

# Gateway to National information on land, water and plant nutrition

## Country overview

Egypt forms the North-Eastern corner of Africa and, with an area of almost one million square kilometers, occupies nearly 3% of the total area of the continent.

Egypt measures 1262 km from west to east and 1073 km, between latitudes 22 and 32° N. This latitudinal location means that most of the country falls within Africa's dry desert region, except for a narrow strip along the northern coast which experiences a Mediterranean type of climate. These relatively favourable climatic conditions, in comparison with the desert areas to the south, have led to a concentration of rain-fed agriculture in the north-west coastal region.

### ■ Socio-economic features

#### ■ Population

Changing Patterns of Population and Arable Land in Egypt 1897 – 1999.

Year	Population	Arable Land	
		Total	Per Capita Land
		(million feddans)	(in feddans)
1897	9.7	4.9	0.51
1907	11.2	5.4	0.48
1917	12.8	5.3	0.41
1927	14.2	5.5	0.39
1937	15.9	5.3	0.33
1947	19	5.8	0.31
1960	26.1	5.9	0.23
1970	33.2	6	0.18
1980	42.1	6.1	0.14
1990	55	7.2	0.13
1999	65	7.8	0.12

#### ■ Ethnic origins of the people and population trends

Egypt is, after Nigeria, the most heavily populated state in Africa. Within the group known as the Arab World, Egypt is by far the most populated of the states, with double the population of the second most populated Arab nation, Morocco. In addition, Egypt has the dubious distinction of having the largest city in Africa and the Arab World. The importance of the population of Egypt is reinforced by a paradoxical land situation, where of the one million km<sup>2</sup> forming Egypt, only some 55 039 km<sup>2</sup> are inhabited, i.e. around 5.5 percent of the total area (CAPMAS 1985a, p.5). Some 99 percent of the population live in the inhabited area, while the remainder are scattered among the oases of the Western Desert, the Mediterranean coastal regions where rainfall allows for agriculture, the Sinai, and the Red Sea littoral.

As a consequence of the crowding the quasi- totality of the population in the Nile Valley and Delta, population densities in Egypt are among the highest in the world, rivalling the most crowded of the Asian states.

The geographic reality of Egypt, limiting the 'useful' area the country to the narrow strip of green hugging the banks of the Nile, and flowing into the Delta in the north, has had two major effects on the distribution of the population. Firstly, it has led to a high level of population density in the inhabited area. Secondly, within that inhabited area, the growth of cities in the last centuries, led by the spectacular growth of the Cairo metropolis, has further limited the cultivated area to some 2.4

percent of the area of the country, representing 23 928 km<sup>2</sup> (Waterbury 1983, p.42). The crowding of a large and increasing population within a restricted geographical area, bounded by inhospitable deserts to the east and west, and by the Mediterranean Sea in the north, has led to great degree of homogeneity within the population of Egypt.

The population of Egypt is typical of that of other Third World countries in particular respect: it is relatively homogeneous and has no sizeable ethnic minorities. Indeed, the ethnic minorities which do exist in Egypt are either located outside the mainstream of the Egyptian economy, for example, the Berbers in the Western Desert oases and the Bedouin in the Eastern Desert and Sinai, or, as in the case of the Nubians in the south, are too small to pose a problem for the homogeneity of the population .

In other respects, the population of Egypt exhibits trends shared by many other countries in the Third World. The high rate of population growth, although it is by no means one of the highest in the Third World (compared, for instance, to Nigeria) is nevertheless quite high. The problem of a high rate of growth of the population is compounded in Egypt by geographical factors rendering 95 percent of the land inhospitable and by a high rate of urbanization. Both factors have contributed to a dramatic increase in population density over the last fifty years. Moreover, despite a slight rise in the total cropped area from 10.79 million feddans in 1960 to 12.16 million in 1985, the rising population in rural areas has led to a decrease in the cropped area per agricultural worker from 3.33 feddans in 1960 to 2.8 in 1985. The harvested area per caput of the whole population is around 0.25 feddans (Dethier 1989, p. 4-5).

