/\text{Ca}^{2+} + \text{Mg}^{2+}$  and  $\text{Mg}^{2+}/\text{Ca}^{2+}$  were calculated. Such ratios were computed for of each source and compared with

similar ratios; concerning water extracts of soils. Results are shown in Table (7). It is noted that the cationic ratios of ground water table, irrigation water, drainage water, and the saturation extract are rather similar in the areas represented by profiles 1, 2, 3, 7, 8, 9 and 10.

**B. Manzala lake water intrusion into ground water table:**

Examination of the cationic ratios of Manzala lake and ground water table show that they are more or less similar in the adjacent area represented by profiles 5 and 6.

**4.2.2 Urbanization growth:**

In the current study urbanization growth concerns expansion of old urban settlements which had already been established in the midst of agricultural lands. Therefore, it does not include the creation of new settlements in the investigated areas. Nor does it include the settlements established in previously unproductive lands such as those in the desert lands or in coast lands, or in areas previously identified as fields of reduced productivity or degraded lands. In this case, urbanization growth discussed in this investigation concerns lands that were taken out of production during the course of the time period studied (1952-1992).

From the point of view of the remote sensing systems, a land changes from a productive agricultural landform into an urban land, there are changes in its Normalized Difference Vegetation Index (NDVI) values. With a cultivated lands, there are initial high NDVI values. Once the land is not under agriculture,

**Table (7): Rates of some cations and anion (me/me) in waters of soil extracts, irrigation canals, drainage canals, Manzala lake, and ground water of the studied areas.**

Prof. No.	Depth	Na	Na	Na	Mg	Na + K	Cl	Cl
		Ca	Mg	Ca + Mg	Ca	Ca + Mg	SO <sub>4</sub>	HCO <sub>3</sub> + CO <sub>3</sub>
1	Top soil	3.18	2.26	1.32	1.41	1.35	0.62	3.08
	Mean soil	3.54	2.90	1.60	1.22	1.62	0.73	3.67
	Irrigation	0.57	0.92	0.35	0.62	0.46	6.45	0.40
	Drainage	2.39	1.13	0.77	2.10	0.87	15.41	4.80
	Ground water	4.00	1.67	1.18	2.39	1.20	27.35	5.80
2	Top soil	1.38	1.75	0.77	0.79	0.78	1.24	3.13
	Mean soil	1.40	1.86	0.80	0.75	0.81	0.94	3.13
	Irrigation	0.48	1.04	0.33	0.45	0.42	3.92	0.33
	Drainage	3.88	1.01	0.80	3.85	0.85	21.84	14.31
	Ground water	1.90	0.99	0.65	1.91	0.67	114.29	2.74
3	Top soil	0.71	1.25	0.45	0.56	0.53	0.46	1.14
	Mean soil	1.99	3.21	1.23	0.62	1.31	0.52	1.39
	Irrigation	0.57	0.92	0.35	0.62	0.46	6.45	0.40
	Drainage	2.39	1.13	0.77	2.10	0.87	15.41	4.80
	Ground water	---	---	---	---	---	---	---
4	Top soil	24.55	7.70	5.86	3.19	6.00	2.04	11.75
	Mean soil	22.64	7.44	5.60	3.04	5.72	1.68	29.77
	Irrigation	0.57	0.92	0.35	0.62	0.46	6.45	0.40
	Drainage	2.39	1.13	0.77	2.10	0.87	15.41	4.80
	Ground water	18.84	2.53	2.23	7.45	2.32	30.24	26.07
	Manzala lake	113.10	4.55	4.37	24.86	4.46	5.54	70.86
5	Top soil	4.23	3.34	1.87	1.27	1.88	1.58	22.80
	Mean soil	4.53	4.62	2.29	0.98	2.31	1.70	8.77
	Irrigation	0.57	0.92	0.35	0.62	0.46	6.45	0.40
	Drainage	---	---	---	---	---	---	---
	Ground water	---	---	---	---	---	---	---
	Manzala lake	113.10	4.55	4.37	24.86	4.46	5.54	70.86

--- : not applicable.

Table (7): cont.

Prof. No.	Depth	Na	Na	Na	Mg	Na + K	Cl	Cl
		Ca	Mg	Ca + Mg	Ca	Ca + Mg	SO <sub>4</sub>	HCO <sub>3</sub> + CO <sub>3</sub>
6	Top soil	143.56	9.30	8.74	15.43	8.90	1.33	11.93
	Mean soil	70.28	11.08	9.57	6.34	9.71	1.36	14.68
	Irrigation	0.57	0.92	0.35	0.62	0.46	6.45	0.40
	Drainage	---	---	---	---	---	---	---
	Ground water	21.86	3.03	2.66	7.21	2.77	50.72	40.98
	Manzala lake	113.10	4.55	4.37	24.86	4.46	5.54	70.86
7	Top soil	2.10	0.93	0.64	2.27	0.65	4.97	101.60
	Mean soil	1.98	1.06	0.69	1.87	0.70	3.57	46.74
	Irrigation	0.89	1.28	0.53	0.70	0.58	3.39	1.82
	Drainage	0.89	1.28	0.53	0.70	0.58	3.39	1.82
	Ground water	1.78	1.15	0.70	1.55	0.72	34.29	9.84
8	Top soil	6.00	3.78	2.32	1.59	2.36	1.19	10.56
	Mean soil	6.68	3.88	2.45	1.72	2.50	1.62	17.94
	Irrigation	0.89	1.28	0.53	0.70	0.58	3.39	1.82
	Drainage	2.96	2.01	1.20	1.47	1.23	47.28	11.77
	Ground water	---	---	---	---	---	---	---
9	Top soil	1.77	1.82	0.90	0.97	0.91	1.25	4.82
	Mean soil	8.06	7.53	3.89	1.07	3.92	0.66	1.43
	Irrigation	0.89	1.28	0.53	0.70	0.58	3.39	1.82
	Drainage	---	---	---	---	---	---	---
	Ground water	---	---	---	---	---	---	---
10	Top soil	0.70	1.30	0.46	0.54	0.47	0.74	4.90
	Mean soil	2.79	2.72	1.38	1.03	1.39	0.38	1.65
	Irrigation	0.48	2.93	0.41	0.16	0.53	1.45	0.34
	Drainage	---	---	---	---	---	---	---
	Ground water	---	---	---	---	---	---	---

--- : not applicable.

subsequent NDVI values are low. This is true whether actual buildings are constructed on the site or the land rendered fallow with no plant canopy cover it. Urban encroachment onto cultivated land is a loss of productive lands.

To assess urban expansion of some settlements in this study, multitemporal features for the change detection analysis were carried out through Flow Chart No. 1. The Tables 8, 9 and 10 and Fig. (9) illustrate the results of such operations. Also a chart illustrating land use for the investigated areas using LANDSAT TM data was acquired on 1995 through Flow Chart No. 2. The nature of urban expansion and its extents will be discussed.

#### **4.2.3 The nature of urban expansion:**

Comparative assessment of urban expansion area during the 40 years (from 1952 to 1992) Maps (14 through 25) show the nature of this expansion up to 1992 and its direction in the studied areas. There are two groups. The first group (Al-Mataria, Faraskor, Domiatta and Rass El-Bar) concern locations where data of past studies were available the year 1952 only; the second group (Al-Aziza, Al-Manzala, Al-Bosrat, Al-Gamalia, Meet Maraga Salsel, Meet Salsel, Al-Gawaber and Al-Hosinia) concern those where data for past studies covered the years 1952 and 1963.

##### **4.2.3.1 Al-Mataria:**

\* In 1992, expansion was around the old town shown by the 1952 area, and stopped to the east and north, because of the Manzala lake. There was a

Table (8): Total urban area around some settlements (villages and towns) from 1952 up to 1996

No.	Village or town	Total urban area/fed. up to the years			
		1952	1963	1992	Estimated 1996
1	Al-Mataria	236	---	505	550
2	Al-Aziza	31	63	179	185
3	Al-Manzala	167	385	794	880
4	Al-Bosrat	31	55	184	200
5	Al-Gamalia	61	107	662	720
6	Meet Maraga Salsel	8	19	72	78
7	Meet Salsel	80	148	238	265
8	Al-Gawaber	14	24	47	52
9	Faraskor	213	---	518	550
10	Domiat	449	---	2642	2800
11	Raas El-Bar	26	---	1228	1400
12	Al-Hosinia	55	239	418	475

--- : Data for 1963 are not available.

Table (9): The magnitude of increase in the urban area (in feddan) and the rate of increase of urban area of some settlements (villages and towns) during 1952 to 1992.

No.	Village or town	% and period rates of increase area/fed.						1992 area increase in times (or folds) compared with 1952
		1952 - 1963 11 years		1963 - 1992 29 years		1952 - 1992 40 years		
		Fed.	%	Fed.	%	Fed.	%	
1	Al-Mataria	---	---	---	---	269	114	"folds"
2	Al-Aziza	32	103	116	184	148	477	1.1
3	Al-Manzala	218	131	409	106	627	375	4.8
4	Al-Bosrat	24	77	129	235	153	494	3.8
5	Al-Gamalia	46	75	555	519	601	985	4.9
6	Meet Maraga Salsel	11	138	53	279	64	800	9.9
7	Meet Salsel	68	85	90	61	158	198	8.0
8	Al-Gawaber	10	71	23	96	33	236	2.0
9	Faraskor	---	---	---	---	305	143	2.4
10	Domjata	---	---	---	---	2193	488	1.4
11	Raas El-Bar	---	---	---	---	1202	4623	4.9
12	Al-Hosinia	184	335	179	75	363	660	46.2
								6.6

See table 8 for actual urban areas in 1952, 1963 and 1992.

--- : Data for 1963 are not available.

Table (10): The annual expansion of urban area expressed as feddan/year and the rate of urban expansion expressed as % in some settlements (villages and towns) during 1952 to 1992.

