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Soil and Water Suitability for Sustainable Agricultural Development in South Valley (Tuskha Area), Egypt

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TUSHKA area is one of the most prospective area for sustainable agricultural development in south valley, Egypt. The present study was undertaken as a trial to evaluate the suitability of soils and water for irrigated various crops in Tushka area under economic and sustainable agricultural development.

Soil survey, classification and land suitability assessment are the main steps for achieving this goal. To realize this object, 25 representative soil profiles have been selected (out of 150 soil profiles) which have been morphologically examined and their relevant physical and chemical properties determined. In addition, water samples were collected from the main wells in the studied area were analyzed.

The major soils of Tushka area belong mainly to the order of the Entisols. The well defined soil parameters used to estimate the suitability index for certain crops are : texture class, including gravel percent, soil depth, salinity status, calcium carbonate content, drainage conditions and slope. The essential requirements for the most economical 15 crops have been included in the calculated indices.

Accordingly, the soils of Tushka area have been distinguished into sand, gravelly sand, loamy sand to sand loam and gravelly textured. Soil depth varies from very shallow to deep. Data indicated that the soils are formed of successive layers of quartizic sand that might be free of or mixed with gravels, iron oxides and /or lime intrusions. These soils are devoid of pedofeatures and most soil characteristics are essentially influenced by the nature of parent material.

The hydrochemical data indicated that the water quality is good to moderately suitable for agricultural purposes.

Accordingly, the soils of Tushka area have been separated into 3 suitability classes (S_3) moderately suitable for growing a wide range of crops with moderate limitations; (S_4) marginally suitable for wheat, cotton, beans, potatoes, sorghum and millets which requires severe limitations, and (S_5) non-suitable as the expected yield will be less that 50% of the optimum yield.

It could be concluded that the most important soil parameters that influence suitability classification in the soils of Tushka area are soil texture, depth of soil profile, gravel content and salinity status. Moreover, these soils need careful management and conservation practices.

Keywords : Soil parameters, Land evaluation, Water suitability, Crop suitability, Tuskha area.

The national agricultural policy of Egypt stressed the importance of land reclamation and extension of arable lands to overcome food security demands of the nation. To fulfil this aim, an assessment of relative potentialities of land and water resources is a must.

In this accord, the scope of land reclamation implies the use of both induction and deduction, particularly when limited land resources have to be allocated to alternative means and areas.

The future agricultural expansion of Egypt demands that all soil resources should be carefully studied and appraised with the aim of estimating their potentials. Among the most promising lands to be considered for agricultural expansion beyond the Nile Delta and Valley are the soils of south valley (Tushka area).

The area studied occupies the extreme south corner of Egypt and is intersected by latitudes 22° 37` and 22° 50` N, and longitudes 31° 28` and 31° 50` E. It is situated on both western and eastern sides of ELSheikh Zaid main canal, (Fig. 1) . It covers an area of about 12000 Fed.

Tushka area occupies a small portion of the Lower Nuba plain from which the majority of the present-day soils have been directly or indirectly derived.

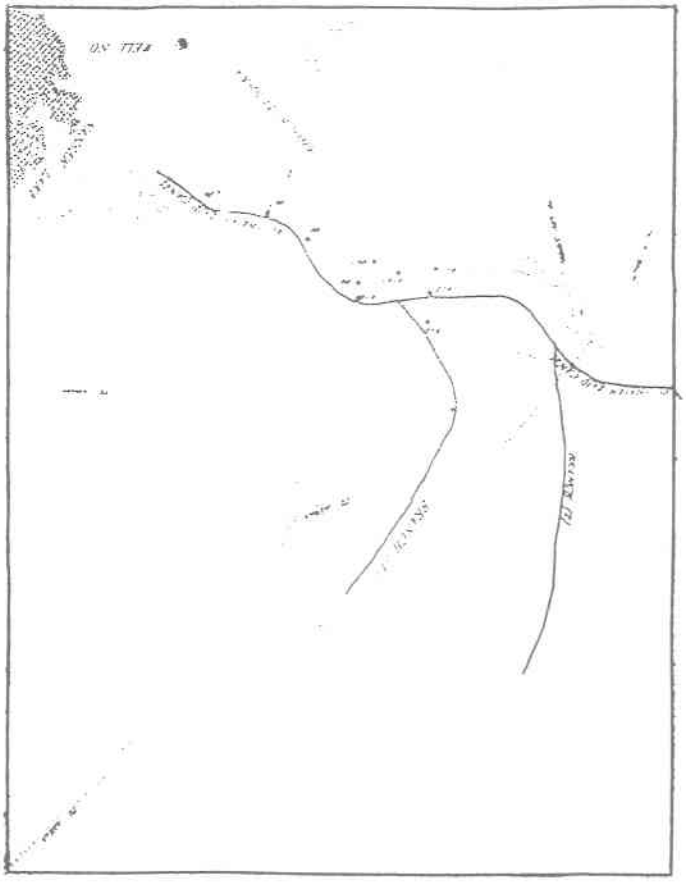

Fig.1. Location of the studied wells.

Geology and Geomorphology

The landscape of the Lower Nuba is dessected by a number of dry streams (Wadis) which flow mainly into the Nile. Among them wadi Dakka and wadi Tushka also going into the Nile but are rather short and have their intake areas located only in the Nuba Plain (elevation over 200m). These wadis have their

impression on the surfaces either as narrow gorges or wide sloping vallies and their floor are mostly covered with drift sand. Moreover, sandy loam and other types of detrital material are frequently present as fillings in these wadis, (Abdel Salam,1962; Abdel Salam *et al.*, 1972, 1974, 1975, and 1978 and El-Demerdashe *et al.*,1978).

