INTRODUCTION

Land evaluation expresses the value of a piece of land for a certain use. In this process two important factors or groups of factors play a role, namely:

a): The demands put to the land with respect to the purpose for which it is to be evaluated, and

b): The quality of the land to meet these demands. As the land use purpose and the quality of the land as well as their interrelationships are well known, the more accurate the evaluation can be.

The evaluation of land for agricultural purposes should not be limited to the kind of crops grown, their requirements and the qualities of the land to meet these requirements, but it must include the necessary managmenent practices applied during production. The degree in which the land conditions meet these requirements are of equal important. Management can be different depending on many factors, environmental, socio-economical or technical. The latter for instance in relation to the dangers for land deterieration, e.g. erosion, salinization. Sometimes also the improvements of land productivity, by adapted management practices, play a role.

The results of an evaluation for a certain land use are expressed in terms of groups or classes of capability, suitability etc., hence the word land classification is used in the different systems of land evaluation. An arrangement in classes and subclasses is most useful for practical application purposes.

The aim of the current study is to evaluate the soils of some areas in north Delta of Egypt. We hope that this study will add new information concerning agricultural sustainability of such areas.

This land evaluation was carried out according to modified Storie index (Nelson, 1963), the USDA system (1973), FAO (1976), and Sys and Verheye's system (1978).

2. REVIEW OF LITERATURE

2.1 Location of the studied area:

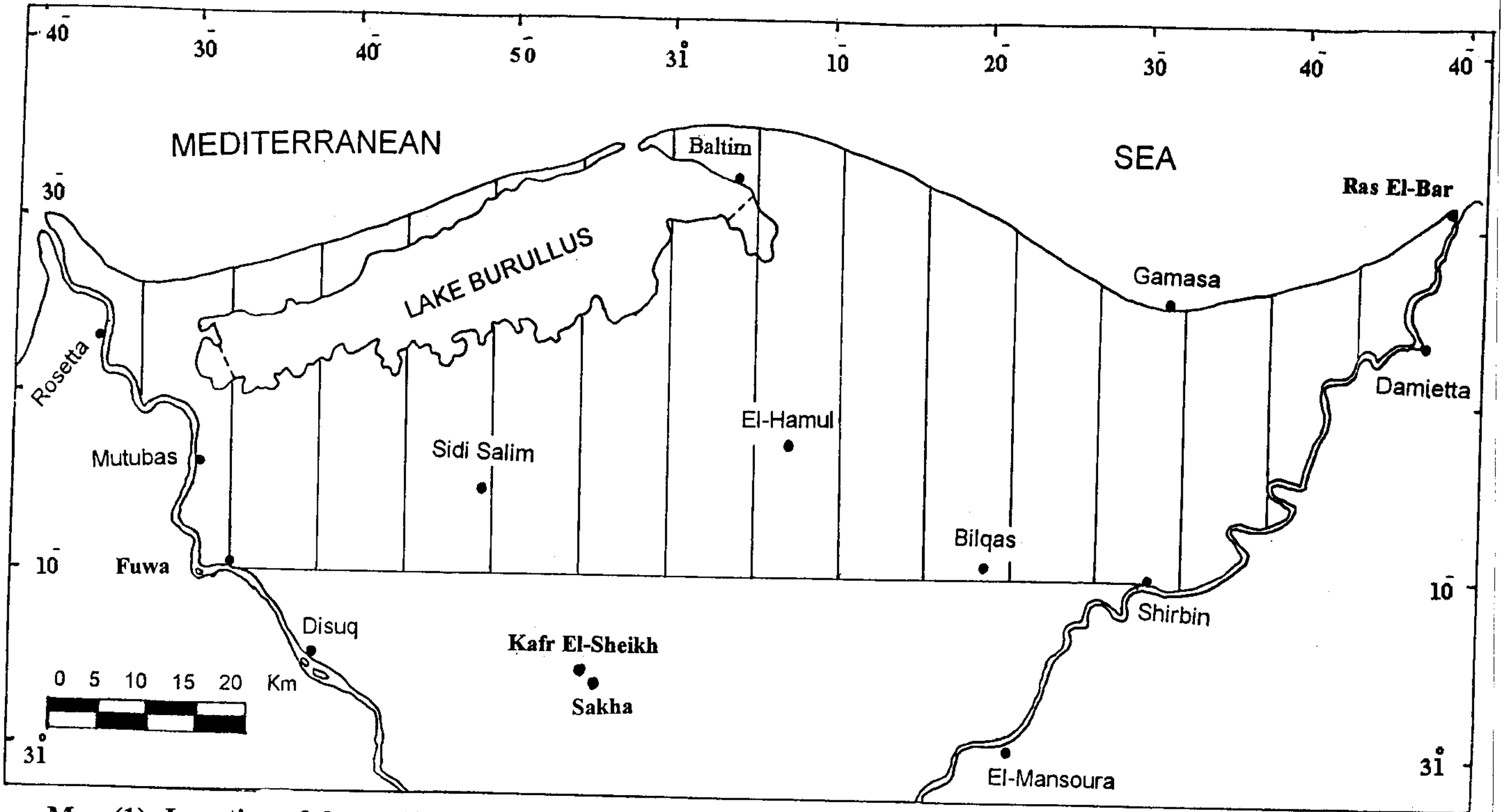
The studied area is located in the northern part of the Nile Delta region and stretching between longitudes 30° 20' and 31° 50' east and latitudes 31° 10' and 31° 36' north. It extends from Damietta branch in the east to Rosetta branch in the west and from the coast of the Mediterranean sea in the north to the cities of Shirbin, Bilqas and Fuwa in the south (Map, 1).

2.2 Climate of the studied area:

The climate of the northern Nile Delta is characterized by a typical Mediterranean fairly cool rainy winter and warm dry summer with small diurnal temperature variations. Climatological data recorded from four main stations located in the towns of Damietta, Baltim, Rosetta and Sakha during the ten years extending from 1978 to 1987 are shown in Table (1). Discussion of some meterological elements (as mean values for 10 years from 1978-1987) for the studied area are given in the following:

2.2.1 Rainfall:

Amounts of rainfall recorded by the four meterological stations near Damietta, Baltim, Rosetta and Sakha averaged 102.3, 154.8, 176.4 and 66.1 mm/year. These data show that the amounts of rainfall vary from location to another. The rainy season usually begins in the second half of October and ends in the first half of March. January is the wettest month where the maximum



Map (1): Location of the studied area.

Table (1) : Some climatological data of Damietta, Baltim, Rosetta and Sakha meteorological stations (1978-1987).