No.	Village or town	Annual increase Fed. and %					
		1952 - 1963		1963 - 1992		1952 - 1992	
		Fed./year	%	Fed./year	%	Fed./year	%
1	Al-Mataria	---	---	---	---	7	2.8
2	Al-Aziza	3	9.4	4	6.3	4	11.9
3	Al-Manzala	20	11.9	14	3.7	16	9.4
4	Al-Bosrat	2	7.0	4	8.1	4	12.3
5	Al-Gamalia	4	6.9	19	17.9	15	24.6
6	Meet Maraga Salsel	1	12.5	2	9.6	2	20.0
7	Meet Salsel	6	7.7	3	2.1	4	4.9
8	Al-Gawaber	1	6.5	1	3.3	1	5.9
9	Faraskor	---	---	---	---	8	3.6
10	Domiata	---	---	---	---	55	12.2
11	Raas El-Bar	---	---	---	---	30	115.6
12	Al-Hosinia	17	30.5	6	2.6	9	16.5

--- : Data for 1963 are not available.

Distribution of the total area of urban land in Al-Mataria (505 fed.) due to expansions during period of:

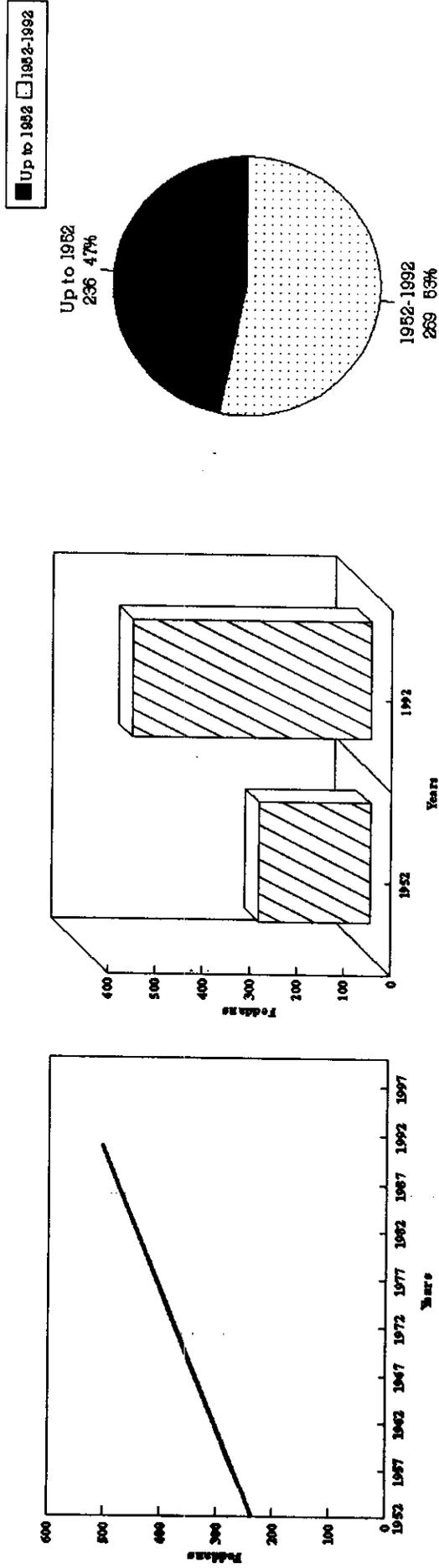


Fig (9): Area by feddans and percentage according to different years for Al-Mataria district.

Distribution of the total area of urban land in Al-Aziza (179 fed.) due to expansions during period of:

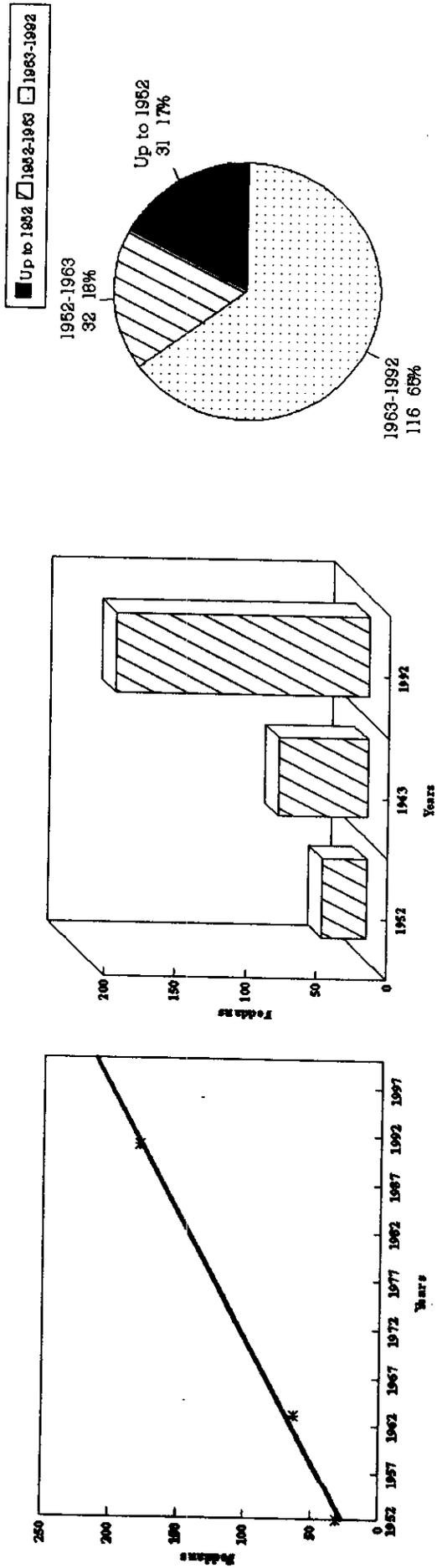


Fig (9): Area by feddans and percentage according to different years for Al-Aziza district.

Distribution of the total area of urban land in Al-Manzala (794 fed.) due to expansions during period of:

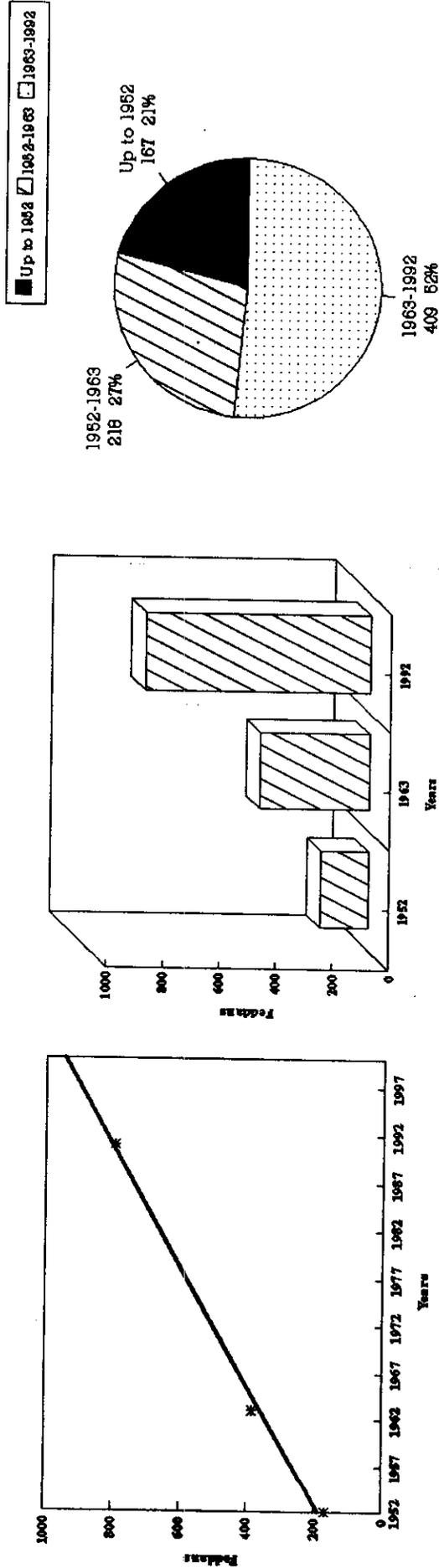


Fig (9): Area by feddans and percentage according to different years for Al-Manzala district.

Distribution of the total area of urban land in Al-Bosrat (184 fed.) due to expansions during period of:

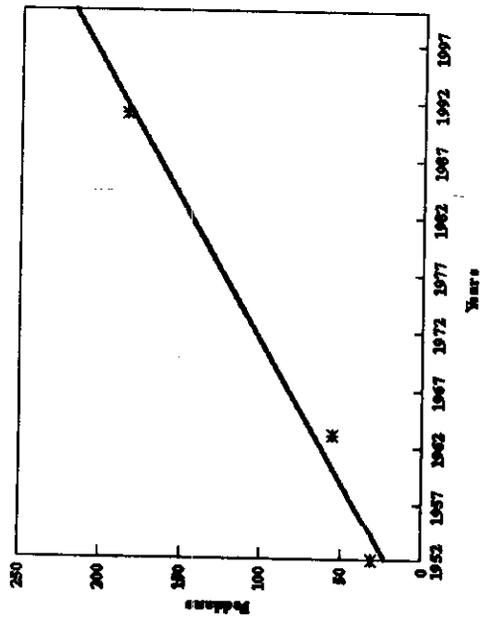
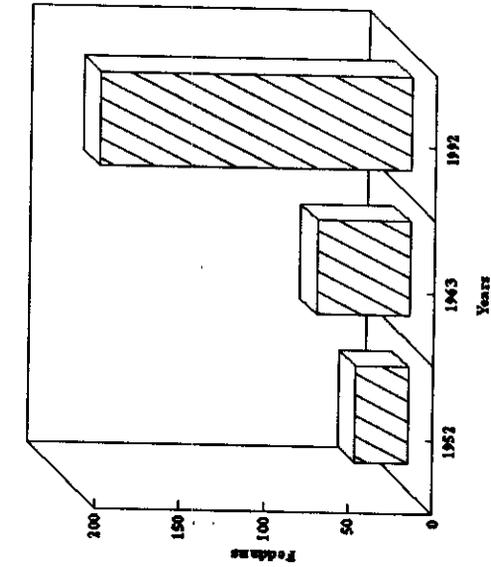
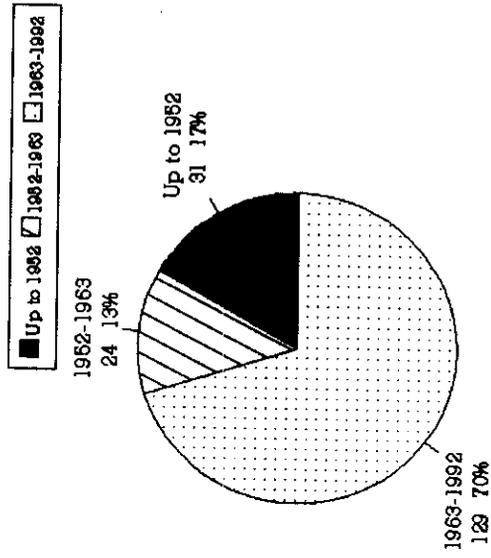


Fig (9): Area by feddans and percentage according to different years for Al-Bosrat district.