As to wadi Tushka, Shata (1962) stated that the thick deposits of calcareous tufa filling the original of the stream near its upper portion is recognized in wadi Kurkur. These deposits were carried out by ravines leaving particularly vertical walls of the tufa which now rises some 15m above the dry stream floor. In the lower portion of wadi Kurkur (at Masakin El-Boum), local patches of calcareous tufa (massive and concretionary forms) are reported in the wadi bed above the sand stone layers. Following the evolution of the dry vallies courses and accepting the view that the Nile acted as the base level for all the drainage lines tributary, reference will be given to wadi Tuskha reported that the calcareous tufa was developed in the Lower Pleistocene age. Shata (1962) was justified to assume that the initial phase in the development of such wadi existed prior to that period.

The landscape of wadi Tuskha is thus appeared to be mainly of an almost flat Nubian surface, usually meet isolated hills (Butts) which represent the end - product of a disappearing landscape.

The lithology of the wadi varies accordingly; the wadi bed is covered with a mantle of alluvium, gravels and blown sand whereas the Butts are built up of sandstone mostly related to the Lower Nuba Tableland.

El-Demerdashe *et al.* (1978) indicated that the Tushka and Dakka areas fall into two naturally defined physiographic zones, the highlands and the wadis. It was postulated that the highlands were made up of two components geomorphic forms an aeolain sand ridge system superimposed on an older "buried" formations. This is an important conception for the eluidation of the general geological history of the region, of the genesis of the soils and of their present distribution. The superficial deposits were shown to be related to the present soil formation as well as to the evidences of their likely geological origin. They added that the genesis of the soils is deduced from their topographic locations, geological aspects and presumed relationship to past and present climatic conditions as reflected in their individual profile morphology.

Climate

The climate of the Tushka area is a typical tropical arid climate identical to that of the southern portion of the western Desert.

The mean annual rainfall is less than 1.0 mm/year. Relative humidity is fluctuating between 19% in summer and 45% in winter. The daily average temperature ranges between 14.1 °C in January and 45°C in July. The daily maximum average temperature ranges between 20.9°C and 40 °C. and the daily minimum average temperature ranges between 6.9°C and 23°C. The wind velocity ranges between 3 and 5 km/hr.

The reference crop evapotranspiration (ETO) rate is between 2.4 mm/day in January and 7.0 mm/day in July. The average crop evapotranspiration is 4.97 mm/day (about $12m^3$/day/fed). According to soil temperature, rainfall, potential evapotranspiration values, the soil moisture regime is Torric or Aridic and the soil temperature regime is Thermic or Hyperthermic.

Natural Vegetation and Present Land Use

Natural vegetation in the south valley (Tushka area) is scarce, or nearly absent No data are available concerning the plant communities in such area.

Water Resources

Groundwater is the only source of water in the study area. According to the regional study of El-Barkouky *et al.* (1979), the aquifer is found in the sand and sandstone body overlying the basement, represented essentially by the Nubian sandstone and the Quaternary sands overlying it at some localities.

Therefore, this investigation was undertaken as a trial to evaluate the suitability of soils and water for irrigating various crops in Tushka area under economic and sustainable agricultural development .

Material and Methods

Based on previous detailed soil survey by Water Management Research Institute (National Water Research Center,1998), one hundred and fifty soil profiles have been morphologically described in the field according to the guidelines to soil description (FAO, 1990) and their physical and chemical characteristics are determined. 25 soil profiles representing the possible trends in

soil characteristics and representing the most predominate soils in Tuskha area have been chosen for this investigation. Gravel content (A): texture (B); soil depth (C); salinity status (D); lime status (E); drainage condition (F) and slope (G) are the soil parameters chosen to calculate the suitability index (ISx) of a given soil for cultivating a certain crop (X).

The equation used for these calculations is IS x = A.B.C.D.E.F.G. The studied crops are : wheat *(Triticum aestivum)*, rice *(Oryza sativa)*, sorghum *(Sorghum bicolor)*, beans *(Phaseolus vulgaris)*, cotton *(Gossypium hirsutum)*, clover *(Trifolium lexandrinum)*

Sugar cane *(Saccharum officinarum)*, onions *(Allium cepa)*, corn *(Zea mays)*, millets *(Pennisetum americanum)* and groundnuts *(Arachis hypogaea)* representing the field crops. Also, certain vegetable crops including tomatoes *(Solanum lycopersicum)*, watermelon *(Colocynthis citrullus)*, carrots *(Daucus carota)* and potatoes *(Solanum taberosum)*.

The essential crops requirements have been considered with regard to the various soil parameters in calculating the sutability index. The degree of land suitability to certain crop depends on the reduction of the yield, accordingly, five suitability classes of land suitability are as follows:

Index symbol	Reduction in yield %	Range of index
S1	No yield reduction	0.85-1.00
S2	10%yield reduction	0.75-0.85
S3	10-25%yield reduction	0.50-0.75
S4	25-50%yield reduction	0.25-0.50
S5	50%yield reduction	< 0.25

The selected soil profiles were mainly representing the soils around the main well dug to irrigate these soils, which lie at western and eastern sides of EL Sheikh Zaid main canal (Table 1 and Fig .1).

