c) *Collecting galleries.*

The most extensive gallery development is at El Qasr.

4.2.2. Water resources at El Omayed area.

We do not have enough information about the hydrology in the test-area of El Omayed. The main water resources are :

- about 13 cisterns which are used for drinking animals but only few are in operation,
- pipeline which is used for supplying fresh drinking water for people and animals,
- surface runoff which is abundant from Khashm El Eish ridge to the non-saline depression, but needs proper management to make full use of the amounts recieved.

Drilled wells (FAO 1970) which are equiped seem to be unknown in El Omayed area. There is only one well (Fig. 12) where water is of high salinity and was used only during the widening of the main road of the first rocky ridge.

It should be pointed out that the availability of water in soil is modified by topographic and edaphic variations in the region. In general, depressions would receive more than average, and ridges would keep less than average rain water due to run-off. Coarse sandy soils as those of sand dunes may act as storehouses of rain water due to easy penetration of water through non-capillary pores ; water is rarely lost through run-off and evaporation, while considerable amounts of water may be lost on the surface of heavy soil. Thus, it is obvious that soil studies are important in assessing the quantity and the effectivity of water resources.

4.3. SOIL RESOURCES.

Decision-makers need to know constraints on soil use. Therefore, it is advisable to prepare a simple synthetic document which summarizes the main controlling soil factors. In order to achieve this, we adopted a special system for classification of soil resources. Numerous studies proposed various methodologies (e.g. USDA, FAO etc ...), but in our case, it seemed appropriate to apply a system already employed in southern Tunisia which has very similar ecological conditions to our test-area (PONTANIER et VIELLEFON 1977 ; ESCADAFAL 1979 ; MTIMET 1980 ; FLORET et PONTANIER 1982).

Accordingly we may distinguish and map three types of land : irrigable, rain-fed cultivated and noncultivable.

4.3.1. Criteria of land classification.

The soil map is taken here as a basis of mapping of land resources. Topographic, climatic and socio-economic conditions are also taken into account.

Land classification criteria are based on the following five main edaphic variables :

a) *Thickness of penetrable layer* : This determines water supply and the volume of soil exploited by roots. The penetrable layer of soil includes the friable horizons over the bedrock. We consider three thickness classes* :

Thickness > 80 cm (index 1) : Penetrable layer is adequate for good development of root system, and its uptake of essential water and nutrients. The land may be used for irrigated or rain-fed cultivation.

Thickness between 80 and 40 cm (index 2) : Water supply and root system volume are just sufficient for rain-fed cultivation but not deep enough for irrigation (water-logging, asphyxia and salinization hazards).

Thickness < 40 cm (index 3) : The soils of this category are neither cultivable nor irrigable. Only range utilization is possible.

b) *Texture and nature of the penetrable layer* : Texture, particularly of surface horizons, controls the penetration of rain and irrigation water. It has also an effect on erosion, and accordingly on the vulnerability of soil to wind deflation and run-off. In El Omayed area, wind deflation is the main controlling effect, since the texture of soil is mostly sandy, and sometimes sandy silt to silty in salt-affected areas (saline depression).

Concerning the nature of the penetrable layer, the extremely high calcium carbonate content of coastal sand dunes leads to the distinction of two types of sandy layers : excessively calcareous sand (s"), and calcareous sand (s.s').

c) *Nature of the bed-rock* : The bed-rock under the penetrable layer may act as a limiting factor, and may impede deep penetration of the root system and of water. It may be either a pedological horizon as slab (D) and calcareous incrustation (E) the geological bed-rock itself, calcareous sandstone (G), most often in the form of consolidated oolitic dunes.

d) *Salinity* : Salinity in the surface horizon (0-60) becomes a real constraint, especially to rain-fed cultivation, when the conductivity of the saturated paste extract exceeds 8 mmohs-cm. This limit characterises the

*The limits of these classes indicate only the mean depth of soil (± 10 cm).