Distribution of the total area of urban land in Al-Gamalia (662 fed.) due to expansions during period of:

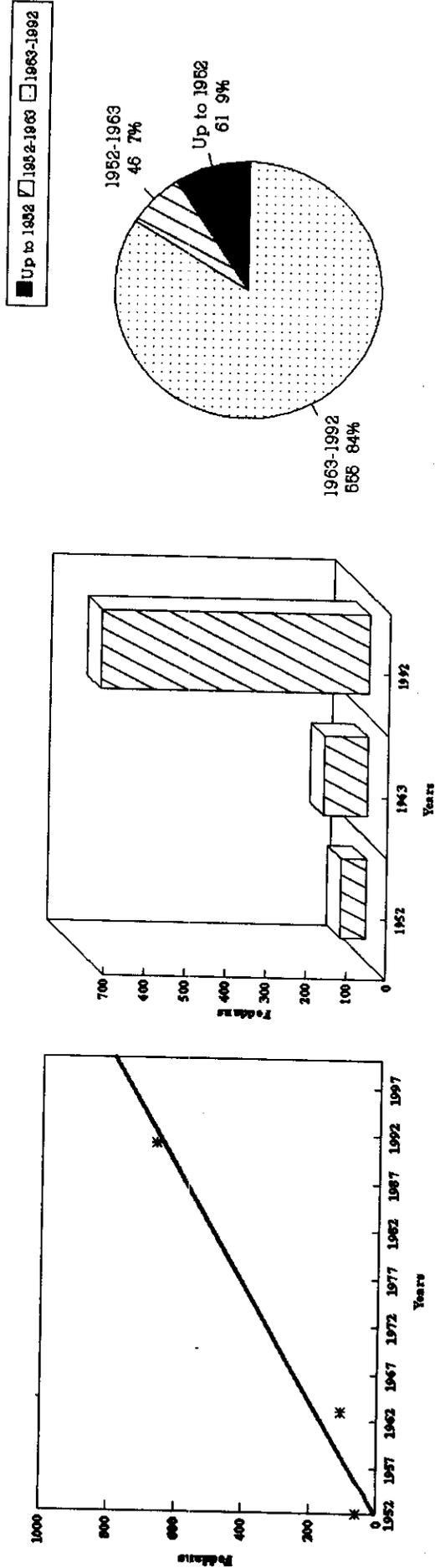


Fig (9): Area by feddans and percentage according to different years for Al-Gamalia district.

Distribution of the total area of urban land in Meet Maraga Salsel (72 fed.) due to expansions during period of:

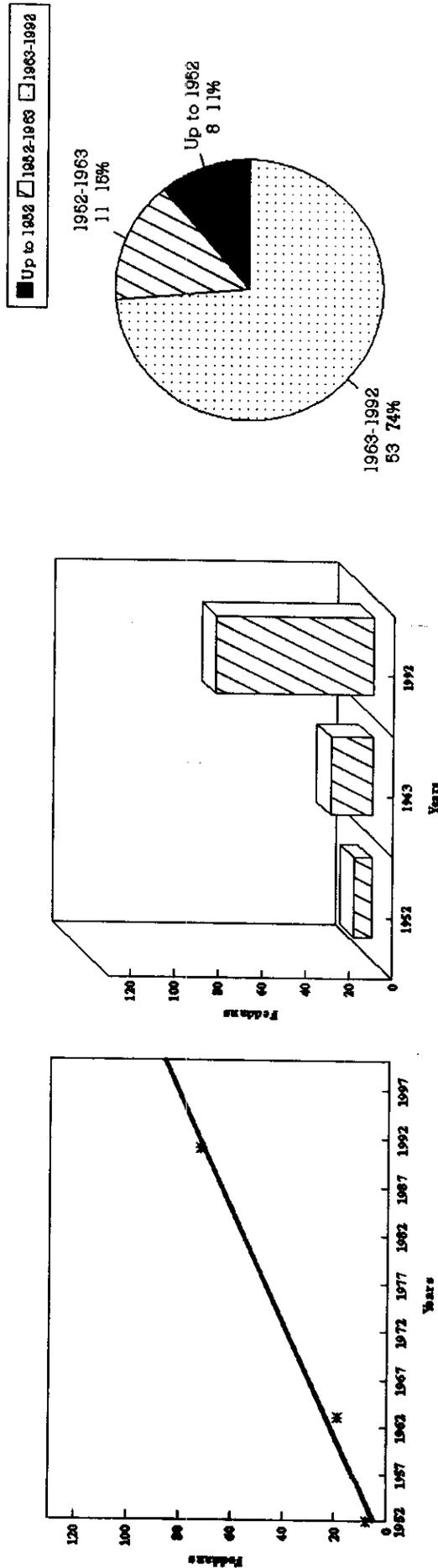


Fig (9): Area by feddans and percentage according to different years for Meet Maraga Salsel district.

Distribution of the total area of urban land in Meet Salsel (238 fed.) due to expansions during period of:

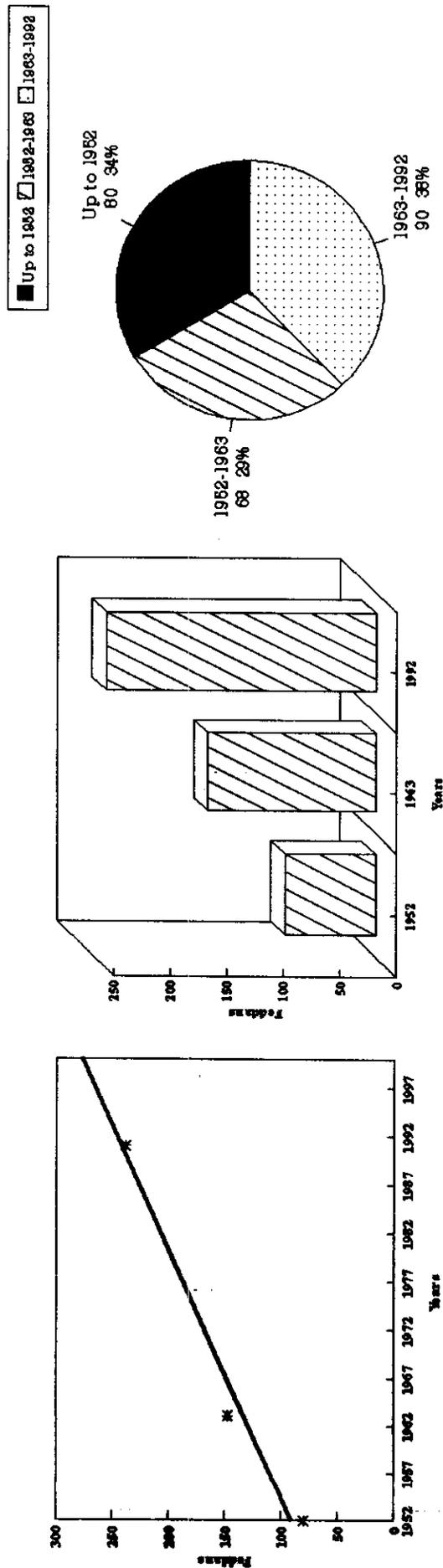


Fig (9): Area by feddans and percentage according to different years for Meet Salsel district.

Distribution of the total area of urban land in Al-Gawaber (47 fed.) due to expansions during period of:

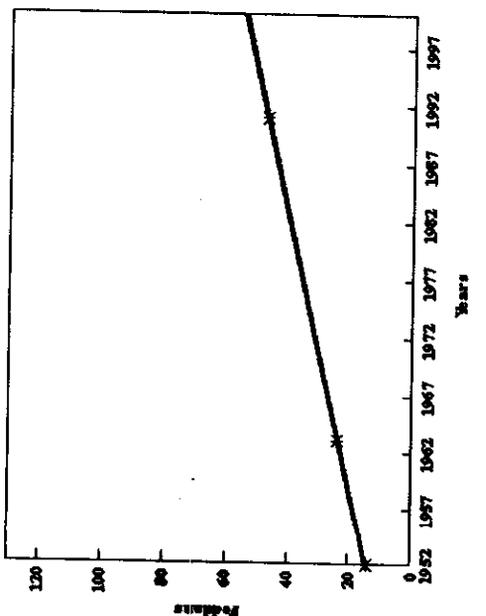
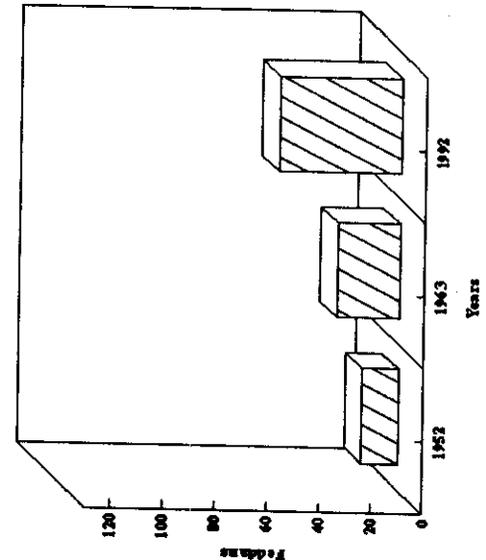
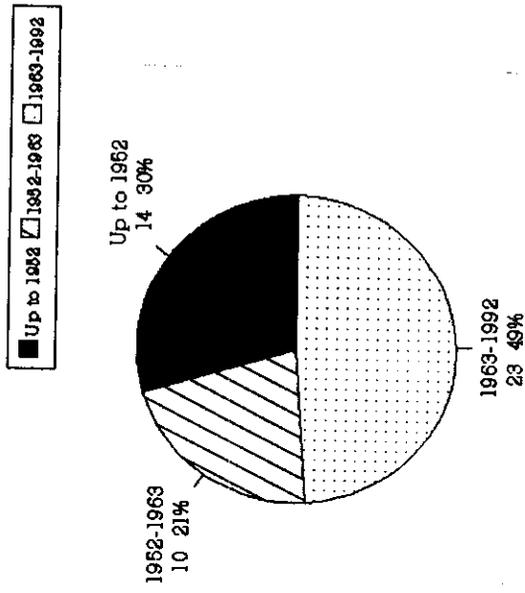


Fig (9): Area by feddans and percentage according to different years for Al-Gawaber district.