According to the morphological description of the soil pits, they are classified following the 7 the approximation (U.S. Soil Survey Staff, (1975) as Typic Torripsamments, Lithic Torripsammonts, Typic Torriorthents and Lithic Torriorthents.

Soil samples were subjected to the standard granulometric, physical and chemical analyses, according to Black (1973).

Undisturbed soil samples were subjected to the determination of moisture retention at 0.33 bar and 15 bars using the pressure membrane and cooker respectively, according to Klute (1986).

In addition, water samples were collected from the main wells in the studied area. The obtained water samples and soil water extracts of the soil samples were analyzed for total soluble salts (EC), soluble Ca, Mg, Na, HCO_3, CL and SO_4 ions using the methods reported by Page (1982). Assessment of land suitability for certain crops is discussed with reference to the systems suggested by FAO (1976); Sys *et al.* (1991) &(1993) and Khadr (2000).

TABLE 1. Well sites.

Coordinates (Deg.)		Coordinates (km)		Level	Canal Chainage (km)	Wells No.
North	East	North	East			
22°39'36.1	31°48'33.8	-3.107	698.198	200	5.75	3
22°41'51.71	31°42'40.48	1.115	688.071	206	17.20	6
22°42'41.2	31°40'53.98	2.608	685.038	200	25.00	8
22°43'58.4	31°39'39.5	4.967	682.915	195	25.60	9
22°44'05.3	31°31'52.9	1.337	682.903	190	25.95	10
22°44'49.8	31°25'26.7	6.636	675.689	190	22.00	11

Results and Disussion

Soil morphology and classification

The soils under study are distinguished into sand, gravelly sand, loamy sand to sand loam and gravelly textured. Soil depth varies from very shallow to deep.

Data in Table 2 indicate that the soils are formed of successive layers of guartizic sand that might be free or mixed with gravel, iron oxides and /or lime intrusions. These soils are devoid of pedofeatures and most soil characteristics are essentially influenced by the nature of parent material.

On the basis of Soil Taxonomy (1975), the soils are placed to the order Entisols. Moderately deep and deep sandy soils, represented by profiles 20,21,22,23,24, and 25 are classified as Typic Torripsamments, whereas, shallow sandy to gravelly sandy soils, represented by profile 3,6.7 and 8 belong to Lithic Torripsamments. Typic Torriorthents are suggested for many different cases such as moderately deep and deep gravelly loamy sand and sandy loam soils, represented by profiles 10,11, 13,14,15,16,17, and 18; moderately deep very gravelly sandy soils, profiles 5 and 12 and moderately deep gravel, represented by profile 9. Lithic Torriorthents are restricted to the very shallow soils and shallow gravelly loamy to sandy loam soils, profiles 1,2,4 and 19.

TABLE 2. Some soil characteristics of the representative soil profiles Tushka area (south valley), Egypt.

Soil Types	Profile No	Slope	Depth/Cm	Gravels %	$CaCO_3$ %	Colour		Textural Class	Structure	Consistence	E.C. dS/m at 25 °C	pH
						Dry	Moist					
Shallow coarse- textured soils (Very shallow coarse- textured soils)	1	Flat	0-25	1.40	11.66	10YR,7/6	10YR,5/6	S	M	SH	1.73	7.6
			25-55	1.40	10.77	10YR,6/6	10YR,5/6	S	M	H	2.63	7.5
	2	Flat	0-20	23.60	11.15	10YR,7/4	10YR,7/3	S	M	LO	0.97	8.0
			20-60	5.60	7.69	10YR,7/4	10YR,7/3	S	SG	LO	1.52	7.8
	3	Flat	0-25	22.30	10.00	7.5YR,6/6	7.5RY,5/6	S	M	SO	0.20	7.0
			25-50	45.80	12.20	2.5YR,5/6	2.5YR,4/6	S	M	SO	0.19	7.1
			50-55	28.90	14.31	2.5YR,5/6	2.5YR,4/6	S	M	SO	0.18	7.2
	4	Flat	0-25	21.50	8.80	7.5YR ,66	7.5YR,5/6	S	M	SH	0.19	7.5
			25-50	31.20	8.60	2.5YR, 5/6	2.5YR,4/6	LS	M	VH	0.81	7.2
	5	Flat	0-25	19.70	8.40	10YR ,7/6	10YR,6/6	LS	M	SH	0.22	7.4
			25-50	25.90	8.60	10YR, 7/6	10YR,6/6	S	M	SO	0.19	7.4
			50-60	27.70	8.80	10YR, 7/6	10YR,6/6	LS	M	SO	0.17	7.4
	6	G.Sloping	0-25	25.80	10.69	7.5YR ,6/6	7.5YR ,6/4	S	M	H	0.30	7.8
			25-70+	33.10	6.6	7.5YR ,6/6	7.5YR ,6/4	S	M	H	0.34	7.7
	7	Flat	0-25	12.80	10.56	7.5YR ,6/6	7.5YR ,6/4	LS	M	H	0.33	7.8
			25-60	9.90	6.86	7.5YR ,6/6	7.5YR ,6/4	LS	M	H	0.71	7.9
			60-65+	15.90	5.02	10YR ,8/2	10YR ,8/1	LS	M	SH	0.36	7.8
	8	Flat	0-25	37.80	4.87	10YR ,6/6	10YR ,8/1	LS	M	SH	1.70	7.9
			25-50	56.90	4.74	7.5YR ,8/4	7.5YR ,8/2	LS	M	SH	1.09	7.9
			50-75+	41.50	5.26	10YR ,8/4	7.5YR ,8/2	LS	M	SH	2.62	7.6
	9	Flat	0-20	25.30	8.42	10YR ,7/4	10YR ,6/6	S	SG	LO	0.44	7.7
			20-90+	44.20	8.95	7.5YR ,6/8	7.5YR ,5/6	S	SG	LO	0.29	7.9
	10	Flat	0-25	69.90	7.26	7.5YR ,6/8	7.5YR ,5/6	S	M	H	0.23	7.7
			25-50	25.70	5.28	7.5YR ,6/8	5YR ,5/6	S	M	SH	0.20	7.3
			50-75+	17.40	8.81	5YR.6/6	5YR ,5/6	S	M	SH	0.16	7.3
	11	Flat	0-25	0.60	3.52	7.5YR ,5/8	7.5YR ,4/7	S	SG	LO	0.28	7.8
			25-50	46.30	4.48	7.5YR ,6/6	7.5YR ,5/6	S	SG	LO	0.18	7.8
			50-75+	58.20	4.1	7.5YR ,6/6	7.5YR ,5/6	S	M	H	0.13	7.6
	12	Flat	0-25	21.00	9.34	10YR ,8/6	10YR ,8/4	LS	M	SH	0.91	7.6
			25-50	58.70	2.63	2.5YR ,5/8	2.5YR ,5/7	LS	M	SH	1.03	7.5
			50-75+	64.4	2.76	2.5YR ,5/8	2.5YR ,5/7	LS	M	SH	0.79	7.7