salsodic class (C.P.C.S.). Beyond a conductivity of 20 mmohs-cm, the constraint is so great that it impedes land cultivation to a great extent. In fact, several factors contribute to determining the threshold, such as texture, slope, water table, and other factors. Thus sandy soils with salinity above 20 mmohs-cm and sometimes more, can be irrigated after salt leaching and setting up a suitable drainage network. Morever, we may distinguish two classes : C1 (conductivity between 8-20 mmohs-cm), and C2 (conductivity > 20 mmohs-cm).

e) *Slope :*

Slope is an important factor in selecting irrigated areas. If, for example, the slope is between 2-5 %, installations become very expensive. This is also the case with irregular detailed topography. We may represent on the map one class : P : slope between 2-5 % or irregular topography.

In fact the topographic map is not accurate enough to make suitable limits.

4.3.2. Land resources map (Fig. 14).

The combination of the edaphic features and their magnitudes provide a base for the classification of land resources :

a) *Class I. Irrigable lands.*

Depth > 80 cm, sandy or silty sandy soils in flat areas (slope 0-2%). As a function of soil salinity, we may distinguish :

Class 1a : not sensitive to sterilization by salts,
Class 1b : sensitive to sterilization by salts.

b) *Class II. Rainfed cultivable land.*

Less deep than previous soils (< 80 cm). They are located in less favourable areas (slope 2 to 5 %, or irregular topography). These sandy soils are always sensitive to wind erosion.

c) *Class III. Non-cultivable land.*

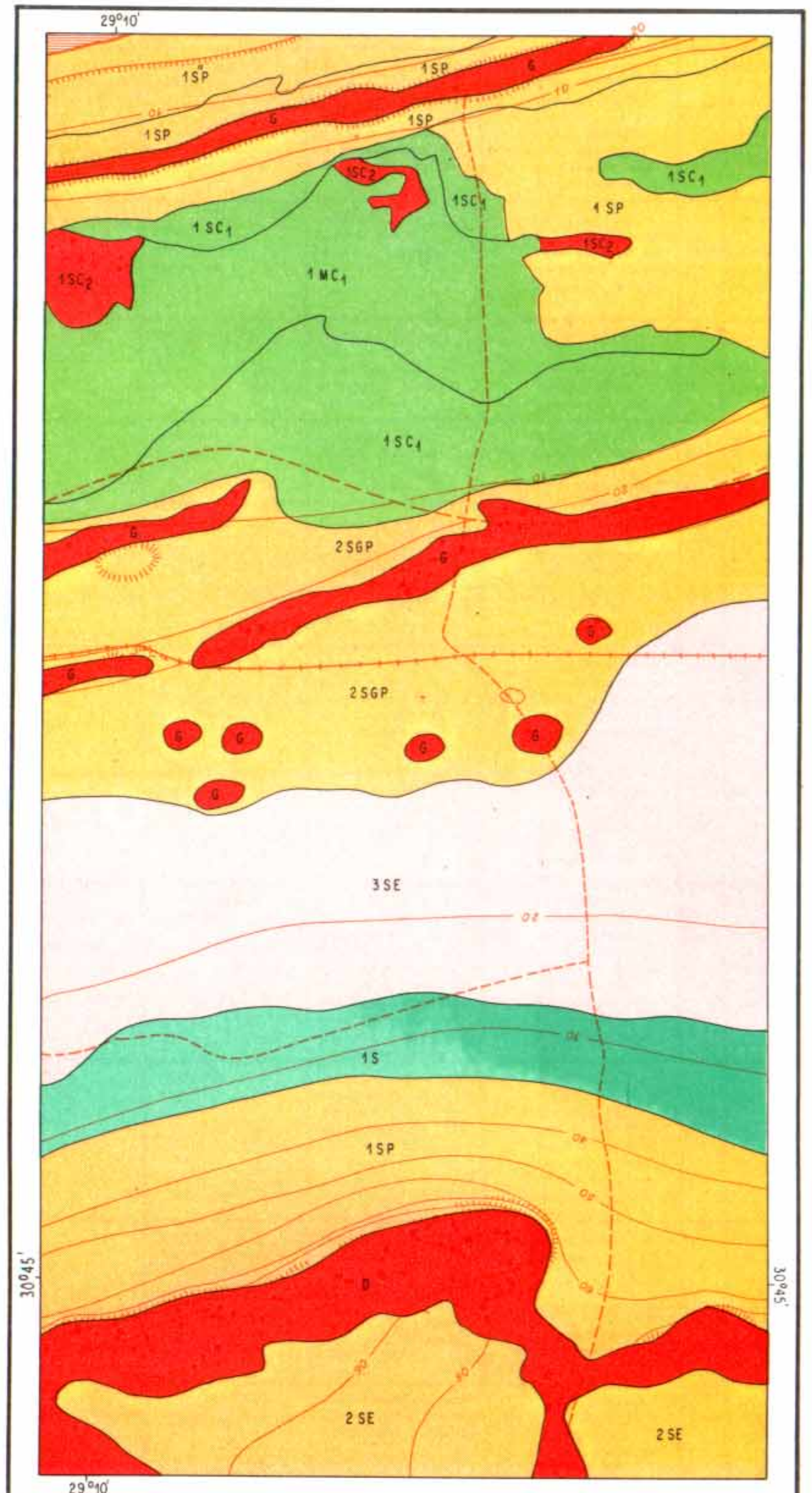
Shallow soil depth (< 40 cm) or excessive salinity (C > 20 mmohs/cm) make cultivation impossible. The only use is for pasture. As a function of soil texture of surface horizon, we may distinguish :