The trend of employment away from agriculture and into services is expected to continue. The political instability in some of the countries which receive Egyptian migrant labour, and the possibility that labour- importing economies in the Gulf may have reached their peak level of absorption, indicate the strong possibility of a return of migrant labour. Tentative figures for returning labourers show that they are employed either in government and public sector (27 percent), where their return increases disguised unemployment, or in construction and agriculture (Higher Specialized Councils 1984, p. 171). The return of migrant labour in the construction and agricultural sectors may have two effects. First, it should decrease child and female labour, and second, it may lead to unemployment in both sectors. This ought to lead to a reduction in agricultural and construction wage rates and increase the influx of labour into the urban informal sector.

The influx of increasing numbers of the rural population to Egypt's major cities is expected to continue. The full effects of such an increase are yet to be seen.

#### ▪ **Economy**

→ The role of agriculture in the country's economy

The Government of Egypt places great importance to the agricultural sector recognizing its significant role in the national economy. It accounts for about 20 percent of both GDP and total exports, and about 34 percent of total employment.

The agricultural sector contributes to the overall food needs of the country and provides the domestic industry with agricultural raw materials. It promotes industrial development through expanding the market for industrial goods such as pesticides, chemical fertilizers, equipment and machines. Also, agriculture helps in financing economic and social development through the capital outflow from agriculture to other sectors of the economy.

#### ▪ **Major food crops and cash crops and trend in production**

The cultivated area increased from 6.2 million feddans in 1982 to 7.8 million feddans in 1995 and the cropped area increased from 11.2 million feddans in 1982 to 14.4 million feddans in 1995 . It is targeted to reclaim about 150 thousand feddans yearly.

- The value of plant production increased from L.E. 3.5 billion in 1982 to L.E. 33.7 billion in 1995.
- The total production of the main strategic food crops has tangibly increased . The total production of cereals increased from 8 million tons in 1982 to 17.5 million tons in 1995. Wheat production increased from 2 million tons in 1982 to 6 million tons in 1996 Maize production increased from 3.3 million tons in 1982 to 5.8 million tons in 1996.
- Rice production increased from 2.4 million tons in 1982 to 5 million tons in 1996.
- The total production of vegetables increased from 8 million tons in 1982 to 14.5 million tons in 1996 and the total production of fruits increased from 2.6 million tons in 1982 to 6.6 million tons in 1996.
- The total production of sugar increased from 649 thousand tons in 1982 to 1.1 million tons in 1996. Sugar imports decreased to about 450 thousand tons in 1996.
- Yields of strategic food crops have increased . Yields of wheat increased from 9 ardabs per feddan in 1982 to 17 ardabs per feddan in 1996. Yields of maize increased from 11 ardabs per feddan to 21 ardabs per feddan. Yields of rice increased from 2.4 tons per feddan to 3.5 tons per feddans. Yields of sugar cane increased from 34 tons per feddan to 47 tons per feddan. Egypt occupies the first rank in the world with regard to the yield of rice and sugar cane.
- The yield of cotton in 1993 was the highest since 60 years i.e, about 8 kantars per feddan.
- The value of agricultural exports increased from L.E. 471 million in 1982 to L.E 2.0 billion in 1996.
- Credit facilities available to the agricultural sector increased from L.E. 1.2 billion in 1982 to L.E. 6.7 billion in 1996.
- State investments in the agricultural sector increased from L.E. 370 million in 1982 to L.E. 3.2 billion in 1995/1996.

#### ▪ **Food security**

Self sufficiency ratios of food crops have increased. There is self sufficiency of rice, vegetables, fruits, dairy products, poultry, eggs and fish and there is also a surplus for export of these crops. In 1995 our exports of potatoes amounted to about 450 thousand tons ,i.e., three times that of potato exports in 1994. Exports of oranges in 1995 amounted to about 200 thousand tons. The self sufficiency ratio of wheat increased from 25% in 1982 to 55% in 1996 and our wheat imports decreased from 6 million tons in 1982 to 5.3 million tons in 1995 in spite of the increase of population and increase of wheat total consumption from 8 million tons in 1982 to 11 million tons in 1995. As a result, Egypt was elected for the first time to Chair the International Wheat Council during the 1994/1995 session.