All abreviation according to FAO (1990)

TABLE 2. *Contd*

Soil Types	Profile No	Slope	Depth/Cm	Gravels %	$CaCO_3$ %	Colour		Textural Class	Structure	Consistence	E.C.dS/m at 25 °C	pH
						Dry	Moist					
Moderately deep very coarse-textured soils	13	Flat	0-25	48.00	9.74	7.5YR ,6/6	7.5YR,5/6	S	SG	LO	0.25	7.2
			25-50	65.10	7.76	7.5YR ,6/4	7.5YR,6/3	S	SG	LO	0.23	7.3
			50-75	60.50	5.66	7.5YR, 6/4	7.5YR,6/3	S	SG	LO	0.22	7.3
			75-80	61.50	5.59	7.5YR, 6/4	7.5YR,6/3	S	M	H	0.22	7.3
	14	Flat	0-25	12.00	5.00	7.5YR, 7/6	7.5YR,6/6	S	SG	LO	0.38	7.7
			25-50	28.70	4.47	7.5YR ,5/4	7.5YR,4/4	S	SG	LO	0.32	7.9
			50-75	35.70	5.79	7.5YR, 5/4	7.5YR,4/4	S	SG	LO	0.35	7.9
			75-85	23.90	4.61	7.5YR ,5/4	7.5YR,4/4	S	M	H	0.35	7.8
	15	Flat	0-25	23.40	9.87	10YR ,7/6	10YR,6/5	S	SG	LO	0.42	7.6
			25-50	45.90	4.08	10YR, 7/6	10YR,6/5	S	SG	LO	0.70	7.5
			50-75	44.40	4.08	10YR, 7/6	10YR,6/5	S	SG	LO	0.88	7.3
			75-85	67.50	3.16	10YR ,7/6	10YR,6/5	S	M	H	0.75	7.4
	16	Flat	0-25	16.10	4.61	10YR ,7/4	10YR,6/4	LS	M	SO	0.37	7.6
			25-50	31.90	5.13	10YR ,7/4	10YR,6/4	LS	M	SO	0.66	7.4
			50-75	7.40	3.03	5YR, 5/6	5YR,4/6	LS	M	SH	0.67	7.4
			75-90	69.80	3.42	5YR, 5/6	5YR,4/6	LS	M	SH	0.79	7.4
	17	Flat	0-25	9.60	8.16	7.5YR ,6/6	7.5YR,5/6	S	M	LO	0.33	7.7
			25-50	32.40	4.61	7.5YR ,6/6	7.5YR,5/6	S	M	LO	0.30	7.7
			50-90	30.10	6.18	2.5YR ,5/6	2.5YR,4/6	S	M	LO	0.39	7.5
	18	Flat	0-25	15.80	7.50	7.5YR, 5/6	7.5YR,4/6	S	SG	LO	0.22	7.5
			25-50	25.70	4.08	7.5YR,4/6	7.5YR,4/6	S	SG	LO	0.19	7.9
			50-75	38.10	3.68	7.5YR,4/7	7.5YR,4/6	S	SG	LO	0.32	8.0
			75-100	36.20	4.21	7.5YR,4/8	7.5YR,4/6	S	M	H	0.34	7.6
	19	Flat	0-25	27.10	10.52	5YR ,5/6	5YR,4/6	S	M	SO	0.35	7.3
			25-50	29.30	9.62	5YR ,5/6	5YR,4/6	SL	M	SO	0.54	7.3
			50-75	29.70	9.62	5YR, 5/6	5YR,4/6	SL	M	H	0.49	7.3
			75-100	20.20	9.54	5YR ,5/6	5YR,4/6	S	M	H	0.57	7.3

All abreviation according to FAO (1990)