Class IIIa : sensitive to wind erosion,
Class IIIb : not sensitive to wind erosion or salinization, but already degraded.

Each mapping unit (soil family) on the soil map forms a basis for the classification and mapping of land resource units. So the same soil family can be arranged with other families for setting up a land class. A family

POTENTIAL LAND RESOURCES MAP FOR AGRICULTURAL DEVELOPMENT

EL OMAYED TEST-AREA



Drawn Jan. 1983 C.E.P.E. L. Emberger.

Scale 1: 50 000

Contour interval : 10 m

Figure 14

LEGEND

EDAPHOLOGICAL CHARACTERISTICS OF THE DIFFERENT UNITS OF THE LAND RESOURCES MAP FOR AGRICULTURAL DEVELOPMENT

Thickness		1			2	3	Bedrock (rocky out-crop) on the surface	
Texture		S''	S	M	S	S	D	G
Slope $< 2\%$	Non-saline $C < 8$ mmhos/cm		1S		2 SE	3 SE	D	G
	Saline $8 < C_1 < 20$ mmhos/cm		1 SC_1	1 MC_1				
	Very saline $C_2 > 20$ mmhos/cm		1 SC_2					
Slope $2 < P < 5\%$, or very irregular topography		1 S''P	1 SP		2 SGP			

CLASSES OF LAND RESOURCES

. Class I. Irrigable land

a — Not sensitive to sterilization by salt

b — Sensitive to wind erosion and sterilization by salts

. Class II. Rainfed cultivable land

Sensitive to wind erosion. Locally irrigable if slope and thickness of the soil allow

. Classe III. Non-cultivable land

a — Sensitive to wind erosion

b — Not sensitive to wind erosion or salinization, but already degraded

EDAPHOLOGICAL FEATURES

Thickness of the penetrable layer

1. $z > 80$ cm
2. $40 < z < 80$ cm
3. $0 < z < 40$ cm

Texture and nature of the penetrable layer

S'' . Sandy texture (excessively calcareous sand)

S(S'). Sandy texture (calcareous to very calcareous sand)

M . Silty sand texture (to sandy silt)

Slope (P) :

. $2 < P < 5\%$ (or very irregular detailed topography)

. Without symbol : $P < 2\%$

Nature of the bed-rock

D . Calcareous slab

G . Limestone (consolidated oolitic dune)