The food gap in Egypt is narrowing. Projections to the year 2000 now show a potential food gap that is only 17 percent (4.5 million tons) of the food gap projected in the early 1980's (26 million tons).

Net incomes of the farmers have improved by about 25%. The average annual rate of growth of agricultural production increased from 2.6% in the 1980's to 3.4% in 1990's.

#### ▪ **Crop diversification**

The cropping pattern in Egypt is somewhat adjusted to soil condition. In the Northern part of the Nile Delta, where soil salinity is somewhat high, crop rotation includes rice and cotton as the main summer crops and wheat and clover as the main winter crops. All these crops have proved to be salt - tolerant or semi - tolerant. Sugarbeet, which is known to be tolerant to salinity, ishas been grown in the Northern Delta and is now supporting a large sugar factory. Further expansion in sugarbeet production is planned in the newly reclaimed land west of the Delta.

## Climate

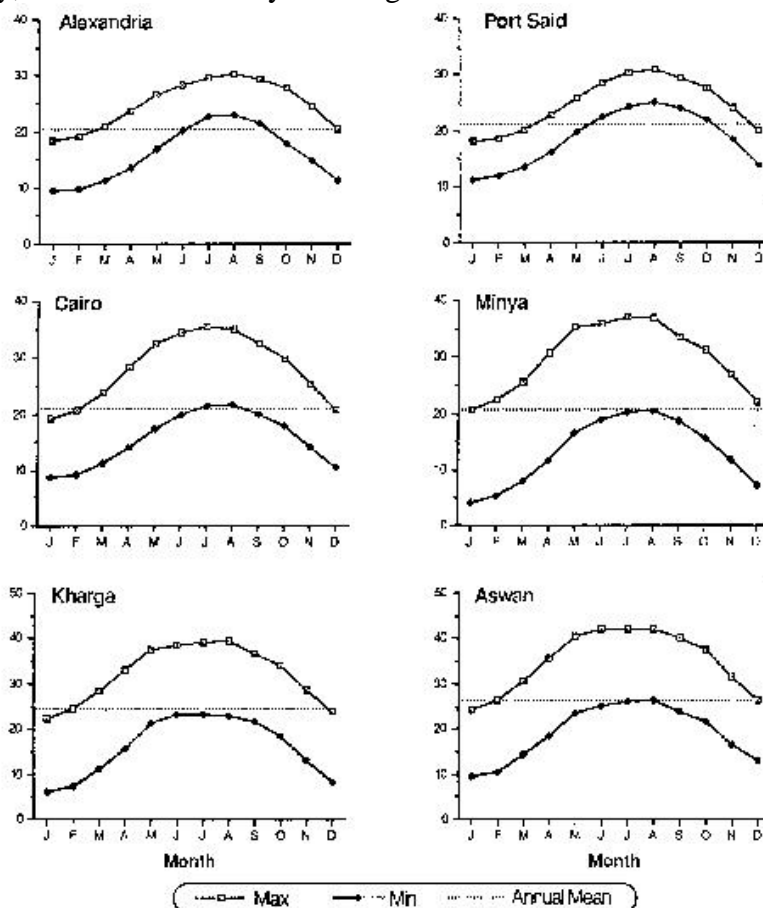
The climate of Egypt is governed mainly by its location in the north-eastern part of Africa on the margin of the largest desert in the world. Its latitudinal position, between 22° and 32° N place it firmly in the sub-tropical dry belt, although conditions on its northern coast are ameliorated by the presence of the Mediterranean Sea.

Egypt's climate can best be expressed as a contest between the hot, dry air masses over the Sahara and the cooler, damper maritime air masses from the north carried by eastward moving depressions. Throughout most of the year the hot, dry tropical continental air masses dominate, but during the winter period air masses of both tropical maritime and polar maritime origin make brief incursions into Egypt from the north, frequently bringing rain with them.

### Temperature:

The climate of a country is most simply described in terms of average values for variables such as temperature, humidity, and precipitation. There is, however, a danger with this approach of overlooking significant fluctuations which are of vital importance to agricultural activity. Given its latitudinal position, it is not surprising that over much of Egypt mean annual temperatures are high and register between 20 and 25 °C. Major variations occur between summer and winter temperature, as well as between coastal and interior locations.