TABLE 2. Contd

Soil Types	Profile No	Slope	Depth / Cm	Gravels %	CaCO3 %	Colour		Textural Class	Structure.	Consistence.	E.C. dS/m at 25 °C	pH
						Dry	Moist					
Deep coarse – textured soils	20	Flat	0-25	34.31	6.84	7.5YR ,6/6	7.5YR,5/6	S	SG	LO	0.25	7.8
			25-50	32.40	4.74	7.5YR ,5/6	7.5YR,4/6	S	SG	LO	0.15	7.4
			50-75	28.60	3.95	7.5YR ,5/6	7.5YR,4/6	S	M	H	0.16	7.4
			75-100	29.80	6.58	7.5YR ,5/6	7.5YR,4/6	S	M	H	0.16	8.0
			100-125	29.50	3.95	7.5YR ,5/6	7.5YR,4/6	S	M	H	0.17	7.6
	21	Flat	0-25	23.40	3.42	2.5YR ,6/8	2.5YR,6/6	LS	M	SO	0.39	7.4
			25-50	31.20	4.47	2.5YR ,6/8	2.5YR,6/6	LS	M	SO	0.75	7.8
			50-75	46.10	4.08	2.5YR ,6/8	2.5YR,6/6	LS	M	SH	0.76	7.6
			75-100	30.80	3.82	2.5YR. 6/8	2.5YR,6/6	LS	M	SH	0.44	7.5
			100-150	19.70	4.21	2.5YR. 6/8	2.5YR,6/6	LS	M	SH	0.55	7.6
	22	Flat	0-25	22.10	10.18	10YR ,8/4	10YR,7/3	SL	M	SO	0.18	7.7
			25-50	50.90	5.81	7.5YR ,6/6	7.5YR,5/6	SL	M	SO	0.18	8.1
			50-75	47.50	4.09	7.5YR ,6/6	7.5YR,5/6	SL	M	SO	0.19	7.6
			75-100	35.10	3.04	7.5YR ,6/6	7.5YR,5/6	SL	M	SO	0.18	7.6
			100-125	35.10	6.07	7.5YR ,6/6	7.5YR,5/6	S	SG	LO	0.20	7.9
	23	G. Sloping	0-25	5.50	11.77	10YR ,8/4	10YR,7/4	S	SG	LO	0.28	7.8
			25-50	29.10	11.54	5YR ,6/6	5YR,5/6	S	M	H	0.19	7.9
			50-75	27.80	9.62	5YR ,6/6	5YR ,5/6	S	M	H	0.17	7.9
			75-100	28.90	10.00	5YR ,6/6	5YR ,5/6	S	M	H	0.17	7.6
			100-125	33.80	8.85	5YR ,6/6	5YR ,5/6	S	M	H	0.16	7.7
	24	G. Sloping	0-25	1.21	3.42	2.5YR ,6/8	2.5YR ,4/4	S	M	LO	0.23	7.5
			25-50	19.90	3.03	2.5YR ,6/8	2.5YR ,4/4	S	M	H	0.2	7.6
			50-75	21.70	2.37	2.5YR ,6/8	2.5YR ,4/4	S	M	H	0.32	7.2
			75-100	36.00	2.11	2.5YR ,6/8	2.5YR ,4/4	S	M	H	0.37	7.6
			100-125	46.30	1.45	2.5YR ,6/8	2.5YR ,4/4	S	M	H	0.24	7.4
	25	Flat	0-25	4.70	9.62	10YR ,7/4	10YR ,6/4	S	SG	LO	0.26	7.8
			25-50	4.50	7.69	10YR ,7/4	10YR ,6/4	S	SG	LO	0.35	7.7
			50-75	11.00	7.69	10YR ,7/4	10YR ,6/4	S	SG	LO	0.27	7.7
			75-150	8.10	5.38	10YR ,7/4	10YR ,6/4	S	M	LO	0.34	7.7

All abreviation according to FAO (1990)

Quality of groundwater

The quality of water used for irrigation is well recognized as an important factor in the productivity of the crops.

Table 3 shows briefly the chemical composition of the representative ground water samples collected from the wells in the studied area. These hydrogeochemical data indicated that the total dissolved solids of water samples vary from 716.8 to 1222.4 ppm, and the water quality is good to moderately suitable for agricultural purposes (Wilcox , 1955). Sodium, chloride and sulfate dominate the ionic composition of irrigation water in most of the studied wells.

Groundwater in all the studied aquifers is low sodium water (S_1) as SAR is less than 10, and high salinity water (C_3) as E.C. value is ranged from 1120 micromhos/cm to 1910. It could be concluded that the groundwater is classified as (C_3 S_1), moderate water class (Richards ,1954) .

This water can not be used even with adequate drainage and a special management for salinity control may be required and crops with good salt tolerant should be selected.

TABLE 3. Chemical composition of ground water in Tushka area.

Well No	EC dS/m	Cations (meq/l)				Anions (meq/l)				SAR	Adj. SAR
		Ca	Mg	Na	K	Cl	HCO_3	CO_3	SO_4		
3	1.43	3.60	2.23	8.80	0.14	4.15	2.6	-	9.57	4.4	1.92
6	1.38	3.30	1.90	4.45	0.08	4.2	2.5	-	9.26	4.8	1.92
8	1.12	3.15	2.25	6.35	0.15	2.39	2.5	-	6.33	3.8	1.88
9	1.49	4.65	1.20	9.58	0.09	9.15	2.5	-	5.19	5.2	1.98
10	1.91	5.10	2.65	11.89	0.17	6.75	2.2	-	11.92	4.6	1.93
11	1.56	3.70	2.85	10.00	0.14	7.15	2.5	-	7.02	3.8	2.02

Land suitability assessment for certain crops

The average of the measurable soil characteristics and some limiting factors of the studied soil profiles are presented in Tables 4 and 5. Classification of these profiles has been carried out according to soil Taxonomy (1975). They belong to order Entisols.