Distribution of the total area of urban land in Faraskor (518 fed.) due to expansions during period of:

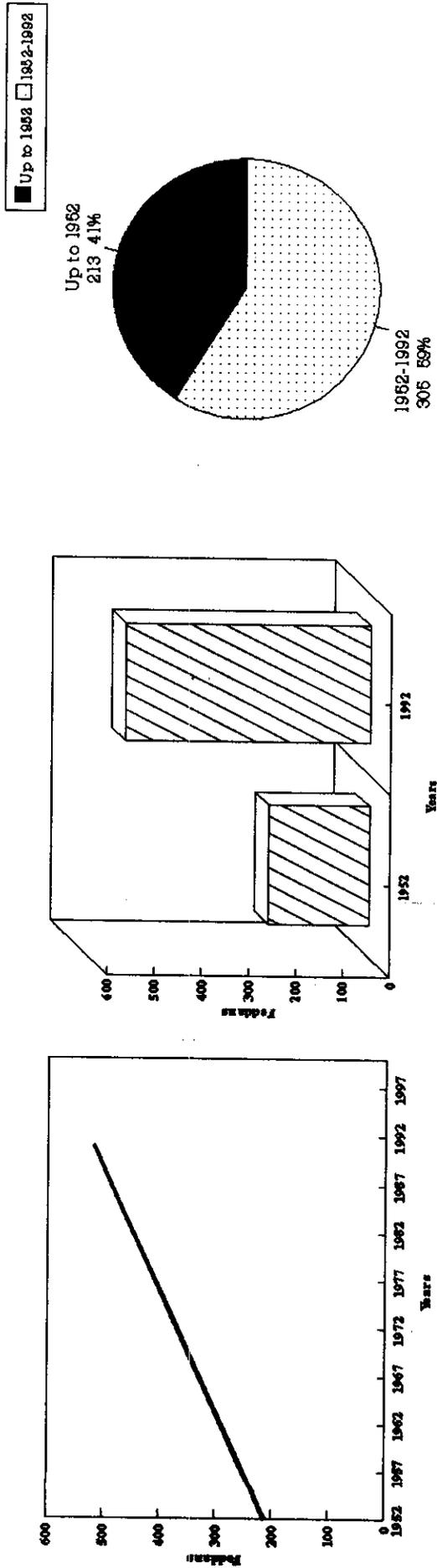


Fig (9): Area by feddans and percentage according to different years for Faraskor district.

Distribution of the total area of urban land in Damietta (2642 fed.) due to expansions during period of:

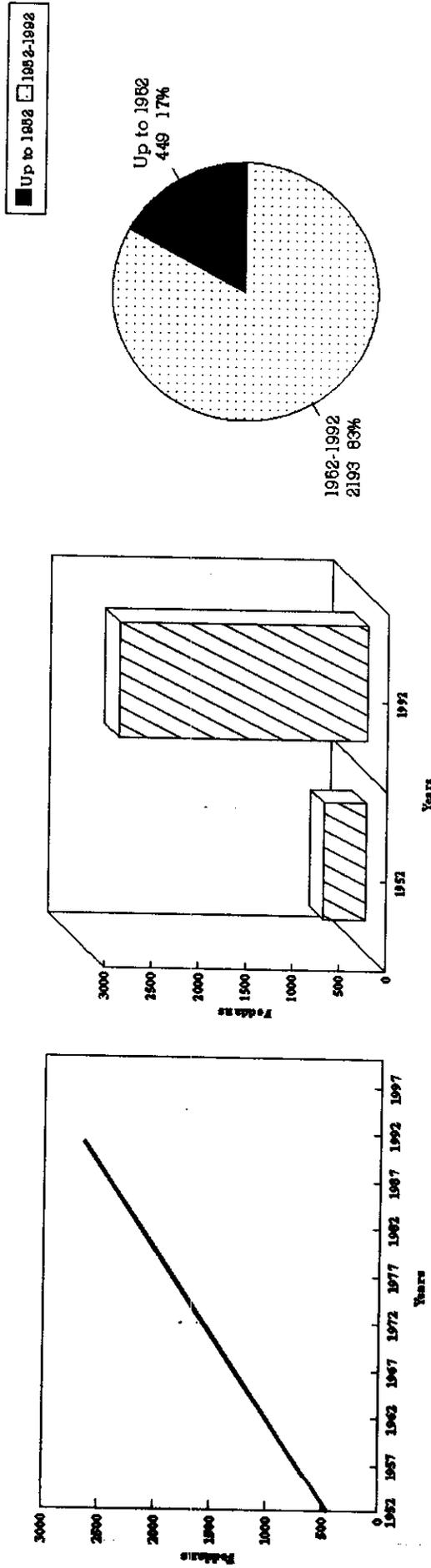


Fig (9): Area by feddans and percentage according to different years for Damietta district.

Distribution of the total area of urban land in  
Rass El-Bar (1228 fed.) due to expansions  
during period of:

■ Up to 1982 □ 1982-1992

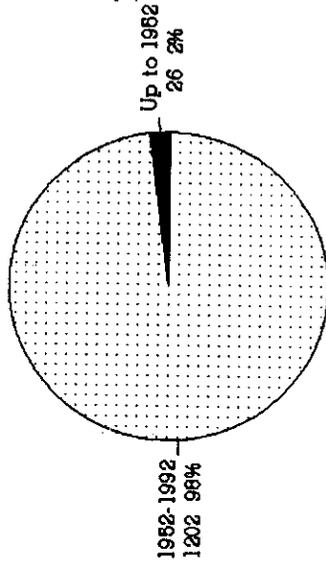
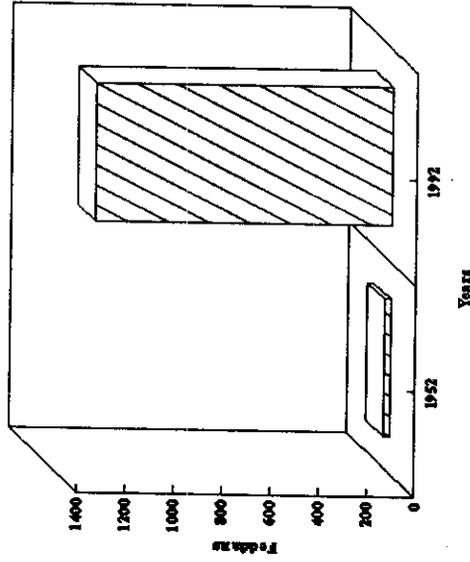
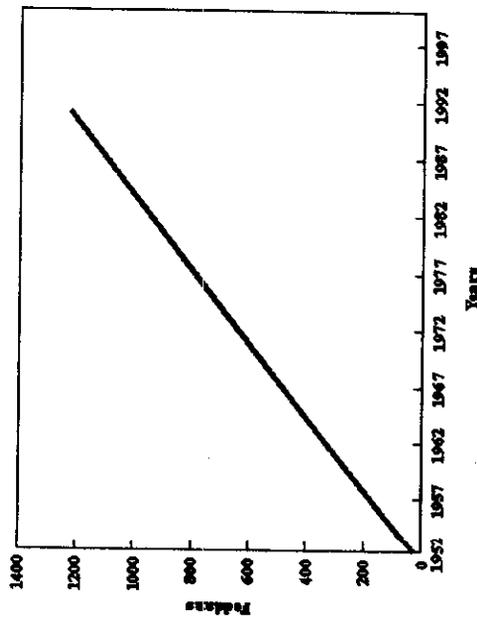


Fig (9): Area by feddans and percentage according to different years for Rass El-Bar district.

Distribution of the total area of urban land in Al-Hosinia (418 fed.) due to expansions during period of:

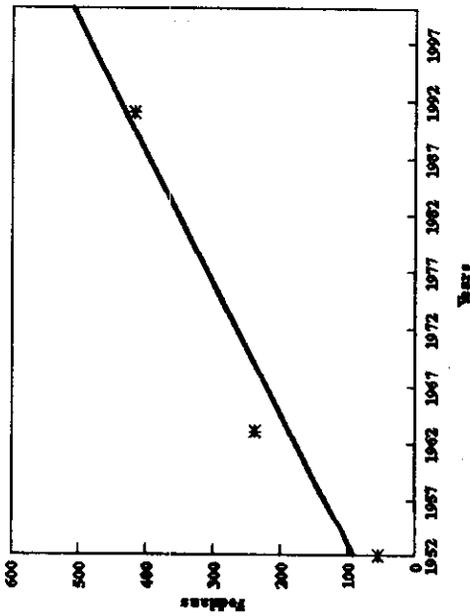
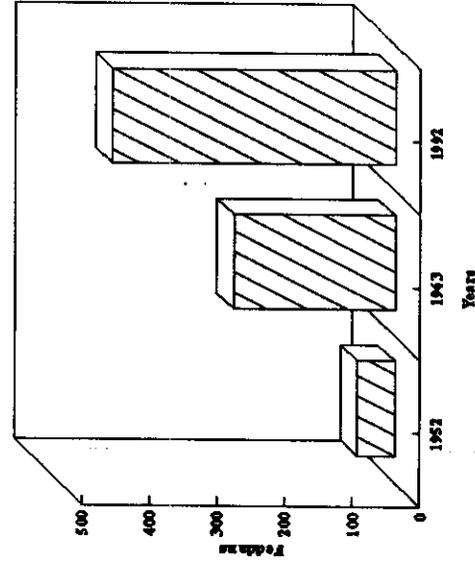
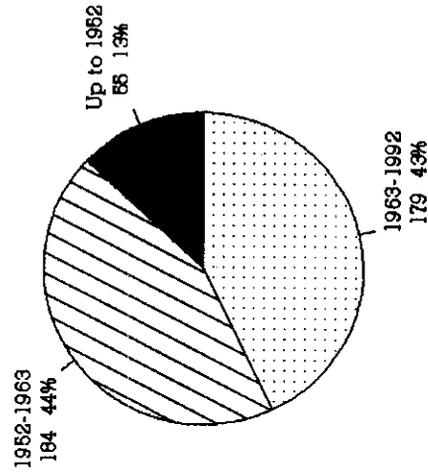
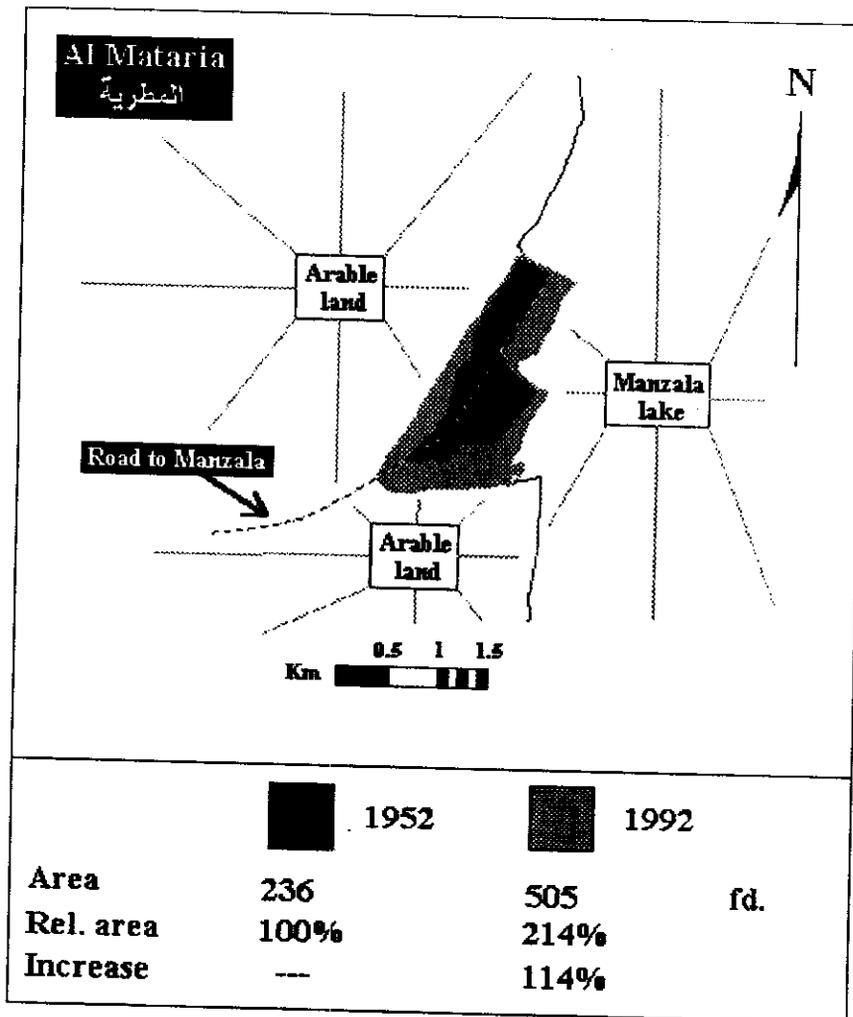
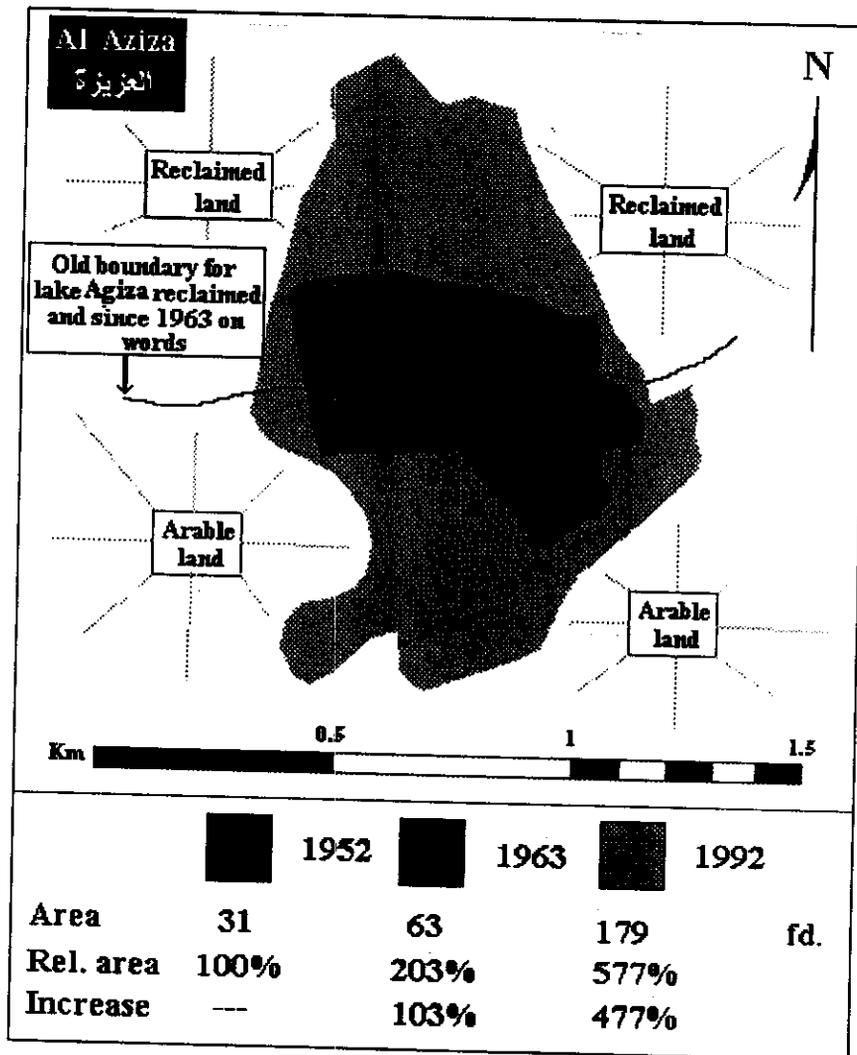


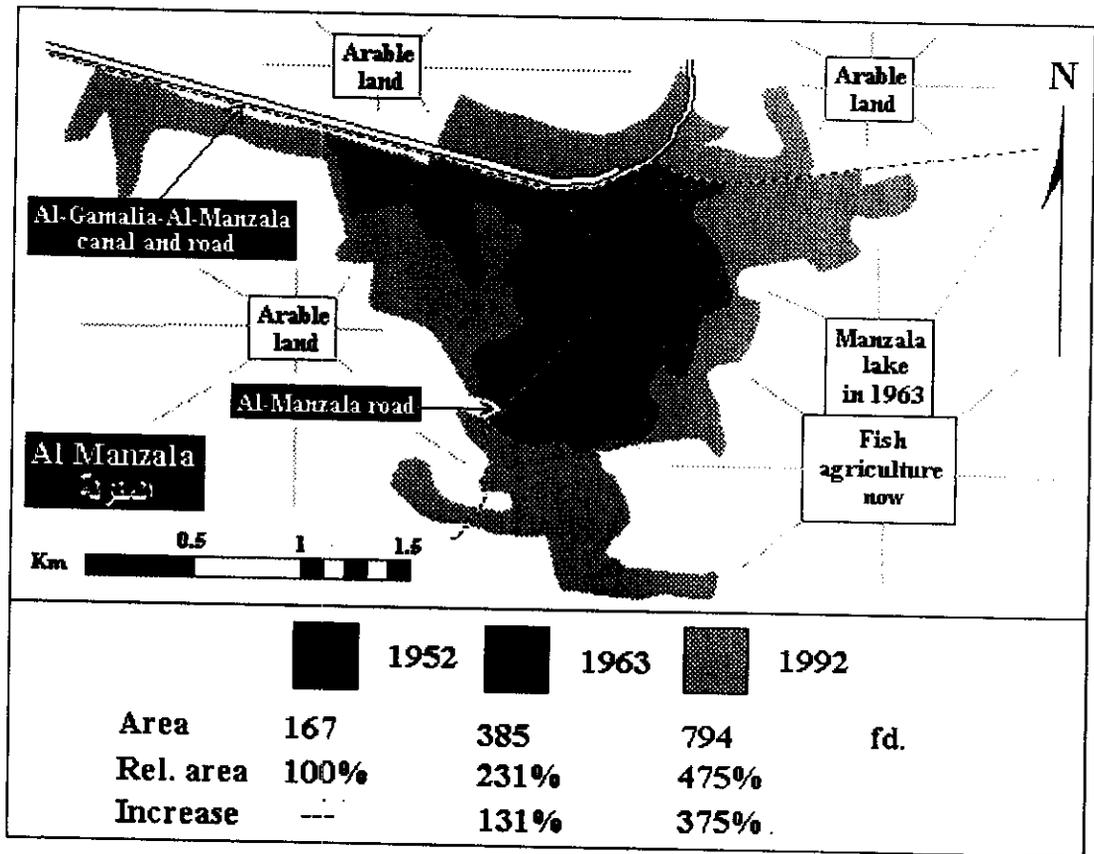
Fig (9): Area by feddans and percentage according to different years for Al-Hosinia district.