Location	Month	Temperature °C Mean of monthly Maximum temp.	Mean of monthly Minimum temp.	Mean daily temp.	Relative humidity %	Evaporation (mm/day)	Rainfall (mm/ month)
Damietta	January	17.8	9.5	12.7	74.8	2.3	23.0
	February	18.3	9.5	13.8	74.2	2.6	17.9
	March	19.6	11.2	14.9	74.8	3.1	10.3
	April	22.8	13.5	17.9	71.9	3.9	2.6
	May	25.7	16.4	20.8	70.5	4.2	1.9
	June	29.0	20.0	24.3	71.0	4.9	0.2
	July	31.1	21.8	25.8	72.9	4.6	0.0
	August	30.5	21.8	25.8	73.8	4.4	0.0
	September	28.6	20.4	24.5	74.1	3.6	0.7
	October	26.6	18.3	22.2	73.5	3.6	4.9
	November	22.8	14.6	18.4	74.2	2.9	16.1
	December	18.5	9.9	14.7	75.9	2.5	24.7
	Mean	24.3	13.2	19.7	73.5	3.6	
	Total annual						92.0
Baltim	January	17.6	10.3	13.7	70.0	3.2	45.3
	February	18.2	10.8	14.3	69.2	4.2	24.6
	March	19.5	12.1	15.5	68.3	4.1	12.2
	April	22.8	14.6	17.8	66.7	4.8	8.5
	May	25.6	17.2	20.9	67.0	5.0	0.1
	June	27.8	16.5	24.3	69.9	5.3	0.0
	July	29.2	17.8	25.7	71.9	5.3	0.0
	August	29.6	18.1	24.5	71.0	5.0	0.0
	September	28.2	16.9	25.0	69.0	4.9	0.0
	October	26.8	15.5	22.9	68.0	4.7	2.7
	November	22.7	12.3	18.9	66.9	4.2	23.0
	December	19.2	11.9	15.4	70.5	3.2	38.4
	Mean	23.9	14.5	19.9	69.0	4.5	
	Total annual						143.5
Rosetta	January	17.5	9.5	13.1	75.4	2.4	48.4
	February	18.7	10.2	14.4	70.7	2.5	31.7
	March	20.2	11.3	15.7	72.8	2.9	13.7
	April	23.7	14.0	19.0	71.4	3.2	7.5
	May	26.3	16.4	22.4	77.2	3.4	3.1
	June	29.2	20.1	26.9	75.2	3.8	0.0
	July	30.3	22.3	28.8	79.5	3.3	0.0
	August	30.5	22.3	29.1	80.3	3.5	0.0
	September	29.5	20.7	27.2	78.0	3.4	0.1
	October	27.4	18.8	25.3	77.5	3.3	5.9
	November	23.3	15.5	20.5	73.0	2.9	23.8
	December	19.9	11.2	15.0	78.3	2.3	42.8
	Mean	24.7	15.2	21.5	75.8	3.1	
	Total annual						160.4
Sakha	January	19.4	6.1	12.8	83.0	2.2	14.2
	February	20.6	6.3	13.4	83.0	2.7	12.9
	March	23.0	7.9	15.4	79.0	3.5	6.7
	April	27.1	10.4	18.8	71.0	5.0	2.6
	May	31.2	14.2	22.7	66.0	6.5	2.9
	June	33.0	17.0	25.0	69.0	6.7	0.0
	July	34.0	19.0	26.5	75.0	5.7	0.0
	August	33.6	18.4	26.0	77.0	5.0	0.1
	September	32.1	17.7	24.9	77.0	4.8	2.4
	October	29.9	15.6	22.8	78.0	3.8	3.9
	November	25.9	12.6	19.2	83.0	2.8	6.9
	December	21.7	8.3	14.9	86.0	2.1	13.6
	Mean	27.6	10.4	20.2	77.3	4.2	
	Total annual						40.7

rainfall amounts averaged 23.0, 45.3, 48.4 and 14.2 mm in Damietta, Baltim, Rosetta and Sakha, respectively.

2.2.2 Air temperature:

The annual mean values of air temperature are 19.7, 19.9, 21.5 and 20.2°C in Damietta, Baltim, Rosetta and Sakha, respectively. The maximum monthly averages of air temperature are recorded during July, while the minimum ones are recorded during January, Table (1).

2.2.3 Relative humidity:

The amount of water vapour in the atmosphere generally relates to air temperature and is called "the humidity". The relative humidity is the measure for the amount of moisture in the air relative to the amount needed to saturate this air. The annual means of the recorded relative humidity are 73.5%, 69.0%, 75.8% and 77.0% in Damietta, Baltim, Rosetta and Sakha, respectively. The means of the monthly relative humidity vary between 71.0% (in June) and 75.9% (in December) in Damietta area; between 66.7% (in April) and 71.9% (in July) in Baltim area; between 70.7 (in February) and 80.3% (in August) in Rosetta area, and between 66.0% (in May) and 86.0% in (December) in Sakha area (Table, 1).

2.2.4 Evaporation:

Evaporation is affected by air temperature, air humidity and wind speed. Data in Table (1) indicate that the mean values of evaporation of the studied area are 3.6, 4.5, 3.1 and 4.2 mm/day in Damietta, Baltim, Rosetta and Sakha meterological stations, respectively. In the same stations the highest recorded means are 4.9, 5.3, 3.8 and 6.7 mm/day during June and July, while the lowest ones recorded during January and December are 2.4, 3.2, 2.3 and 2.1 mm/day in the four respective areas.

2.2.5 Aridity:

The degree of aridity (Table, 2) was calculated by the application of Emberger's factor (1939) and Lang's factor (1920).

Emberger's factor, $(Q) = 100R / [(M+m)(M-m)]$

where: Q : degree of aridity.

R : mean annual rainfall (mm).

M : mean maximum temperature of the warmest months.

m : mean minimum temperature of the coldest months.

Lang's factor $= R / D$

where: R : mean annual rainfall (mm).

D : average annual temperature (°C).

Table (2): The calculated aridity degrees.

Station	R (mm)	M°C	m°C	D°C	Emberger's factor	Lang's factor
Damietta	102.3	31.1	9.5	19.7	11.7 %	5.2
Baltim	154.8	29.6	10.3	19.6	20.1 %	7.9
Rosetta	176.4	30.5	9.5	21.5	21.0 %	8.2
Sakha	66.1	34.0	6.1	20.2	5.9 %	3.3

According to Emberger's factor, the values of Q at Rosetta and Baltim areas are considered of arid climate but Damietta and Sakha areas are located under desert conditions. Values of Lang's factor indicate that the four studied areas are lying mainly within the belt of arid climate.

2.3 Topography of the studied area:

The northern half of the Delta region has an elevation of less than 5 m.a.s.l., while the elevation of the southern one is ranged from 5 to 17 m.a.s.l. The land surface of the central northern part of the Delta slopes directly towards the north. On both sides of the Delta central part, i.e., east and west, the land surface slopes towards the northern east and the northern west, respectively.

The topography of the studied area affects the hydrological system, depth of water table and soil salinity and alkalinity. On the eastern side of the studied area, the elevation of Damietta branch is approximately 2m higher than that of the western side, i.e, Rosetta branch (Abu El-Izz, 1971), subsequently the majority of irrigation channels take their water from Damietta branch and follow the high topographic stretches, while the drainage channels follow the low topographic stretches.

The topography of land plays an important role in fixing the depth of water table, thus soils in the higher elevations have deeper ground water table than soils located in the depressions (Jenny, 1941). Also, the soils located on slopes tend to be less affected by salinization process than soils in depressions.

Abbas *et al.* (1967) reported that, with the approach to Burullus lake in the north of Nile Delta, the elevation of soil decreases, soil texture becomes heavier and the depth of the ground water table becomes nearer to the surface. In his study on soil relief, texture, and ground water. El-Naggar (1980), found in the coarse textured soils of the elevated areas adjacent to the river that, the ground water was very deep and soils were generally normal (non saline non alkali), while, in the fine textured soils of the lower areas far from the river, the ground water was shallow and soils were saline or saline alkali.