The application of the computer program including 8-digit code - system representing the well defined soil parameters, gives the suitability indices for 15 crops as recorded in Table 5. The mean of the calculated indices for each profile

TABLE 4. Soil parameters of the studied profiles.

Soil Properties	Number of the Studied Location (Sites)												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Gravel (%)	1.40*	11.60	33.58	26.35	23.62	30.49	11.48	33.32	40.01	37.67	35.03	48.03	58.09
Textural Class	S	S	S	LS	LS	S	LS	LS	S	S	S	LS	S
$CaCO_3$ (%)	11.17	8.84	11.39	8.7	8.55	8.06	8.14	4.96	3.59	7.12	4.03	4.91	7.59
Salinity mmhos/Cm	2.22	1.34	0.19	0.50	0.2	0.33	0.54	1.80	0.32	0.20	0.2	0.91	0.23
Drainage	PD	PD	WD	MWD	PD	MWD	MWD	WD	MWD	WD	WD	PD	WD
SAR	5.33	6.81	1.75	1.94	1.25	3.4	4.36	8.30	4.29	1.23	0.9	4.07	2.32
Slope (%)	0.5-2	0.5-2	0.5-2	0-0.2	0-0.2	0.5-1	0.5-1	0-0.2	0-0.2	0-0.2	0-0.2	0-0.2	0-0.2
pH	7.55	7.87	7.06	7.35	7.40	7.74	7.85	7.80	7.85	7.43	7.73	7.60	7.27
Profile Depth (Cm)	55	60	55	50	60	70+	65+	75+	90+	75+	75+	75+	80
BulkDensity(g/Cm)	1.66	1.58	1.72	1.50	1.56	1.58	1.60	1.80	1.64	1.62	1.65	1.71	1.54
Available Water (Cm /m)	4.2	5.4	4.6	8.2	7.1	5.5	4.5	4.8	4.9	5.2	4.4	4.2	4.8

Soil Properties	14	15	16	17	18	19	20	21	22	23	24	25
Gravel (%)	25.28	41.38	27.02	25.02	28.95	23.91	30.92	28.45	38.16	25.02	25.02	7.42
Textural Class	S	S	LS	S	S	SL	S	LS	SL	S	S	S
$CaCO_3$ (%)	5.03	5.67	4.12	6.29	4.87	9.83	5.21	4.04	5.83	10.36	2.48	6.86
Salinity mmhos/Cm	0.35	0.68	0.60	0.35	0.27	0.49	0.18	0.57	0.19	0.19	0.27	0.32
Drainage	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	MWD
SAR	2.33	3.26	2.08	2.80	1.15	2.29	1.64	2.07	1.51	1.61	2.46	3.51
Slope (%)	0-0.2	0.5-2	0.5-2	0.5-1	0.5-1	0-0.2	0-0.2	0-0.2	0-0.2	0.5-1	0.5-1	0.5-1
pH	7.83	7.46	7.46	7.61	7.75	7.30	7.90	7.58	7.78	7.78	7.46	7.72
Profile Depth (Cm)	85	85	90	90	100	100	125	150	125	125	125	150
BulkDensity(g/Cm)	1.55	1.45	1.61	1.64	1.65	1.66	1.60	1.55	1.57	1.65	1.64	1.62
Available Water (Cm /m)	6.9	8.4	5.3	5.0	4.8	4.5	3.8	6.8	5.6	5.1	5.3	5.8

*The figure in this table represent the average of figures in the different layers of the profile.

TABLE 5. The calculated suitability indices for various crops in studied profiles.

The Studied Crops	Suitability Indices for Various Crops in Studied Profiles (IS)											
	1	2	3	4	5	6	7	8	9	10	11	12
Wheat	0.18	0.18	0.32	0.41	0.22	0.32	0.20	0.23	0.32	0.32	0.32	0.21
Clover	0.13	0.25	0.28	0.39	0.19	0.28	0.48	0.14	0.28	0.28	0.28	0.19
Sugar cane	-	0.08	0.26	0.27	0.07	0.18	0.16	0.21	0.21	0.24	0.24	-
Rice	0.38	0.40	0.22	0.35	0.30	0.25	0.44	0.21	0.25	0.22	0.22	0.31
Onions	0.22	0.23	0.28	0.39	0.19	0.28	0.24	0.24	0.28	0.28	0.28	0.20
Corn	0.12	0.25	0.28	0.39	0.19	0.28	0.48	0.14	0.28	0.28	0.28	0.20
Cotton	0.10	-	0.36	0.35	0.10	0.26	0.18	0.26	0.29	0.33	0.33	0.08
Sorghum	-	0.11	0.34	0.38	0.10	0.31	0.23	0.27	0.27	0.37	0.37	-
Millet	0.22	0.23	0.39	0.50	0.24	0.39	0.18	0.24	0.39	0.39	0.39	0.25
Groundnuts	0.19	0.39	0.42	0.54	0.25	0.42	0.38	0.19	0.42	0.42	0.42	0.28
Carrots	0.19	0.39	0.42	0.54	0.25	0.42	0.38	0.19	0.42	0.42	0.42	0.28
Potatoes	0.07	0.12	0.37	0.33	-	0.22	0.21	0.14	0.30	0.32	0.32	-
Watermelon	0.34	0.35	0.39	0.50	0.24	0.39	0.35	0.33	0.39	0.39	0.39	0.25
Tomatoes	0.34	0.35	0.39	0.50	0.24	0.39	0.35	0.33	0.39	0.39	0.39	0.25
Beans	0.37	0.39	0.39	0.50	0.24	0.39	0.47	0.37	0.39	0.39	0.39	0.25
Mean	0.21	0.28	0.35	0.43	0.19	0.32	0.47	0.23	0.32	0.33	0.33	0.19
Suitability class	S_5	S_4	S_4	S_4	S_5	S_4	S_4	S_5	S_4	S_4	S_4	S_5