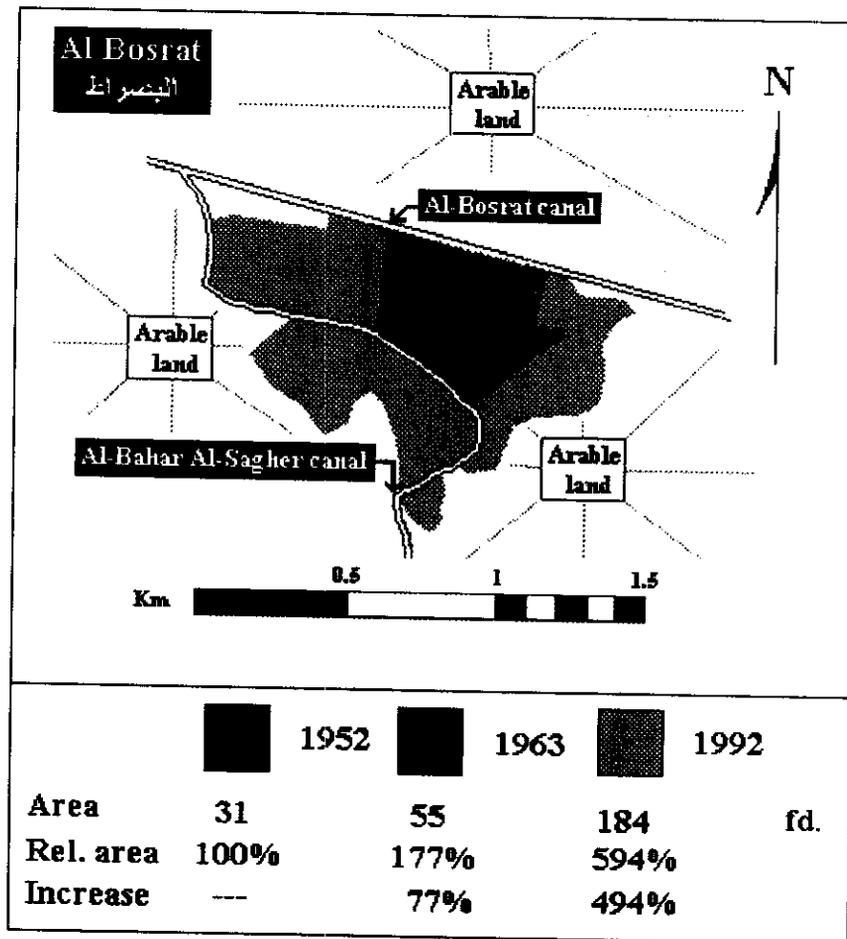
Map ( 14 ): Expansion of urban area during the period 1952 to 1992.



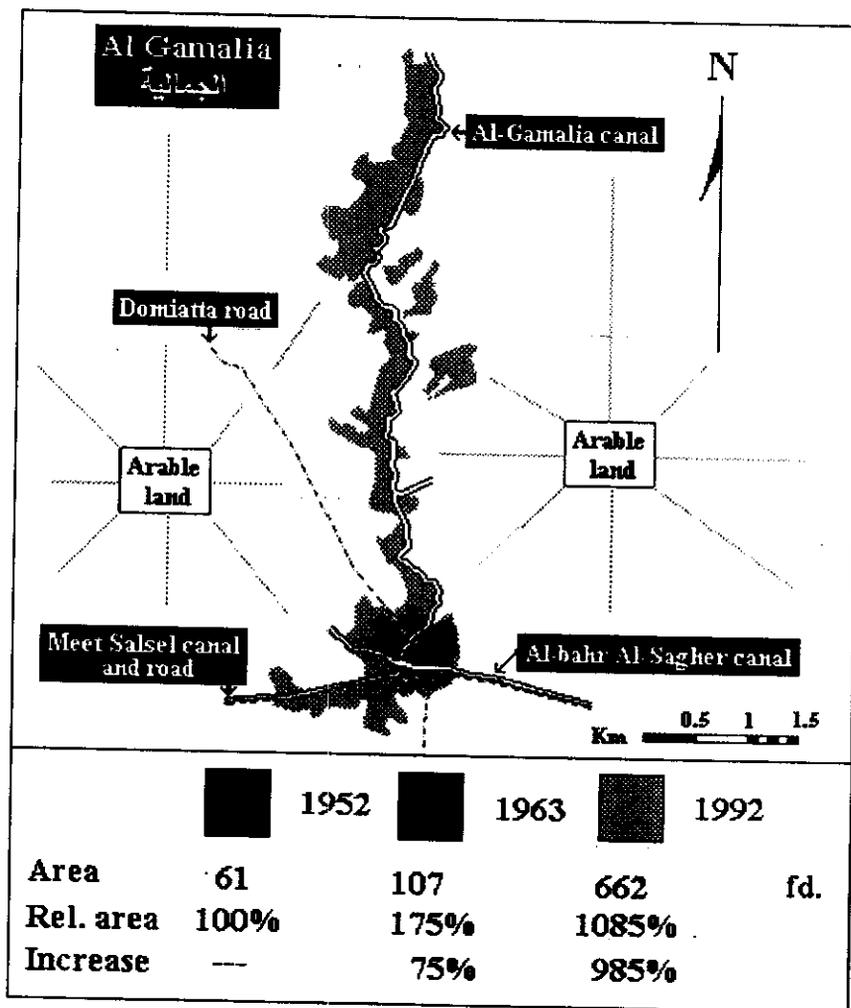
Map ( 15 ): Expansion of urban area during the period 1952 to 1992.



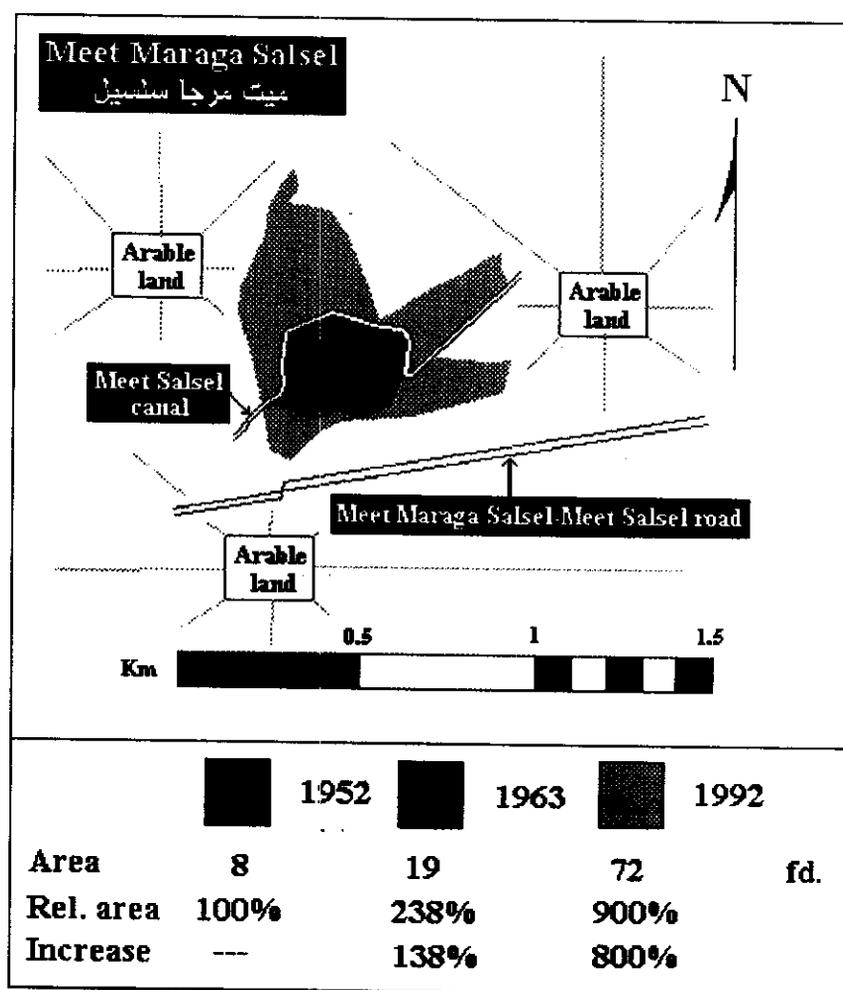
Map ( 16 ): Expansion of urban area during the period 1952 to 1992.



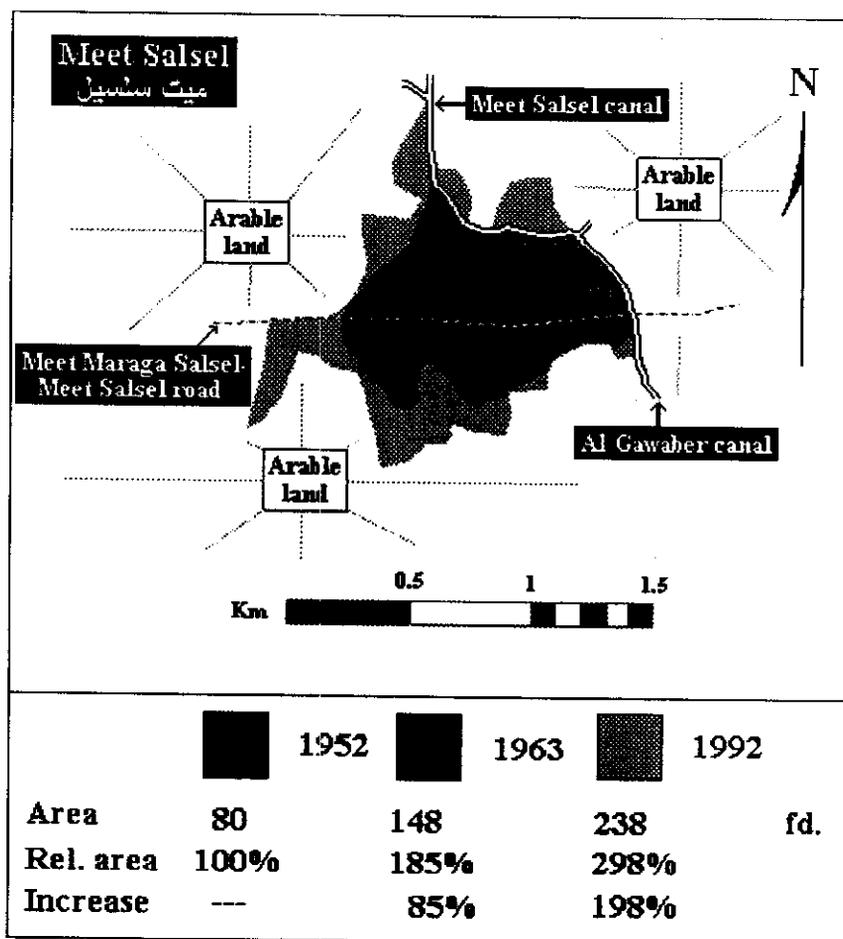
Map ( 17 ): Expansion of urban area during the period 1952 to 1992.