E . Calcareous incrustation over calcareous sand stone

. Without symbol : the bedrock does not appear to 120 cm depth

Conductivity (C) of saturated paste extract (0 - 60 cm)

C_1. $8 < C_1 < 20$ mmhos/cm

C_2. $C_2 > 20$ mmhos/cm

. Without symbol : $C < 8$ mmhos/cm

TABLE 21 : SYNOPTIC TABLE OF GENERAL ECOLOGICAL CONDITIONS AND LAND RESOURCES

PHYSIOGRAPHIC SYSTEMS	PHYSIOGRAPHIC UNITS N°	PHYSIOGRAPHIC UNITS UNIT	PRESENT LAND USE	SOILS	EDAPHOLOGICAL CHARACTERISTICS SYMBOL	EDAPHOLOGICAL CHARACTERISTICS CHARACTERISTICS	POTENTIAL LAND RESOURCES CLASS	POTENTIAL LAND RESOURCES LAND RESOURCES
COASTAL SYSTEM	1	Beach						
	2	Coastal sand dune	uncultivated land	Raw mineral soil over excessively calcareous sand dune (Typic torripsamments)	1S"P	Deep and very sandy soils with more of 80% calcium carbonate - very irregular topography	II	Rainfed cultivable land (planting fig-trees without ploughing) ; very sensitive to wind erosion, fixation of dune with *Elymus farctus*
RIDGES AND DEPRESSIONS SYSTEMS	3 4 5	First depression Northern slope of the first rocky ridge Southern slope of first rocky ridge	Fig-trees, pastures	Slightly evolved soils ; modal grey subdesertic soils over very calcareous sand (Typic torripsamments)	1SP	Deep sandy soil with 30-50% of calcium carbonate ; slope between 2-5% and more (except in the first depression)	II*	Rainfed cultivable land (fig-trees, cactus) sensitive to wind erosion. Locally irrigable in the first depression
	6 8 10	First rocky ridge (1RR) Second rocky ridge (2 RR) Third rocky ridge (3 RR)	Human settlement, pastures	Lithosol over limestone (Lithic torriorthents)	G	Very shallow soils (< 40 cm) with outcrop of limestone (consolidated oolitic dune)	III_b	Non cultivable land not sensitive to wind erosion but already degraded
	7a	Salt marsh	Halophytic plant (*Halocnemum* sp.)	Salsodic soils : very saline with degraded structure (Typic salorthids)	$1SC_2$	Conductivity > 20 mmhos/cm. Shallow saline water table (about 1m.deep)	III_b	Non cultivable land Not sensitive to wind erosion
	7b	Hummocky depression	Pastures, barley	Salsodic soils (Typic calciorthids)	$1MC_1$	Conductivity between 8-20 mmhos/cm ; silty sand texture	Ib**	Irrigable land sensitive to wind erosion and to sterilization by salts
			Pastures	Slightly evolved soils = saline grey subdesertic soils (calcic gypsiorthids)	$1SC_1$	Conductivity between 8-20 mmhos/cm mainly under 50-60 cm depth. Sandy texture (with silty gypsiferous sand)	Ib***	Irrigable lands , sensitive to the wind erosion and to sterilization by salts
	7c	Sandy mesodeposits	Fig-trees	Slightly evolved soils = modal grey subdesertic soils (typic torripsamments)	1SP	Deep sandy soils (slightly saline about 2m deep and more). Very irregular topography and often slope between 2-5%	II	Rainfed cultivable land (fig-trees). Very sensitive to wind erosion
	7d	Sandy indurated convexities	Human settlement	Lithosol over limestone (lithic torriorthents)	G	Very shallow soils (< 40 cm) with outcrop of limestone (consolidated oolitic dune)	III_b****	Non cultivable land
	9 11	Inter-ridges sandy slopes Southern sandy slopes	Fig-trees, pastures	Slightly evolved soils - modal grey subdesertic soils, locally moderately deep lime accumulation in amas and nodules, sometimes calcareous incrustation. (Typic torripsamments)	2SGP	Moderately deep sandy soils over consolidated oolitic dune (between 40 and 80 cm depth, sometimes more or less). Slope between 2-5%.	II*****	Rainfed cultivable land (fig-trees, cactus), locally irrigable when slope < 2%. Very sensitive to wind erosion
	12	Non saline depression	Pastures	Calcimagnesic soils with calcareous incrustation (Typic calciorthids)	3SE	Shallow sandy soils over calcareous incrustation and shelly hard sandstone (about 1m depth). Often salt-affected in depth	IIIa	Non cultivable land sensitive to wind erosion. Range management
	13	Sandy glacis	Pastures and fig-trees (fans at the foot of gullies)	Slightly evolved soils = modal grey subdesertic soils, locally moderately deep calcareous accumulation in amas and nodules (Typic torripsamments)	1S	Deep sandy soils slope < 2%	Ia	Irrigable land Not sensitive to the sterilization by salts but sensitive to wind erosion
					1SP	Deep sandy soils ; slope between 2-5% with gullies	II	Rainfed cultivable land (fig-trees, cactus). Very sensitive to wind erosion
INLAND PLATEAU SYSTEM	14	Cliff and outcrop of Inland plateau	Pastures	Calcimagnesic soils with calcareous slab (Typic paleorthids)	D	Very shallow soils over calcareous slab, locally saline by patches	IIIb	Non cultivable land Not sensitive to wind erosion
		Undulating sandy surface		Slightly evolved soils = modal grey subdesertic soils, moderately deep calcareous incrustation (typic torripsamments)	2SE	Moderately deep sandy soils over calcareous incrustation (between 40 and 80 cm depth sometimes more or less)	II******	Rainfed cultivable land sensitive to wind erosion