Along the coast, mean maximum temperatures vary from 18-19 °C in January to 30-31 °C in July and August (Figure). For these same stations the mean minimum temperatures show variations from 9-11 °C in January, to 21-25 °C in July and August.



Mean maximum and mean minimum temperatures at selected stations, 1931 – 60

The temperature range between the maximum and minimum figures is between 6° and 10 °C. At a distance from the moderating influence of the Mediterranean at inland stations such as Minya, Kharga, and Aswan, the temperature range attains values as high as 16-17 °C. Here, the mean maximum temperatures are much higher in summer reaching figures of 37- 42 °C in June, July,

and August. In January, mean maximum temperatures are 20-24 o C. Mean minimum temperatures are lower in winter than at the coastal stations, with values in January of 4 - 9 o C. At this time, the coldest places are the oases of the Western Desert. In summer, the mean minimum temperatures rise to between 20 and 26 o C, to give values close to those of their coastal equivalents. In effect, the inland stations have higher maximum temperatures in summer and lower minimum temperatures winter.

The mean monthly temperatures do, however, conceal the very large daily fluctuations in temperature which occur in Egypt at certain times of year. This is so particularly in spring and early summer when khamsin winds prevail. The khamsin is a very hot and dry wind which brings dusty unpleasant conditions to much of upper Egypt and in the spring can cause considerable damage to newly emerging plants. Such winds are produced by eastward - moving depressions with centers tracking along the coastal fringe of northern Africa. In front of the depression, anticlockwise winds draw in tropical continental air from over the Sahara. These winds blow from the south and south-east and can bring temperature rises of up to 10 o C in a few hours. Such hot and dry conditions do not persist for long because cooler and moister air of Atlantic origin follows behind the depression causing temperatures to dip markedly. These cold fronts are often associated with squalls which produce ferocious, but short-lived, dust storms.

Khamsin conditions occur most frequently between February and June when there is still a marked temperature gradient between the air over the Mediterranean Sea and that over the Sahara. After June, conditions throughout the Mediterranean are much warmer and the depression tracks are displaced further northwards. In autumn, the depressions move south once again but, because warm temperatures still prevail over much of the region, the khamsin effect, although still present, is not as marked .

The timing of the khamsin is seen clearly in the table below which shows the number of occasions each month when the maximum daily temperature on consecutive days registered an increase of more than 5 o C.

Number of occurrences when the maximum temperature on consecutive days registered an increase of >5 °C (1970 - 3):

Month	Alexandria	Giza
January	0	2
February	8	4
March	18	17
April	17	20
May	13	15
June	10	8
July	1	2
August	3	1
September	0	0
October	7	6
November	2	2
December	1	1

### **Precipitation and evapotranspiration**

The key feature of the precipitation in Egypt is that there is very little and it is concentrated along the northern coastal zone. The rainy season is the winter period from October to May when the depressions follow their southern tracks over the Mediterranean region. Most of the precipitation is associated with the warm and cold fronts of these systems.

Many of the fronts are weak by the time they reach Egypt and rainfall is light and showery. Rainy periods usually last for one to four days.

Occasionally, however, an active system can produce substantial amounts of rainfall.

Although such falls are exceptional, Alexandria has received 47.9mm in a single day and Giza 53.2 mm.

The highest annual precipitation totals, reaching 180 mm, are recorded around Alexandria (Fig. 4). To the west, the Mediterranean coastal strip receives between 120 and 150 mm. From Alexandria eastwards, annual totals decline to about 80 mm at Port Said. Inland, there is a very sharp precipitation gradient with only 50 mm falling in the middle of the Nile Delta. By the time Cairo is reached the annual total has dropped to 22 mm. Further inland, it continues to decline until at Aswan a value of 1 mm is recorded. Over most of the interior of Egypt it is not unusual for a year to pass without any precipitation at all being recorded. Throughout Egypt rainfall reveals considerable variability over time and space. For example, at Alexandria a rainfall of 168 mm has been recorded in a single month, which represents about 95 percent of the long - term annual average. On the other hand, during ten months of the year at Alexandria none can be recorded at all and the remaining two months can have minimum values of 1 mm. At almost every other station in Egypt any month can be totally dry in a given year. Equally there are considerable variations over short distances in any one year. With the weak frontal systems, it is possible for it to have rain at one locality, while a few kilometers away no precipitation at all will be received. From the agricultural point of view, precipitation is of little value as everywhere in Egypt it is too meagre to permit reliable crop production.