2.4 Soil physical properties of the studied area:

2.4.1 Soil texture:

The mechanical composition of the soils in the northern delta region varies from one site to another depending on the physiographic features and the main soil forming process. In general, soils tend to be finer northwards, especially south Burullus and Manzalla lakes due to the gradual decrease in the water current velocity combined with the effect of lagoons which act as barriers due to their higher water densities. Soils of coarse sediments found in the coastal plain are deposited under mixed marine conditions, (Abbas *et al.*, 1967).

El-Nahal *et al.* (1977) reported that the recent Nile alluvium soil covers the majority of Nile Delta area is characterized by light to heavy clay texture with minor variations through the whole profile. The same authors reported that the area located in the north along the sea coast and northern lakes, represents the marine-alluvium sediments and characterized by a heavy clay texture. This is a natural result of sedimentation pattern according to which coarser particles are deposited first resulting the increase of finer particles down the stream. The same pattern occurs laterally in both sides of the river branches where texture is light close to the stream (sandy loam to clay loam) and gets finer with increasing distance from the banks.

Hermas (1991) found in his study on the northern part of the Nile Delta region that the alluvial plain, which represents the majority of the soils in this area, is generally formed of the predominant fine particles deposited in the flood basins and back swamps with clay to silty clay textures. Towards the river banks, scattered medium textured soils (loamy soils) are deposited. In the coastal plain area between Qalabsho and Baltim where the soils are formed mainly under mixed marine conditions, soil texture varies from sandy loam to loamy sand or sandy. In between the fine textured soils and the coastal plain transitional area is represented by Abu Madi. The overlap between the coastal plain and the alluvial plain sediments is the main feature. Soil surfaces area characterized by their fine texture, while subsoils are generally coarse textured.

2.4.2 Soil moisture characteristics:

Concerning the relation between soil moisture characteristics and soil texture, Zane (1959) found that the range of available moisture in soils is negatively correlated with the soil content of the sand fractions meanwhile it was highly and positively of correlated with silt fraction. Sekhon and Arora (1967) reported that the available moisture was significantly correlated with the (silt + clay) and clay contents, whereas it inversely correlated with sand. Talha *et al.* (1978) found that soil moisture characteristic curves of the alluvial soils of Egypt were more affected by soil texture than alkalinity or salinity, and the slope of the curves was greater with increasing sand content. Lavti and Paliwal (1980) found that clay and (clay + silt) contents were correlated significantly with water holding capacity. El-Tony (1982) reported that there was highly significant positive correlation between available water and total porosity, but on the other hand the available water correlated negatively with coarse sand percentage. He also added that the highest direct effect on available water is related to total porosity, followed by clay content. Hagag (1994) in his study on the northern Delta region found that any increase in clay, silt and organic matter contents were accompanied by a significant increases in the soil moisture contents of field capacity and wilting point.

2.4.3 Hydraulic conductivity:

Hydraulic conductivity is obviously affected by soil structure and texture, depending on the size of the conducting pores. In many soils, hydraulic conductivity does not remain constant, due to various chemical, physical and biological processes.

Concerning the relation between hydraulic conductivity and physical soil properties, Tayel (1970) stated that hydraulic conductivity was a function of clay content. Pandey and Pathak (1975) found that hydraulic conductivity could be predicted from the values of clay.

Bhatnager *et al.* (1979); Lavti and Paliwal (1980) and Hagag (1994) found a highly significant and negative correlation between hydraulic conductivity and both clay and silt content, while the correlation was positive with coarse sand.

2.4.4 Soil porosity:

Plyusnin (1960) showed that ideal soil should have pore spaces almost equally divided between large and small sizes in order to have adequate aeration, permeability, and water holding properties.

Concerning the effect of soil texture and porosity, Abd El-All (1984) stated that the values of bulk density, total porosity, pore size distribution, available moisture and soil permeability are closely related to soil texture, through the direct effect of the clay content on the formation and stability of soil aggregates. El-Naggar (1986) in his study on the northern Delta region found that the increase in clay content was accompanied by a significant increase in soil porosity. Hagag (1994) mentioned that increase in clay and silt contents were accompanied by significant increase in soil total porosity. While increase in sand contents caused a significant reduction in soil total porosity.

2.5 Soil chemical properties:

Soil salinity is the main problem in the northern Delta region and becomes more severe with approaching the Mediterranean coast and around the coastal lakes, where soils are extremely saline, El-Nahal *et al.* (1977).

Khadr and El-Gabaly (1955) stated that the ratio of exchangeable Mg^{++}/Ca^{++} varied from 0.28 to 0.80 for soils under the basin irrigation system. In soils which are a part of Maryout lake and under perennial irrigation, the ratio reached a high value of 2.23 in the subsurface layer (35-65 cm.) because these soils have been covered with sea water for a long time.

Ghaith (1961) found that the soils of the bottom of Burullus lake contained 1.74% total soluble salts. The dominant anion was chloride and the dominant cation was sodium. Exchangeable magnesium and sodium were the dominant cations and reached 48.0% and 24.6% of the cation exchange capacity, respectively. However, in the barren soils adjacent to the lake, the total soluble salts content was too high since it was about 19.7% in the surface crust and decreased with depth to reach 6.9% in the 50-100 cm. soil depth. The dominant anion was chloride followed by sulphate, while the dominant cation was sodium followed by calcium and magnesium, and exchangeable magnesium was the dominant followed by calcium and sodium. He also found in the cultivated soils around the lake, that, the total soluble salts content was 0.5% in the top soil and increased with depth up to 28.3%, due to the reclamation process which led to leaching salts downwards. The dominant exchangeable cation was Mg^{++} followed by Ca^{++} and Na^{+}. The author pointed out that these soils may be considered as slightly saline and need more deep drainage and leaching.

Ghally (1976) found that soils derived from marine deposits contained higher percentages of Mg-interlayers than those deposited alluvially. He attributed this finding to the presence of a considerable amounts of dolomite, attapulgite or vermiculite materials rich in magnesium.

El-Naggar (1986) mentioned that the soils surrounding the coastal lakes have higher levels of salinity and sodicity and are generally dominated by exchangeable magnesium. Sodium chloride is the dominant salt in the soil extract and occurance of soluble salts followed the order: $NaCl > MgSO_4 > CaSO_4 > Ca(HCO_3)_2$. He also mentioned that although soluble sodium concentrations in the solution extract are higher than those of magnesium, yet the latter dominates the exchangeable cations due to its substantially greater replacing power.

2.6 Status of some macro nutrients in soils:

2.6.1 Nitrogen:

There are three major forms of nitrogen in mineral soils: **(a)** organic nitrogen associated with the soil humus, **(b)** ammonium nitrogen fixed by certain clay, and **(c)** soluble inorganic ammonium and nitrate compounds. Total amounts of nitrogen in mineral soils range between 0.02 and 0.5% (Brady, 1974).

Concerning the total nitrogen content in the soils of Egypt, El-Hineidy *et al.* (1957), showed that it ranges from 0.095 to 0.13% in the surface layer of the experimental field of Cairo University in Giza. Jenny (1962), stated that the total nitrogen decreases with depth in many soil profiles. He added that the average value of total nitrogen content was 0.14% in the 0-20 cm. layer followed by less amounts in subsurface layers, and become stabilized between 0.035 and 0.040% at 60 cm. depth. Similar trends were obtained by Abdel-Motteleb (1970).

El-Toukhy (1987), found that the total nitrogen in the surface layers of the soils adjacent to Idko lake ranged from 20 to 250 mg/100 g soil. Abdel-Razik (1994), mentioned that the total nitrogen content of El-Salhiya area ranged from 0.027 to 0.27%. She added that the highest content was recorded in the surface layers of the studied profiles and the lowest content was found in deeper ones.