* Laterally some salt marsh in the first depression
** Drainage and leaching of salts will be required
*** Drainage will be required . Type and frequency of irrigation and crops have to be adapted to this type of soil
**** Very small areas
***** - almond-tree - olive-tree
****** Rainfall seems not sufficient for fig trees or cactus. Good pasture.

could also share others in several classes (as a function of slope for instance).

Each class on the map of land resources is represented with a specific colour, as an index which sums up levels of the five main edaphological features.

The Table 21 gives a synoptic view of ecological conditions and land resources.

4.4. PLANT RESOURCES.

4.4.1. Rangelands.

The standing crop of above ground phytomass was estimated during october 1982 (which represents the end of the long grazing and dry period) using 100 randomly distributed quadrats, each of 4 m^2. In each quadrat, all the above ground organs were harvested except three shrubby species whose phytomass was estimated through a relationship between phytomass and dimensions. The harvested organs were weighed after cleaning in the field, and the samples were brought to the laboratory for water content determinations.

The dimensions of the shrubby species were converted to weights using the following regression equations :

Thymelaea hirsuta equation (SHALTOUT, in prep.)

$$y = 35.69 + 0.001\ x$$

Anabasis articulata equation (ABDEL-RAZEK 1976)

$$y = 0.363 + 0.6\ x$$

Limoniastrum monopetalum equation (calculated for the present study)

$$y = 0.154 + 0.079\ x$$

where :
- . x is the biovolume of the shrub in cm^3 in case of the first equation and in m^3 for the other two equations
- . y is the above ground phytomass of the shrub in gr. dry weight in the case of the first equation and in kg. dry weight for the other two cases.

This estimation is used to evaluate the highest and lowest seasonal production according to the rate of the seasonal variation in the standing crop phytomass which was calculated from EL GHAREEB (1975), EL BAYYOUMY (1976) and AYYAD *et al.* (1979). The difference between the highest and lowest seasonal values gives the approximate value of the net primary production (primary production after heterotrophic consumption) in mean rainfall conditions. Results are shown in the map and the legend of Figure 15. The relative contribution of the common species in the total above ground phytomass is given in