The Studied Crops	Suitability Indices for Various Crops in Studied Profiles (IS)												
	13	14	15	16	17	18	19	20	21	22	23	24	25
Wheat	0.23	0.32	0.32	0.41	0.32	0.32	0.50	0.32	0.41	0.50	0.32	0.32	0.41
Clover	0.22	0.28	0.28	0.39	0.28	0.28	0.50	0.28	0.39	0.50	0.28	0.28	0.50
Sugar cane	0.18	0.25	0.25	0.36	0.25	0.25	0.45	0.25	0.36	0.45	0.23	0.24	0.30
Rice	0.18	0.22	0.22	0.31	0.22	0.22	0.40	0.22	0.31	0.40	0.22	0.22	0.45
Onions	0.22	0.28	0.25	0.39	0.28	0.28	0.50	0.28	0.39	0.50	0.28	0.28	0.50
Corn	0.22	0.28	0.28	0.39	0.28	0.28	0.50	0.28	0.39	0.50	0.28	0.28	0.50
Cotton	0.23	0.35	0.35	0.46	0.35	0.35	0.55	0.35	0.46	0.55	0.32	0.33	0.36
Sorghum	0.25	0.35	0.35	0.44	0.35	0.35	0.55	0.35	0.44	0.55	0.39	0.35	0.45
Millet	0.28	0.39	0.39	0.50	0.39	0.39	0.61	0.39	0.50	0.61	0.39	0.39	0.61
Groundnuts	0.30	0.42	0.42	0.54	0.42	0.42	0.66	0.42	0.54	0.66	0.42	0.42	0.84
Carrots	0.30	0.42	0.42	0.54	0.42	0.42	0.66	0.42	0.54	0.66	0.42	0.42	0.84
Potatoes	0.20	0.35	0.35	0.47	0.35	0.35	0.55	0.35	0.47	0.55	0.28	0.30	0.34
Watermelon	0.28	0.39	0.39	0.50	0.39	0.39	0.61	0.39	0.50	0.61	0.39	0.39	0.37
Tomatoes	0.28	0.39	0.39	0.50	0.39	0.39	0.61	0.39	0.50	0.61	0.39	0.39	0.77
Beans	0.28	0.39	0.39	0.50	0.39	0.39	0.61	0.39	0.50	0.61	0.39	0.39	0.77
Mean	0.24	0.33	0.33	0.45	0.33	0.33	0.55	0.33	0.45	0.55	0.33	0.33	0.71
Suitability class	S_5	S_4	S_4	S_4	S_4	S_4	S_3	S_4	S_4	S_3	S_4	S_4	S_4

defines its general suitability class according to the ranges illustrated in Table 4 but not for specific crops. Grouping of the investigated profiles into suitability classes for certain crops (15) is presented in Table 5.

It could be concluded from the data in Tables 2 and 5 that most of the soils of Tushka area are considered suitable lands for cultivating a wide variety of crops. According to the suitability classification of FAO (1976) and Sys *et al.* (1991 a,b), and (1993).

These lands can be grouped into two categories

1- Suitable (S_1, S_2, S_3, and S_4): These include most of the deep profiles, medium textured, slightly to moderately saline, slightly to moderately calcareous, well drained and having almost leveled surface.

2- Non - suitable or conditionally suitable (S_5) : These lands required specific management practices and proper choice of crops. This order is mostly shallow soils, gravelly, highly saline and calcareous with hardpans. This kind of lands can be reclaimed in the future if an appropriate drainage network is constructed and soil leaching is conducted accompanied by a good drain age system.

The studied profiles which represent 150 investigated soil profiles in the soils of Tushka area can be classified into arbitrary defined land suitability according to the values of the land index (Table 6) as follows:

Class 3 (S_3). This class includes most of the studied soils (profiles 19,22 and 25). The lands in this class can be cultivated with wide range of crops with moderate limitations. Some profiles in this class have shallow depth, coarse to medium texture, mostly saline to slightly saline and classified as Typic Torripsamments.

Class 4 (S_4). The suitability indices range between 0.25-0.50. Therefore, cultivation of the lands of this class requires severe limitations. Some field crops can be grown and gives 50-75% of the optimum yield. Profiles 2, 3, 4,6,7. 9, 10. 11, 14, 15, 16, 17, 18, 20, 23, and 24 represent this class and classified as Typic Torriorthents.

Class 5 (S_5). These soils can be considered non-suitable lands for cultivating most crops as their suitability indices for most of the studied crops are less than 0.25. profiles 1,5,8, 12, and 13 represent this class and classified as Lithic Torripsomment and Lithic Torriorthents.

Severe limitations, which can be partially overcome in such soils, are particularly salinity hazards and shallowness of soil profiles (55-60 cm). The foregoing discussion shows that the prevailing conditions in the soils of Tushka area have some defects such as shallowness of rooting zone stoniness, low moisture , in some cases, high salinity levels.