Laura (1974); Hamed (1983) and El-Toukhy (1987), concluded that there was highly significant and positive correlation between total nitrogen and organic matter. Also, there was a clear negative trend between total soluble salts and total nitrogen, while the relation was highly significant and negative with available nitrogen.

El-Hineidy *et al.* (1957) found that the available nitrogen represent 10% of the total nitrogen content of the soil, while its value obtained by Abdel-Motteleb (1970), was about 20%. El-Toukhy (1987), indicated that available nitrogen ranged form 0.5 to 10.6 mg/100g soil in the surface layers of the soils adjacent to Idko lake. Abdel-Razik (1994), found that available nitrogen content ranged from 28.3 to 100.8 ppm, in the soils of El-Salhiya.

2.6.2 Phosphorus:

Soil phosphorus is usually categorized under two classes: organic and inorganic, each of which is further subdivided.

Regarding the total-P content, Tisdale and Nelson (1960), stated that it constitutes 0.11% of the earth's crust. Moreover, Kaila (1963), reported that the average total-P content of the ploughed layer for sandy, fine sandy, loamy and silty soils were 820, 890, 950 and 1050 ppm, respectively.

As for the total-P content of Egyptian soils, Morsy (1967), in a study on some soil samples of El-Minya Governorate, found that the total-P content varies between 0.026 and 0.106%. Ibrahim *et al.* (1984), and Holah *et al.* (1985), reported that the values of total-P in Egyptian soils ranges from 323 ppm in sandy soils to 1355 ppm in the clayey ones. Most of the total-P exists in the inorganic form, constituting about 77.3 to 96.8% of total-P. Organic-P, however, comprises about 1.7 and 23.1%. El-Toukhy (1987), found that total-P content ranged from 260 to 1760 ppm and it was positively correlated with clay, silt and organic matter, while the correlation was negative with sand fraction. Recently, Abdel-Razik (1994), found the total-P values ranged from 180 to 920 ppm in the soils of El-Salhiya area.

Regarding the available-P, Morsy (1967), pointed out that the water soluble P content ranged from 0.10 to 1.09 mg/100 g soil while the $NaHCO_3$ extractable phosphorus varied between 0.61 and 5.24 mg/100 g soil. Abdel-Motteleb (1970), reported that the water soluble phosphorus values varied between 0.62 and 1.61 ppm in the surface layer and decreased progressively to 0.23-0.72 ppm in the deepest layer.

El-Toukhy (1987), found that available phosphorous, which was extracted by $NaHCO_3$ from different Egyptian soils ranged from 2.5 to 44.8 ppm. Results of Abdel-Razik (1994) indicated that $NaHCO_3$ extractable P content ranged from 0.12 to 23.0 ppm in the soils of El-Salhiya.

The solubility and availability of native and applied phosphate under saline-sodic conditions, have been studied under wide experimental conditions. In this respect, Grunes (1959), stated that the salts which hydrolyse to give a change in pH would show more changes in the solubility of slightly soluble phosphate. Nouri *et al.* (1970), observed slight increase in available P associated with increasing salinity. Chumachenko (1970), in laboratory experiments showed that Na_2SO_4 and NaCl, which are the main salts in saline soils, enabled phosphates to be transformed into mobile forms. Hamed (1983) and El-Toukhy (1987), showed an increase in the availability of phosphorus with increasing the total soluble salts of soil saturation extract.

2.6.3 Potassium:

Potassium is present in soils mainly as a structural constituent of K-feldspars and micas, which are the most important reserves of soil K. There is evidence that not only the soluble and exchangeable-K, but also nonexchangeable-K make a significant contribution to the nutrition of plants.

The values of total potassium in the soils of Egypt reported by many investigators ranged between 2 and 47 me./100g. according to soil texture (Lasheen, 1966; Aboul Roos, 1968; El-Kherbawy, 1971; Assal, 1981 and El Toukhy, 1987).

The soluble-K in the soils of Egypt ranges between 0.004 and 4.0 me./100 g. (Abdel-Bar and Ghobrial, 1960; Mashaly, 1968 and El-Toukhy, 1987). The higher values were found in the fine textured soils, while the lower ones were found in coarse textured soils.

With regard to the effect of soil salinity on soluble-K, Anter (1963), estimated soluble-K in 100 soil samples from Beheira Governorate and found that its values ranged from 0.1 to 13.2 me./L with a gradual increase in the amount of K in the saturation extract as total salt content increased. Similar results were recorded by Abdel-Motteleb (1972) and El-Toukhy (1987).

The exchangeable-K in the Egyptian soils ranges between 0.08 and 4.9 me./100 g. according to soil texture (Lasheen, 1971; Assal, 1981 and El-Toukhy, 1987).

2.7 Status of some micro nutrients in soils:

2.7.1 Iron:

Iron is the most abundant nutrient element in the earth planet as a whole and the fourth most abundant in rocks of the Earth's crust (Aubert and Pinta, 1977).

Randhawa (1971), reported that Indian soils, which belong to many soil groups, contain 0.46-27.5% total Fe. He added that, in most soils, Fe is mainly bound in clay and silt fractions.

The total Fe content in the soils of Egypt have been studied by several investigators. Tayel *et al.* (1966) and El-Gala and Hendawy (1972), found that the Fe content of the alluvial soils ranged from 1-7% depending on the clay + silt percentage rather than the clay content alone. Soils with more than 7% $CaCO_3$ were generally poor in total iron content. Holah (1977), found that total iron content in some soils of Egypt varied between 1.09 and 8.30% with an average of 5.95%. The highest values were recorded for the alluvial soils and the lowest for the sandy ones, while the calcareous soils came in between though closer to the sandy than to the alluvial soils. Similar values of total iron content for the alluvial and calcareous soils of Egypt were reported by Abdallah (1977), El Halawany (1978), Hegazy (1980), El Sokkary and Lag (1980) and El-Toukhy (1987). In this respect, El Falaky (1981), found that 60% of the variations in total Fe content of the Egyptian soils could be due to the variation in the silt and clay content.

Concerning the factors affecting iron availability, Brown (1952), mentioned that the deficiency of iron is quite common in calcareous soils because of its low availability. In water-logged and paddy soils, the problem of iron and manganese deficiency is very common because of change in redox potential. Under condition of satisfactory aeration, iron is found in most soils, principally precipitated as oxides and phosphate. Agrawal (1963), observed a negative relationship between ESP and exchangeable iron content of some Indian soils. Singh (1964), reported that Fe^{++} content of a soil increased with decreasing pH. Sorensen *et al.* (1971), concluded that soil organic matter content was closely related to amounts of Zn, Mn, and Fe released.

Concerning available iron in Egyptian soils, variable amounts have been reported by different investigators, depending on soil characteristics and the extracting solution. Holah (1977) indicated that the average values of available iron were 5.3 ppm in the Nile alluvial soils and 4.6 ppm in the sandy soils.

These values reveal that such soils are marginal with respect to their iron content according to the limits proposed by Lindsay and Norvell (1978). El-Toukhy (1987), stated that the DTPA-extractable Fe ranged from 2 to 15 ppm, with an average of 8.3 ppm. He also mentioned that there was highly significant and positive correlation between available iron and each of clay and organic matter, while the correlation was negative with sand. Similar relationships were obtained by Abdel-Razik (1994), although she gave wider range of DTPA-extractable iron i.e., 4-32 ppm, respectively.