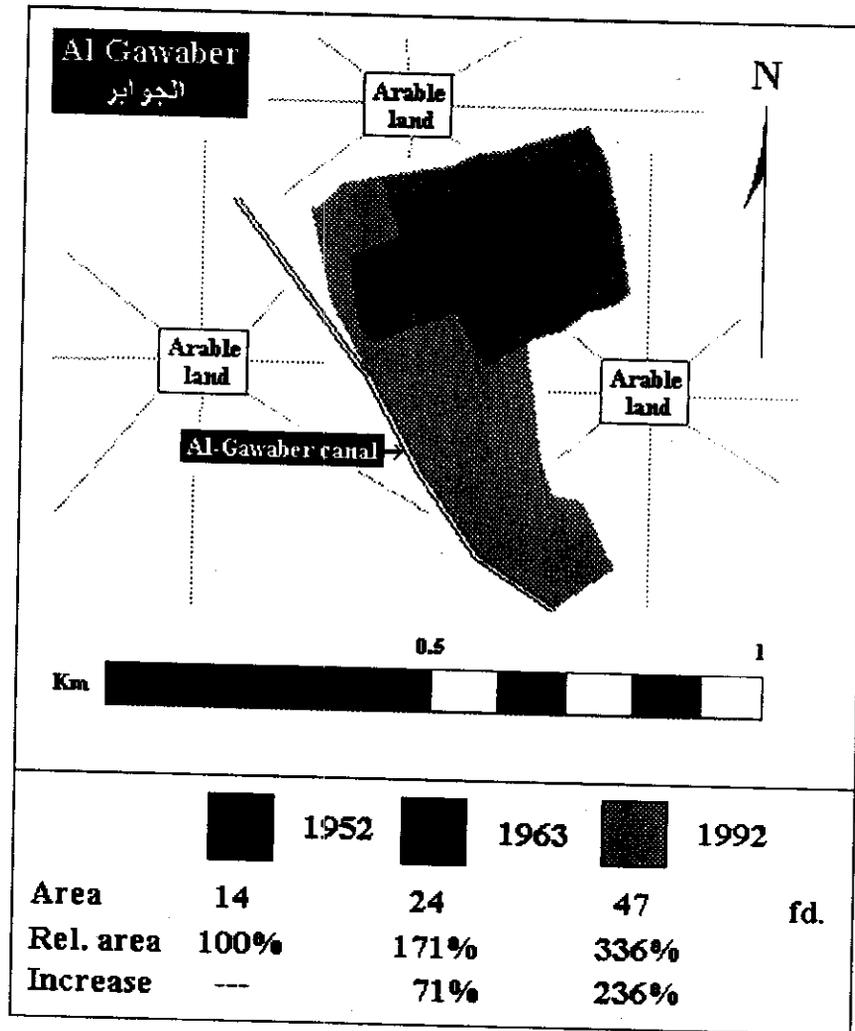
Map ( 18 ): Expansion of urban area during the period 1952 to 1992.



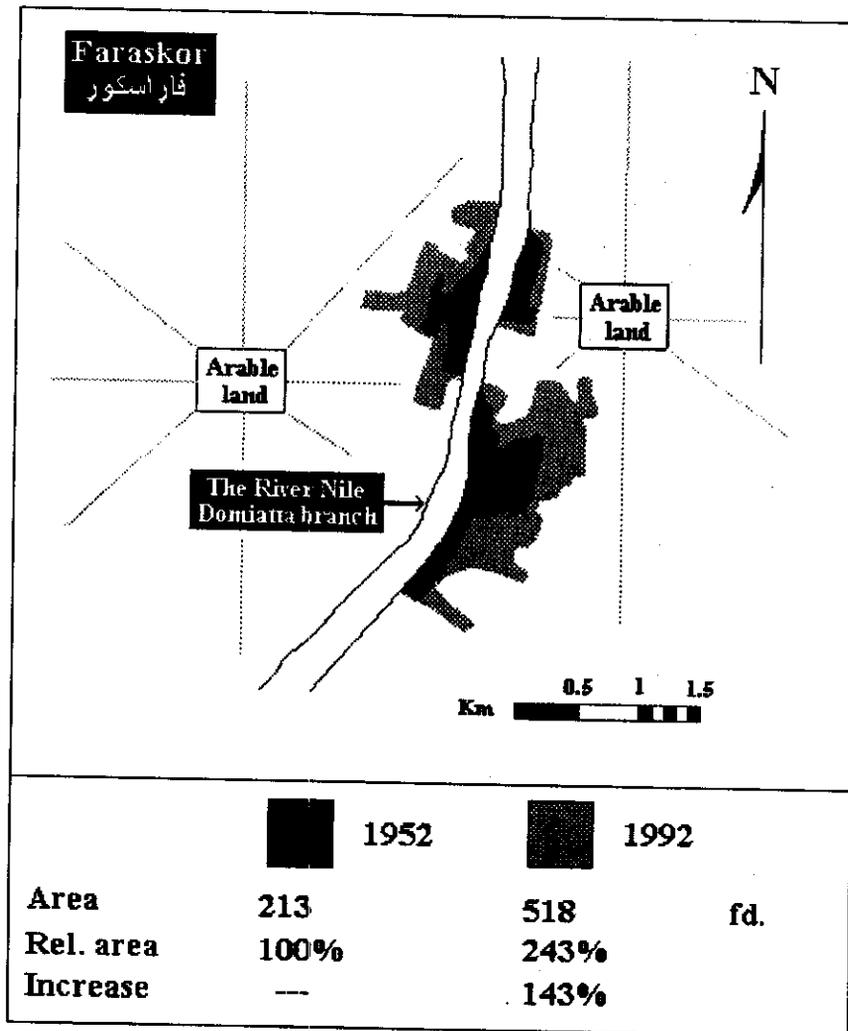
Map ( 19 ): Expansion of urban area during the period 1952 to 1992.



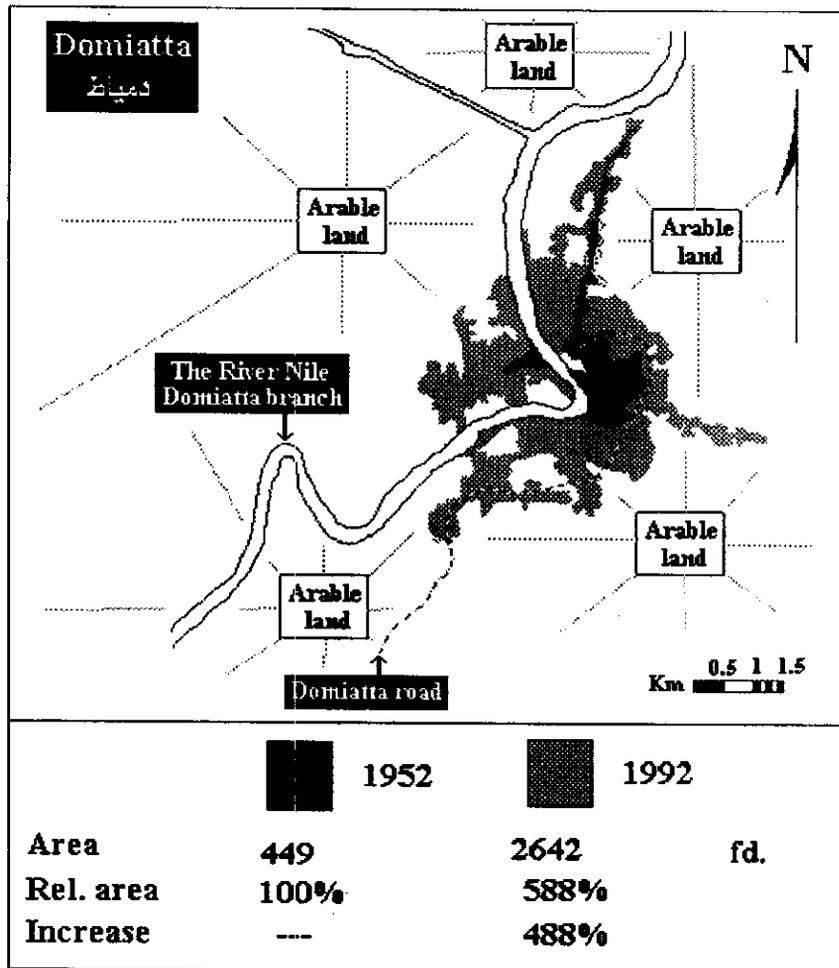
Map ( 20 ): Expansion of urban area during the period 1952 to 1992.



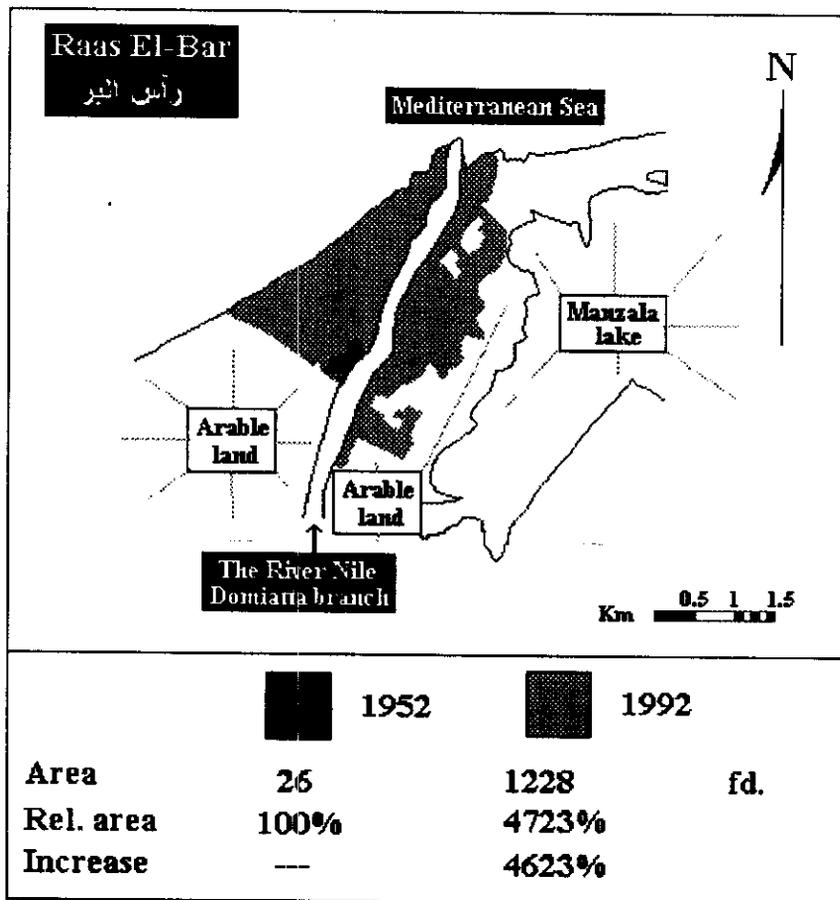
Map ( 21 ): Expansion of urban area during the period 1952 to 1992.