In conclusion, it is worth mentioning to note that in spite of the fact that appreciable area is suitable for cultivation and irrigation agriculture, yet economical studies should proceed for its evaluation. The irrigation source should be secured either by conveyance of lake Nasser water or by wells.

In short, the present investigation showed that the studied area (Tuskha area) is potential from the agricultural point of view. The area is recommend for development provided that the following recommendations are taken into consideration.

Firstly, detailed soil survey should be applied, prior to reclamation. This is to impose sharp delineation and to estimate the cost of development including land leveling. Secondly, the soil classification map should, be consulted, the Typic Torriorthents may be cultivated with fruit trees having roots of medium penetration together with other selected field crops. For the Typic Torripsamments, fodder plants may be convenient, bearing in mind that the filtration rate of the soils is high and the water requirements together with the conveyance loses should be calculated. The Lithic Torripsamments and Lithic Torriorthents should better be considered for non-agricultural purposes.

TABLE 6. The suitable crops for each class according to the obtained suitability classes.

Suitability Class	Suitable crops	Profile No.
S_3	Beans, Watermelon, Tomatoes, Groundnuts, Carrots and Millets.	19, 22, 25
S_4	Wheat, Cotton, Beans, Potatoes, Sorghum, Groundnuts, Carrots and Millets	2, 3, 4, 6, 7, 9, 10,11, 14,15, 16, 17, 18, 20, 21, 23, 24
S_5	Beans, Corn, Sunflower, Watermelon, Onions, Cotton, Tomatoes and Carrots.	1, 5, 8, 12, 13

Conclusion

In conclusion, it is worth mentioning to note that in spite of the fact that any appreciable area is suitable for cultivation under irrigated agriculture, yet feasibility studies should proceed the implementation.

The present study reveals that the soils of Tuskha area have their potentiality from the sustainable agricultural development point of view. The area is recommended for agricultural development providing that the following recommendation should be taken into consideration:

1 .The possibility of creating new varieties of different crops that can endure drought, high salinity, high and low temperature changes, self-resistance to agricultural pests through the utilization of advanced scientific methods of genetic engineering and fiber cultivation.
2 .Modern irrigation system should be applied.
3 .The climatic conditions should be considered when planning for crop rotation. Further microclimate studies may be needed.
4 .The most promising lands are marginally suitable for agricultural development. The remedial measures recommended are those related the improvement of soil fertility and structure.

Noteworthy to state that establishment of shelter belt in the crucial measure to determine the passive impact of wind erosion and, in turn, increasing land productivity.

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مدى ملاءمة أراضى ومياه منطقة توشكى بجنوب الوادى للتنمية الزراعية المستدامة

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تعتبر أراضى منطقة توشكى بجنوب الوادى - مصر من اكثر المناطق للتنمية الزراعية المستدامة فى مصر. وتهدف هذه الدراسة إلى تقييم أنواع الآراضى السائدة فى منطقة توشكى والمياه ومدى ملائمة كل من الاراضى والمياه للإنتاج الزراعى. ولإجراء هذه الدراسة تم اختيار ٢٥ قطاعاً أرضياً وصنفت مورفولوجياً فى الحقل وحللت خصائصها الطبيعية والكيميائية معملياً وتتبع تحت المجاميع التالية :

Typic Torripsamments, Lithic Torripsamments. Typic Torriorthents. Lithic Torriorthents.

وقوام تلك الآراضى خشن ويتراوح بين الرملي والحصوى والرملى والطمى ولكن القوام السائد هو الرملى الخشن المختلط بالحصى. وتتكون من طبقات متتابعة من الرمل الكوارتزى الخالى أو المختلط بالحصى وأكاسيد الحديد أو مكتنفات جيرية . وتعتبر هذه الآراضى حديثة التكوين والتطور لأنها تخلو من التكوينات البيدولوجية ومعظم خصائصها تكون موروثه من مادة الآصل.وقد أظهرت نتائج تحليل مياه الآبار بان تركيز الآملاح بالمياه يتراوح بين ٧١٦,٨-١٢٢٢,٤ جزء فى المليون وأن هذه النوعية من المياه تعتبر جيدة أو متوسطة الجودة لرى المحاصيل والآغراض الزراعية.وقد استخدم فى هذه الدراسة بعض صفات الآراضى التى لها تأثير مباشر على نمو المحاصيل . كما اخذ فى الاعتبار الاحتياجات الضرورية للمحاصيل تحت الدراسة وتم عمل برنامج خاص باستخدام الحاسب الآلي لتحديد مدى ملائمة هذه الآراضى لنمو ١٥ محصول اقتصادى.

وقد أوضحت نتائج هذه الدراسة أن أراضى منطقة توشكى يمكن تقسيمها إلى ٣ أقسام هى :

(S_3): أراضى متوسطة القدرة لنمو عدد كبير من المحاصيل تحت ظروف عوامل محددة .

(S_4) : أراضى يمكن زراعتها باتباع إجراءات خاصة لنمو القمح ، القطن - السمسم والبطاطس، وغيرها.

(S_5): أراضى غير مناسبة للزراعة حيث يتوقع أن ينخفض المحصول لأكثر من ٥٠٪.

وقد وجد أيضا أن العوامل التى تؤثر على تقسيم وتقييم أراضى منطقة توشكى تبعا لمدى ملاءمتها للزراعة هي القوام وعمق القطاع الأرضي والملوحة. لذا يجب الاهتمام بعمليات الخدمة الزراعية والاحتياجات الغسيلية لتكون الاراضى ملائمة للإنتاج الزراعى والتنمية الزراعية المستدامة.