2.7.2 Manganese:

The total manganese content in soils varies widely from traces to 10000 ppm. Most soils contain an average from 500 to 1000 ppm of total Mn. The variations noticed can rarely be correlated with soil typology, but they are often high between soils of the same type in a given climatic region (Aubert and Pinta, 1977). Swaine (1955), reported that the range of total Mn in soils of the world is 200 to 3000 ppm.

Regarding the status of Mn in the soils of Egypt, Ghanem *et al.* (1971), found that it ranged from 116 to 1300 ppm. Their data showed that the alluvial soils have the highest Mn content (533-1300 ppm), while the sandy soils have the lowest content (116-233 ppm). The calcareous soils are intermediate, containing from 400 to 533 ppm. El-Gala and El-Bagouri (1972), found similar trends.

The two main factors determining the magnitude of total Mn content in the soil are the clay and organic matter content (El-Sherif *et al.*, 1970; El-Damaty *et al.*, 1971 and El-Toukhy, 1987). Many investigators showed a close positive correlation between total Mn content of the soils and their clay and silt content (El-Laboudi *et al.*, 1971; El-Sokkary and Lag, 1980; Awadallah *et al.*, 1982 and Abdel-Razik, 1994).

Regarding the available Mn in the soils of Egypt, Safwat (1980), reported that the amounts of DTPA-extractable Mn ranged from 0.7 to 26.7 ppm with an average of 8.2 ppm. These levels decreased with depth in alluvial soils at Nile valley which contained higher levels than the soils near the desert. He added that fine-textured soils have more exchangeable and active Mn than the coarse textured ones. Taha (1980), found that the available Mn extracted by different solutions varied with type of soil as well as the type of the extracting solution. He added that DTPA-extractable Mn ranged between 5.5 and 26.5 ppm in the alluvial soils. El-Toukhy (1987), showed that DTPA-extractable Mn ranged from 2 to 34 ppm with an average of 14.58 ppm. He also stated that there was significant and positive relationship between available Mn and each of clay and silt content.

2.7.3 Zinc:

Zinc concentration in soils vary widely, ranging from traces to 900 ppm, with average concentration of 50 to 100 ppm. Variations are due principally to the different concentrations in the rocks from which the soils were derived (Aubert and Pinta, 1977).

Concerning the status of total Zn in the soils of Egypt, El-Kadi (1970) found that total amount of Zn ranges from 18 to 156 ppm. The highest values are found in the heavy alluvial soils, the sandy soils have the lowest values, while calcareous soils contain moderate amounts. Almost similar values were reported by some other investigators (Abdel-Wahid, 1976; El-Sikhry, 1976 and Aboul-Roos *et al.*, 1981). Abdel-Razik (1994), showed that values of total Zn content in the soils of El-Salhia area ranged from 20 to 120 ppm.

The main factors influencing the total Zn content in soils of Egypt are the content of clay fraction, organic matter and $CaCO_3$ (Abdel-Wahid, 1976; El-Sokkary, 1979; and Aboul-Roos *et al.*, 1981).

Availability of soil Zn for plant use is dependant on many factors. Lee and Craddock (1969) reported that as soil pH increased, zinc forms a hydroxide which is practically insoluble consequently its availability decreases.

Baughman (1956), found that two thirds of the Zn in a sample of Maumee soil and one half in Floyd of Indian were associated with organic matter. The Zn fixing power of the two soils was in the order of their organic matter content. Leeper (1947), reported that $CaCO_3$ might act as a strong adsorbent of Zn. Jurinak and Bauer (1956), reported that Zn was adsorbed on the crustal surfaces of dolomite and magnesite by replacing Mg.

Regarding the status of available Zn in the soils of Egypt, El-Kadi *et al.*,

(1972) found that available zinc ranged between 0.07 and 2.46 ppm. In a study on available Zn in some alluvial soils, Kamh (1977), found that DTPA-extractable Zn ranges from 2.8 to 5.6 ppm. Hassan (1979), found that mean values of about 1.4, 1.8, 18.0 and 0.7 ppm characterize the profiles of calcareous, lacustrine, alluvium and sandy soils, respectively. The highest content of the available Zn is that of the alluvium, whereas the lowest one is associated with sandy soils. El-Toukhy (1987), found that DTPA-extractable Zn ranges from 0.8 to 10.6 ppm with an average of 1.98 ppm. Abdel-Razik (1994), gave a relatively wider range of DTPA-extractable Zn ranging from 0.2 to 12.8 ppm. in the soils of El-Salhiya.

2.7.4 Copper:

The total copper content of soils ranges from traces to 200-250 ppm, the average values range from 15 to 40 ppm. Values up to 5000 ppm or more have been reported for some soils of copper-rich areas usually located near the ore deposits (Lovering *et al.*, 1950 and Huff, 1951). Swain (1955) reported that the total copper content ranges from 1 to 100 ppm in the normal agricultural soils of the world. The total amount of copper in the soils is determined by the type of parent material, the degree of weathering, and the texture of the soil.

The content of total copper in the soils of Egypt ranges from 2 to 210 ppm, depending on soil type. The average values of the alluvial soils range from 28 to 126 ppm, the corresponding ones of the desert sandy soils range from 2 to 10 ppm and those of the calcareous soils were found to be from 6 to 13 ppm (El-

Gibaly *et al.*, 1970; Kishk *et al.*, 1973; Salama, 1981 and El Sayad, 1983). El-Toukhy (1987), mentioned that the total copper content in the surface layers of the soils adjacent to Idko lake range from 60 to 139.2 with an average of 100.7 ppm.

It was observed that the total Cu content in soils increases with increasing clay and organic matter content (Aboul-Roos and Abdel-Wahid, 1978; Salama, 1981; and El-Toukhy, 1987).

Regarding copper availability, El Damaty *et al.* (1973), found highly significant negative correlation between Cu forms and soil pH in spite of the narrow range through which these values occurred. They also found highly significant positive correlation between organic matter and exchangeable Cu. Sabet *et al.* (1975), found highly significant positive correlation between clay percentage and each form of available Cu. Also the percentage of silt significantly correlated with available Cu forms.

With respect of the amount of available copper in the soils of Egypt, El-Sayed (1971), reported that the chemically available Cu (soluble in 0.1 N HCl) in some soils ranged from 0.05 to 3.73 ppm with an average of 0.88 ppm. El-Toukhy (1987), mentioned that DTPA-extractable Cu ranges from 0.6 to 11.8 with an average of 5.7 ppm. He also found highly significant and positive correlation between DTPA-extractable Cu and each of clay, silt and organic matter. He added that an increase of one percent in either clay, silt or organic matter will increase DTPA-extractable Cu by 0.027, 0.068 and 0.987 ppm, respectively.

2.7.5 Boron:

In general, soils differ widely in their total B content according to the type of rock or parent material from which they were drived. Sea water contains appreciable amounts of B of about 5 ppm as an average. Though the action of active wind, boron salts spread from the sea into the atmosphere and then fall down with rain water on the adjacent areas. Edelman (1939), estimated such B falling down to be about 30 g/ha/year in Holland soils.

Swaine (1955), reported that the total B content of the soils of the world varies from 2 to 100 ppm. Kanwar (1976), concluded that total B content varies from 7 to 630 ppm in Indian soils.