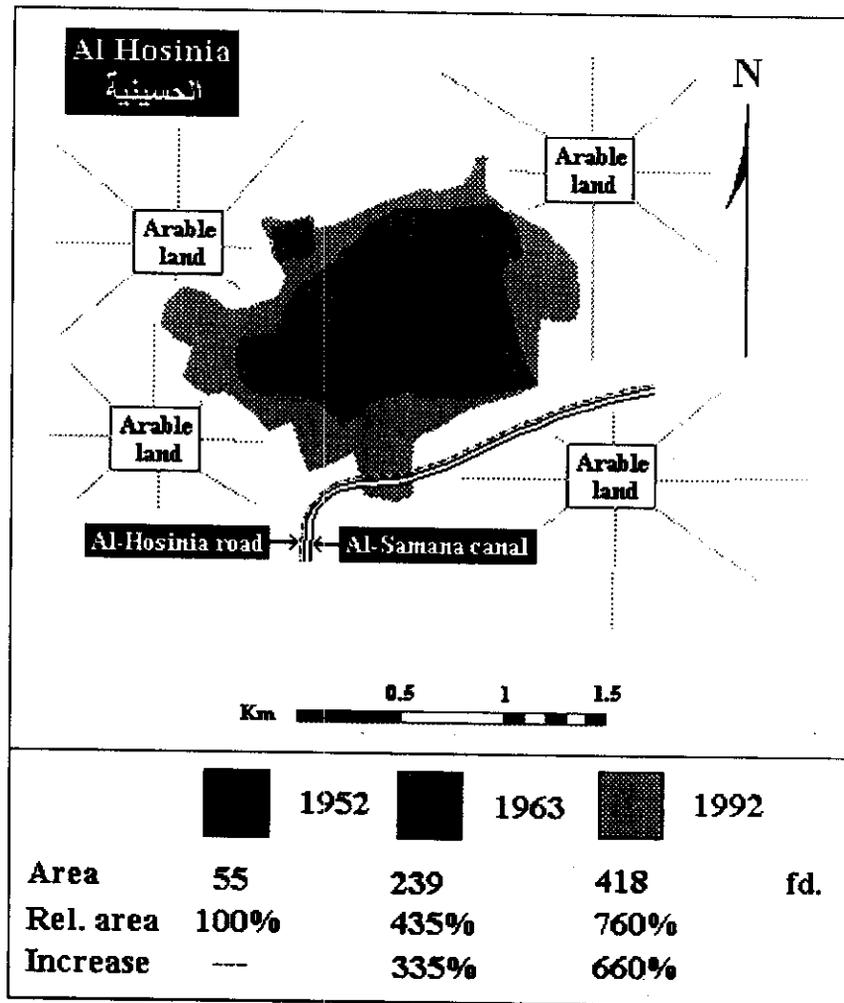
Map ( 22 ): Expansion of urban area during the period 1952 to 1992.



Map ( 23 ): Expansion of urban area during the period 1952 to 1992.



Map ( 24 ): Expansion of urban area during the period 1952 to 1992.



Map ( 25 ): Expansion of urban area during the period 1952 to 1992.

rather moderate expansion to the west and the south where land was available. The general shape of expansion followed the direction of the road (south west - north east). The road is crossing the center of the town. The increases in the area during 1952-1992 was 114%.

#### **4.2.3.2 Al-Aziza:**

- \* In 1963, expansion was around the old town shown by the 1952 area, the direction was mainly east-west. There were limited expansions otherwise. The expansion stopped to the north where there was a lake named Al-Agiza lagoon, part of this lagoon was later reclaimed and turned into a land, upon which urban expansion took place.
- \* In 1992, the expansion was mainly south-north in direction, increasing toward the north and the south. The shape of the area was rather oval-shape.
- \* The 1952-1992 expansion was on the expense of lands which were mainly of a 3<sup>rd</sup> class productivity according to the 1963 report of the Soil Survey Department, Soil and Water Research Institute (SWRI). The expansion of the north direction was on the old lagoon area (reclaimed after 1963). The increases in the area during 1952-1992 was 477%.

#### **4.2.3.3 Al-Manzala:**

- \* In 1963, expansion was around the old town a continuation of the 1952 area, its direction to the north stopped adjacent to the Al-Gamalia-Al-Manzala irrigation canal. Its direction towards the west extended along the Al-Manzala-Al-Gamalia road, more expansion occurred parallel to the canal.

- \* In 1992, expansion occurred in all directions crossing the Al-Gamalia-Al-Manzala canal.
- \* Part of the expansion through the 40 years (1952-1992) was in a newly reclaimed area (east of the town), which was part of the Manzala lake. The other part of expansion occurred in arable land of 3<sup>rd</sup> to 4<sup>th</sup> class of productivity. Such productivity classification is according to the 1963 report by Soil and Water Research Institute (SWRI, 1963). The increases in the area during 1952-1992 was 375%.

#### **4.2.3.4 Al-Bosrat:**

- \* In 1963, expansion was around the old town shown by the 1952 area. It was in all directions, except the north direction, where there was Al-Bosrat canal. The southward expansion was stopped by the fresh-water canal "Al-Bahar Al-Sagher canal", beyond which no expansion occurred.
- \* In 1992, expansion took the same trend as that of the 1963, but in 1992 expansion went beyond Al-Bahar Al-Sagher canal southwards.
- \* The 1952-1992 expansion at the expense of arable lands which were mainly of a 2<sup>nd</sup> class productivity, according to the 1963 report of the Soil Survey Department, Soil and Water Research Institute (SWRI, 1963). The general shape of the urban area after the latest expansion was rectangular, whose base was along the Al-Bosrat canal. The increases in the area during 1952-1992 was 494%.

#### **4.2.3.5 Al-Gamalia:**

- \* In 1963, expansion was around the old town shown by the 1952 area. The main expansion was in a north west direction along the Damietta road and the Al-Bahr Al-Sagheer canal. Limited expansion occurred southwards and eastward.
- \* In 1992, the great majority expansion was in a north direction along Al-Gamalia canal (mainly to its west side), with small scattered areas east of it. The expansion took a shape of a very narrow strip (from 50 to 500 m width), covering a rather long distance (about 7 km), along the canal. There were another expansions south west along the Meet Salsel canal and road.
- \* The 1952-1992 expansion was on arable lands. The northward expansion and part of the westward one was on a 3rd class productivity, the remaining small part of expansion was on a 2nd class productivity, according to (SWRI, 1963). The general shape of the urban area in 1992 was a very narrow long strip. The increases in the area during 1952-1992 was 985%.

#### **4.2.3.6 Meet Maraga Salsel:**

- \* In 1963, expansion was around the old town shown by the 1952 area. The expansion stopped to the north by Meet Salsel canal, but in south stopped near from the Meet-Maraga-Salsel-Meet-salsel road.
- \* In 1992, expansion was radial in shape and goes in many directions, the 1st eastward stopped south near from the Meet-Maraga-Salsel-Meet-Salsel road, the 2nd north-eastward stopped south by Meet Salsel canal, the 3rd (small part) southward stopped near the same road and the 4th was the valuable one

northwards and no clear boundaries stopped it.

- \* The 1952-1992 expansion was at the expense of lands which were mainly of a 2nd and 3rd class productivity according to the 1963 report of the Soil Survey Department, Soil and Water Research Institute (SWRI, 1963). The increases in the area during 1952-1992 was 800%.

#### **4.2.3.7 Meet Salsel:**

- \* In 1963, expansion was around the old town shown by the 1952 area. The eastward and southward expansions were stopped by Meet Salsel canal from north and Al-Gawaber canal from east.
- \* In 1992, expansion took the same trend in 1963, but in 1992 was crossed the Meet Salsel canal northwards. No expansion was happened in eastward. The westwards expansion was along the Meet-Maraga-Salsel-Meet-Salsel road in south part. The road crossed the town at the middle.
- \* The 1952-1992 expansion was at the expense of lands which were mainly of a 2nd class productivity according to the 1963 report of the Soil Survey Department, Soil and Water Research Institute (SWRI, 1963). The increases in the area during 1952-1992 was 198%.

#### **4.2.3.8 Al-Gawaber:**

- \* In 1963, expansion was around the old town shown by the 1952 area. The eastward expansion was a small part than other expansion.
- \* In 1992, expansion was to southwards stopped by Al-Gawaber canal, also, the expansion didn't across the west side of Al-Gawaber canal because the

west side fall in Meet Salsel border.

- \* The 1952-1992 expansion was at the expense of lands which were mainly of a 2nd class productivity according to the 1963 report of the Soil Survey Department, Soil and Water Research Institute (SWRI, 1963). The increases in the area during 1952-1992 was 236%.

#### **4.2.3.9 Faraskor:**

- \* The old town shown by the 1952 area, was separated to three parts, (two eastward the Damietta branch and expansion also eastward and didn't cross the other side of river and; one westwards the Damietta branch and expansion also westwards and didn't cross the other side of river). The increases in the area during 1952-1992 was 143%.

#### **4.2.3.10 Damietta:**

- \* In 1992, expansion around the old town shown by the 1952 area. The expansion eastward and southwards was along the Damietta road and river Nile of main Damietta branch. The increases in the area during 1952-1992 was 488%.

#### **4.2.3.11 Rass El-Bar:**

- \* In 1992, expansion crossed Damietta branch eastwards and stopped to the north by the Mediterranean sea and to south no clear boundary noted. The increases in the area during 1952-1992 was 4623%.

**4.2.3.12 Al-Hosinia:**

- \* In 1963, expansion was around the old town shown by the 1952 area. The expansion was no clear boundary stopped it.
- \* In 1992, expansion took the same trend in 1963, but part of the new town crossed the Al-Samana canal and Al-Hosinia road.
- \* The 1952-1992 expansion was at the expense of lands which were mainly of a 3<sup>nd</sup> class productivity according to the 1963 report of the Soil Survey Department, Soil and Water Research Institute (SWRI, 1963). The increases in the area during 1952-1992 was 660%.