In Egypt, El-Seewi and El-Malky (1979), reported that the total B content is 113 ppm on average. The average B content of clay samples is two times that of the sandy ones.

Variations in total B content are due to variations in soil texture, organic matter content and total soluble salts. It seems that the finer the texture, the higher the organic matter, and the higher the total soluble salts, the higher the total boron content of the soil (Cornillon, 1970; Kovaceric-Tatic, 1974; Helal, 1982 and El-Toukhy, 1987).

Concerning available boron in the soils of Egypt, Kishk (1963), reported that the average values of the hot water soluble boron of Nile Delta soils were 3.7 and 11.6 ppm in non-saline and saline soils, respectively. Awad and Mikhael (1980), showed that the values of hot water soluble B in the soils of the northern part of the Delta, ranged from 1.4 to 8.5 ppm. El-Toukhy (1987), stated that the hot water soluble B in the surface layer of the soils adjacent to Idko lake ranged from 0.39 to 8.3 with an average of 3.4 ppm. His data revealed highly significant and positive correlation between hot water soluble B and each of clay percentage, total soluble salts and exchangeable sodium percentage.

2.8 Land evaluation:

2.8.1 General aspects:

Lewis (1938) reported that the most important information in land evaluation are texture of horizons, depth of profile, nature of the parent material and chemical and mechanical analyses of the soil.

Soil Survey Staff (1951) reported that the productive soil is generally regarded as one that will give good yields, in relation to inputs of materials and output per acre, when used for production of a combination of the principal grains and grasses-corn, oats, wheat, clover, and other common crops. The most useful expression of soil productivity is the average crop yield under defined management classes. For marking comparisons among soils, it is convenient, although less precise, to have a productivity rating or index under defined management classes in terms of national standards. This is calculated as follows:

$$\text{Productivity rating index} = \frac{\text{Expected yield/acre}}{\text{Standard yield/acre}} \times 100$$

Such productivity rating index allows rough comparisons among soils, especially by people who do not have in mind the standard yields of various crops.

Teaci (1974), summarized the factors to be considered in land evaluation as follows:

1. Cosmic and atmospheric factors such as:
   - a) Light (duration-intensity).
   - b) Temperature (average, maximum and minimum).
   - c) Rainfall (average, evapotranspiration).
   - d) Wind (frequency, strength, direction).

2. Edafic factors:
   - a) Topography (forms, energy, slope).
   - b) Lithology (texture, geochemics, mineralogy).
   - c) Hydrology (water, its nature and dynamics).
   - d) Soil (depth, texture, humus content, pH, salinity).

3. Biological factors:
   - a) Vegetative cover.

b) Soil microfauna.

4. Economic factors:

   a) Distance to market.

   b) State of roads.

   c) Area and shape of plots.

Bibby and Mackney (1975), pointed out that land capacity groupings depends on having specific informations concerning the response of individual soils to management and to the combined effect of soil's topography and climate on crop production. These informations are required under the following headings:

1. Morphological and laboratory data on soil profiles.
2. Soil erosion and flood hazards, soil water movement and storage and soil variability.
3. Type and frequency of phenologically adapted crops which can be grown.

   Flexibility of cropping is important, but it does not completely outweight the ability to produce consistent, high yields of a narrow range of crops.
4. The effect of different types and intensities of management on crop yield and soil conditions.
5. The influence of climatic and topographical aspects on soil management, crop husbandry, crop quality and yield.

2.8.2 Methods of land evaluation:

Land may be evaluated directly, by trial, that is by growing crops. Direct evaluation is of limited value unless the evaluator has the resources to collect a large amount of data (Olson, 1981). Thus most land evaluation systems are indirect. They assume that certain soil and site properties influence the success of a particular land use in a reasonably predictable manner, and that the quality of land can be deduced from observation of those properties (Vink, 1983). Informations about soil and site properties are the raw material for indirect land evaluation. These are often considered as land characteristics which can be directly observed or assessed. Indirect land evaluation normally uses a combination of characteristics and qualities (Beek, 1978). Land evaluation include qualitative and quantitative systems.

2.8.2.1 Qualitative rating:

Qualitative classification of land is an empirical assessment based on assumed relationships between crop performance and diagnostic criteria. A diagnostic criterion is defined as a variable, which may be land quality, land characteristic, or a function of several land characteristics (FAO, 1976).

2.8.2.1.1 U.S.D.A. System of land capability classification:

This system is one of a general appraisal and not relates to a specific land utilization type.

Klingebiel and Montgomery (1961), classified lands according to their capability into three major categories of soil grouping: (1) Capability unit, (2) Capability subclass, (3) Capability class.

The first category, i.e., the capability unit is a grouping of soils that have about the same responses to management systems of common cultivated crops and pasture plants. Soils in any one capability unit are adapted to the same kinds of common cultivated and pasture plants and require similar alternative systems of management for these crops. Long time estimated yields of adapted crops for individual soils within the unit under comparable management do not vary more than about 25 percent.

The second category, i.e., the sub class is a grouping of capability units having similar kinds of limitations or hazard. Four general kinds of limitations or hazards are recognized: (1) Erosion hazard, (2) Wetness, (3) Rooting zone limitation, and (4) Climate.

The third broadest category in the capability classification places all the soils under eight capability classes. The risks of soil damage or limitations in use become progressively greater from class I to class VIII. Soils in the first four classes under good management are capable of producing adapted plants, such as forest trees, range, the common cultivated field crops and pasture plants. Some soils in classes V and VI are also capable of producing specialized crops, such as certain fruits and ornamentals, and even field and vegetable crops under highly intensive management involving elaborate practices for soil and water conservations. Soils in class VIII do not return on site benefits for inputs of management for crops, grasses, or trees without major reclamation.

The grouping of soils into capability units, subclasses, and classes is done primarily on the basis of their capability to produce common cultivated crops and pasture plants without deterioration over a long period of time.

2.8.2.1.2 Land suitability evaluation (FAO, 1976):

The FAO framework for land evaluation (1976) was designed mainly for use in developing countries, but may also have future applications in more advanced countries (Sys and Verheye, 1978). The structure of this framework is shown in Table (3).

Table (3): structure of land suitability classification.

Order	Class	Subclass	Unit
S, Suitable	S1 S2 S3 etc.	S2m S2e S2me etc.	S2e-1 S2e-2 etc.
Sc, Conditionally suitable (this is a phase of the order suitable)	Sc2	Sc2m	
N, Not suitable	N1 N2	N1m N1e etc.	

It consists of four levels of decreasing generalization:

(i) Land Suitability Orders which reflect kinds of suitability.

(ii) Land Suitability Classes which reflect degree of suitability within orders;

(iii) Land Suitability Subclasses which reflect kinds of limitations, or the main kinds of improvements required and

(iv) Land Suitability Units which reflect minor differences within subclasses in the management required.

Land Suitability Orders denote whether the land is suitable (S) or not suitable (N) for the particular use under consideration. Order S is defined as "Land on which sustained use of the kind under consideration is expected to yield benefits which justify the inputs, without unacceptable risk or damage to land resources". Order N is defined as "Land which has qualities that appear to preclude sustained use of the kind under consideration".

Within each order, land suitability classes are numbered according to decreasing degrees of suitability. Although there is no limit to the number of classes within the order suitable, five is the recommended maximum and three is the normal as, highly suitable class S1, moderately suitable class S2 and marginally suitable S3.

Variation in the number of classes may cause confusion in indexing, e.g. the marginally suitable category could be S3 in some cases, S4 or S5 in others depending on the total number of classes recognized. An alternative which gives a constant numbering to the lowest suitability class by subdividing classes, e.g. S2.1, S2.2 etc., is permitted but not recommended.

There are normally two classes within the order not suitable. Class N1 denotes land that is currently not suitable and class N2 denotes land that is permanently not suitable.

The boundary between N1 (currently not suitable) and the lowest category of the order suitable S3 (marginally suitable) may vary with economic and social conditions. But the boundary between currently N1 and permanently not suitable N2 is essentially fixed.

In its basic structure, the framework resembles the USDA land capability classification. The S1, S2, etc. and N1, N2, etc. classes of the framework parallel classes I-VIII in the land capability classification. In both systems subclasses are represented by a letter notation after the class number which denotes the main kind of limitation (or improvement required), and units are represented by a numerical notation of the form -1, -2, etc. like the USDA land capability classification, the FAO framework can also be employed at any level of generalization.

2.8.2.2 Quantitative rating:

2.8.2.2.1 Storie Index Rating (SIR):

The most widely used multiplicative system for rating the quality of land is the Storie Index Rating which was originated in California. It was firstly appeared in 1933, but has subsequently been revised and reprinted on several occasions (Storie, 1933, 1944, 1964, 1976). Adaptations of the system have been used in many other parts of the world. As originally conceived by Storie (1933), the Storie Index Rating (SIR) is given by the following relation:

$$SIR = A \times B \times C.$$

Where: A is the character of soil profile, B is the texture of soil surface and C is the miscellaneous factors such as drainage, alkalinity, steepness of the slopes.

Later, Storie (1944) introduced a new factor "C", to evaluate slope and the original factor C became factor X (miscellaneous factors that can be modified by management) and thus SIR became:

$$SIR = A \times B \times C \times X.$$

Where: A is character of soil profile, B is texture of soil surface, C is soil slope, and X miscellaneous factors.

Each factor is scored as a percentage but multiplied as a decimal. The final index is expressed as a percentage where more than one property is considered as in factor X, each is also scored as a percentage, then all are multiplied together as decimals and expressed as the combined percentage for the factor. All derivatives of the Storie system use this convention. The Storie Index Rating has been widely used in California particularly for taxation purposes (Weir and Storie, 1937; Storie and Weir, 1942; Storie and Harradine, 1950; Storie, 1954; and Edwards *et al.*, 1970). In other areas the Storie Index Rating has been modified to include other factors which were not important in California. Inclusion of a factor for climate has been included in India by Shome and Raychaudhuri (1960) and in Hawaii by Nelson (1963) and by Olson (1974). A management factor has been included in New Zealand by Leamy (1962, 1974). In the humid tropics, Sys and Frankart (1972) and Frankart and Sys (1974) added a soil colour factor as a factor for the development of an organic rich topsoil. Soil and site properties are usually included within the miscellaneous (X) factor in the basic Storie Index Rating and drawn out as separate factors, e.g. salinity, (Bowser, 1940; Omar and El-Kalei, 1969; Sys and Verheye, 1972; Borden and Warkentin; 1974 and Sys, 1979).

In a FAO development project, Bramao and Riquier (1967) and Riquier *et al.* (1970) proposed an Index for soil productivity given by the equation:

Soil productivity index = P x T x (N or S) x O x A x M x D x H

Where:
- P = effective soil depth;
- T = texture and structure of A horizon;
- N = base status;
- S = soluble salts content;
- O = organic matter of A horizon;
- A = mineral exchange capacity and nature of clay in B horizon;
- M = reserves of alterable minerals in B horizon;
- D = drainage;
- H = Soil moisture content.

2.8.2.2.2 Sys and Verheye's system:

An attempt to evaluate land characteristics for irrigation according to the FAO framework for land evaluation (1976) was undertaken by Sys and Verheye (1978). This attempt is based essentially on the principles of land classification in arid and semi-arid regions suggested by the same authors in 1972. Since then, the system has been checked in many arid countries and certain progress was achieved.

The aim of this system is to provide a method that permits a suitable evaluation for irrigation purposes based on the standard granulometric and physico-chemical characteristics of soil profiles. Regarding of their criteria is made in such a way that the classification can be done according to the FAO framework using specific guidelines for the definitions of the orders (S and N) and classes (S1, S2, S3, N1, N2). Following this system, the characteristics influencing land suitability with regard to irrigation capability can be regrouped under the subclasses of the FAO framework as follows:

- t : topographic limitation.
- w : wetness limitations, mainly based on drainage conditions.
- s : limitations concerning soil physical conditions which include:
  - S1 : Texture including stoniness.
  - S2 : Soil depth.
  - S3 : Calcium carbonate status.
  - S4 : Gypsum status.
- n : salinity and alkalinity limitations.

The evaluation of these land characteristics can be achieved in a relative limitation scale where five levels are used (Table, 4).

Table (4): Limitation levels and their rating.

Symbol	Intensity of limitations	Rating
0	no	95-100
1	slight	85-95
2	moderate	60-85
3	severe	45-60
4	very severe	<45

Based on the number and intensity of limitations, Sys and Verheye (1978) suggested definitions of suitability orders and classes. The suitability index for irrigation (Ci) is calculated, and this value is also integrated in the definition where:

$$Ci = t \times \frac{w}{100} \times \frac{S1}{100} \times \frac{S2}{100} \times \frac{S3}{100} \times \frac{S4}{100} \times \frac{n}{100}$$

In light of the calculated Ci values, the orders, classes and subclasses of lands can be distinguished as follows:

Order S : Suitable land for irrigation : land units with only moderate, slight or no limitations and no more than one severe limitation, that however does not exclude the use of the land. Ci is more than 25.

Class S1: land units without or with only 3/4 slight limitations (Ci + 25).

Class S2: land units with more than 3/4 slight limitations and no more than 2/3 moderate limitations (Ci 50 to 75).

Class S3: land units with more than 2/3 moderate limitations and / or one severe limitation that does not exclude the use of the land for irrigation (Ci 25 to 50).

Order N : Not suitable : land units with one or more severe limitations that excludes the use of the land, or with one or more severe limitations (Ci -25).

Class N1: land units with severe or very severe limitations that can be corrected.

Class N2: land units with severe or very severe limitations that can not be corrected.

2.8.3 Land evaluation for agriculture utilization in Egypt:

Fathi (1957), proposed a parametric method for evaluating the soils of Egypt and defined two principle factors in land evaluation. First basic factors, determines the soil fertility and gave it 100 degree when computing the ideal properties of highly productive soils. Second one is the environmental factors which are responsible for changing the values of the first factor and have a range from 0.0 to 1.0. The basic factors include the following:

a) Each of both soil salinity and alkalinity has 30 degree divided as follows: slightly saline 25 degree, moderate saline 20 degree, strongly saline 15 degree; slightly alkaline 25 degree, moderate alkaline 20 and strongly alkaline 12 degree.

b) Soil stratification as an indicator to the presence of impermeable pan and its depth, it has 30 degrees. At the depth of 200 cm., it has 30 degrees, while at depths of 150 cm., 100 cm., and 50 cm., it has 25, 20 and 15 degrees respectively.

c) Soil texture has 20 degrees: sandy soil 5 degrees, sandy loam 15 degrees, loamy soil 20 degrees, clay loam 18 degrees and heavy clay 13 degrees.

d) Soil structure has 20 degrees ranging from 5 for single granules to 20 for strong structure.

The environmental factors include the following:

a) Depth of water table ($<$50 cm = 0.6, 50-100 cm = 0.7, 100-150 cm = 0.8 and more than 150 cm = 1.0).

b) Irrigation (irrigation without using power 1.0, by using power 0.9 and 0.5 for basin irrigated soils).

c) Urban conditions (ranges from 0.0-0.3). This factor depends on communication and labour facilities and the availability of markets.

By multiplying the sum of the basic factors with the multiple product of the environmental factors, soil could be evaluated.

Land classification has been carried out by the soil survey report, Ministry of Agriculture since 1960s until 1980s. In this classification soils are grouped according to the following factors:

1. Physical and chemical properties of the soil.
2. Soil productivity and its capability for crop production, field crops,

horticulture and vegetables.

3. Favourable ratio of output to input and soil management.

For soils of Egypt, six classes have been defined as follows:

Class I : Excellent cultivated soils suited for all field crops and having a higher output to input ratio. These soils are medium in texture with deep profile. Total soluble salts do not exceed 0.3% with an electric conductivity (EC) less than 4 mmhos/cm at 25°C in the saturation extract of soil paste, soil pH is not more than 8.5 and ESP is less 15%.

Class II: Cultivated soils producing most of field crops with less inputs in its management. These soils have a good irrigation and drainage systems; the profile is deep with heavy texture; total soluble salts range from 0.3-0.5% or EC ranges from 4-8 mmhos/cm at 25°C. Soil pH does not exceed 8.5 with ESP less than 15%.

Class III: Cultivated soils not suitable for most of field crops, their production is medium with moderate inputs. Soil texture is very heavy with deep or medium profile depth. Total soluble salts range from 0.5-1.0% or the EC ranges form 8-16 mmhos/cm at 25°C. The pH of the soil paste does not exceed 9 and the ESP is more than 15%.

Class IV: Cultivated soils, their production is limited or may be suitable for crop production under certain conditions with medium or high inputs. The drainage or irrigation systems in these soils are bad.

The following soils could be defined under this class:

1. Sandy soils which have more than 90% fine and coarse sand.
2. Calcareous soils with $CaCO_3$ more than 20%.
3. Heavy clay soils with higher salinity and low permeability and suffering from problems in drainage.
4. Alkaline soils with problems in drainage.
5. Water logged soils in which both large and small pore spaces are filled with water. These conditions prevent tillage.
6. Shallow soils with rocks which prevent root growth and water permeability.

Class V : Barren or submerged soils which are not suitable for cultivation or reclamation.

Class VI: Soils not suited for crop production or any cultivation such as rocky soils, sand dunes or soils having problems with irrigation or lack in water supply. These soils may be used for building or other uses.

Capability grouping in the previous classification is based on specific informations of the soil properties. The criteria for placing soils in their capability classes are as follows:

1. Soil depth:

a. Deep, more than 150 cm.

b. Medium, 50-150 cm.

c. Shallow, less than 50 cm.

2. Soil texture:

a. Very heavy soils (clayey soils).

b. Heavy soils (clay soils).

c. Medium soils (silty or silty clay).

d. Light soils (loamy soils).

e. Very light soils (sandy soils).

3. Water table depth:

a. Low, more than 150 cm.

b. Medium, 80-150 cm.

c. High, 10-80 cm.

d. Marshes at the surface of soil.

4. Salinity of water table:

a. Less than 5000 ppm.

b. 5000 - 10000 ppm.

c. 10000 - 20000 ppm.

d. More than 20000 ppm.

5. Alkalinity:

a. Non alkaline (Ca : Na less than 1 : 4), ESP is less than 15.

b. Alkaline (Ca : Na more than 1 : 4), ESP is more than 15.

6. Salinity:

a. Normal (EC of the soil paste extract is less than 4 mmhos/cm at 25°C.

b. Moderately saline (EC 4-8 mmhos/cm at 25°C).

c. Saline (EC 8-16 mmhos/cm at 25°C).

d. Highly saline (EC more than 16 mmhos/cm at 25°C).

7. Permeability:

a. Low (less than 0.1 cm/hour).

b. Moderate (0.1 - 1.0 cm/hour).

c. High (more than 1.0 cm/hour).

Labib (1963), in the classification of the southern part of the Nile Delta soils, suggested the following criteria in evaluating these soils.

1. Texture variations (clayey, clay loam to sandy clay, loamy and sandy loam to sandy).
2. Total soluble salts, non saline (0.0-0.15%), slightly saline (0.15-0.35%), moderately saline (0.35-0.65%) and strongly saline (more than 0.65%).
3. Nature of soluble ions.
4. Cation exchange capacity.
5. Exchangeable sodium percentage, non alkaline ($ESP < 10$), slightly alkaline (ESP 10-15), moderately alkaline (ESP 15-25) and strongly alkaline ($ESP > 25$).
6. Soil reaction (pH in 1:2.5 water suspension).
7. $CaCO_3$ content.
8. Organic matter content and its relation to soil texture.

Ibrahim (1983), in his approach to evaluate the sandy soils, showed that the following properties should be considered as limiting factors in utilization of these soils for agricultural purposes;

- Soil profile depth (A).
- Soil texture of the uppermost layer (B).
- Gravel content of the upper layer (C).
- Soil salinity of the uppermost layer (D).
- $CaCO_3$ and gypsum of the uppermost layer (E).

He presented a preliminary chart based on assignment of rating percentages according to the above mentioned factors, therefore the soil rating would be equal to ABCDE. He mentioned also that this method allows each limitation to be considered separately and at the same time allows limitations to be combined into a single rating value.

Abdell All (1984), in his evaluation of the soils of the expansion areas in El Fayoum Governorate, considered certain soil properties as limiting factors in utilization of these soils for agricultural purposes, these properties are: Soil profile depth (A); Soil salinity (B); Soil alkalinity (C); Soil drainage (D); $CaCO_3$ content % (E); Soil texture (F); Soil structure (G); Local elevation (H); Slope % (I); Gravel content % (J) and Soil permeability (K). He combined these properties in order to rate the investigated soils in the following formula:

A.B.C.D.E.F.G.H.I.J.K

Erain (1986), suggested the most effective eight factors determining land capability under the local Egyptian conditions, as : Water availability for agriculture (A); drainage conditions (D); effective depth of soil (F); stoniness; texture and structure of the root zone (T); $CaCO_3$ and gypsum content (C); cation exchange capacity of the root zone (E); TSS and ESP of the root zone (S) and slope% (P).

Moussa (1991), suggested that the quantitative systems are more suitable under the Egyptian conditions, where their results are compatible with the studied area conditions. He also added that Storie index and Sys & Verheye could be considered as favourable systems under the conditions prevailing in the soils of Egypt.

El-Hemely (1992), used the modified Sys and Verhey's system (1978) in the quantitative land capability classification. According to this system, the studied soils of El-Nobaria are located into S2, N1 and N2.

Abdel-Razik (1994) showed that, by using the USDA system and the FAO system, El-Salhiya area is moderately and marginally suitable. Applying Storie index and the system of Sys and Verheye, the studied area is suitable for many field crops, vegetables and fruit trees. Her results may suggest that the quantitative systems are more suitable under the Egyptian conditions, where these results are compatible with the studied area conditions. Finally she added that Storie index and Sys & Verhey system, could be considered favourable under the conditions prevailing in the soils of Egypt.