#### **Egypt: mean annual precipitation, 1940 - 60**

As crop growth is only possible with irrigation, a knowledge of water losses is essential for planning water application rates. Unfortunately, relatively little accurate information is available on evaporation and transpiration and transpiration rates in Egypt. Many meteorological stations in Egypt contain Piche evaporimeters, but the validity of the results obtained from these instruments as an indication of true environmental water losses has been questioned. The data is available for class "A" evaporation pans at Giza and Aswan (Table below). These reveal maximum daily values in June of 12.9mm at Giza and 19.3 mm at Aswan. At Aswan the annual pan loss is close to 5 m, or about double that recorded at Giza.

**Table : Class "A "pan evaporation rates for selected stations in Egypt:**

Month	Evaporation (mm day <sup>-1</sup> )	
	Giza	Aswan
January	3.0	6.3
February	4.2	8.5
March	6.4	12.3
April	8.6	15.2
May	11.4	17.5
June	12.9	19.3
July	11.1	19.0
August	10.3	18.8
September	9.1	16.5
October	6.9	12.8
November	4.3	19.1
December	3.1	7.3
annual mean	7.6	13.6

Source: Ali (1978).

### **Climate and crops**

As far as agriculture is concerned, the critical climatic factors are those which occur during the growing cycle of the crops. What occurs happens at other times of the year is relatively unimportant. Given the warm temperatures throughout the year and the perennial irrigation system, Egypt has permitted the cultivation of both winter and summer crops. Traditionally, before the advent of perennial irrigation in the nineteenth century, the Nile Valley was characterized by winter crops, of which the most important was wheat. With the development of summer cultivation, crops such as cotton, rice, sugar cane, and millet became important (Beaumont and McLachlan 1985).

The most widely grown winter crop is wheat, which is cultivated along the whole length of the Nile Valley. The seeds are usually sown in early November following fallow, maize, or cotton. Harvesting takes place in late April or early May.

The first four weeks after sowing are a critical period for the wheat crop when the seeds germinate and the shoots emerge above ground level. This is followed by the main growth phase which includes maximum tillering (weeks 5-14), ear initiation (weeks 14-19), and flowering (weeks 19-22). Finally, between weeks 22 and 26 the ripening of the wheat occurs.

Although sowing dates vary somewhat between different parts of the Nile Valley, it is interesting to compare the wide range of climatic conditions tolerated by the wheat crop during its growth. For example, around Alexandria the range of temperatures experienced is relatively small compared with elsewhere in Egypt, and in particular when compared with Aswan. Similarly, the Alexandria and Nile Delta regions enjoy much more humid conditions than, for example, Aswan, where for most of the year relative humidity values are about one-half of those found in the north. With wind speed, it is the extremes of the country, at Alexandria and Aswan, where the highest values are recorded.

**Table (5): Penman potential evapotranspiration rates for selected stations in Egypt**

Month	Evaporation (mm day <sup>-1</sup> )			
	Alexandria	Giza	Aswan	Kharaga
January	1.2	2.0	2.2	2.2
February	1.7	2.7	3.2	3.1
March	2.5	3.5	4.1	4.2
April	3.1	4.9	5.5	5.8
May	4.1	6.2	6.8	7.0
June	4.6	6.7	7.8	7.9
July	4.7	6.8	7.6	7.5
August	4.5	6.3	7.5	7.6
September	3.5	5.3	6.4	6.5
October	2.4	4.0	4.4	4.6
November	1.4	2.3	3.0	3.1
December	1.1	1.6	2.2	2.2
Annual mean	2.5	4.4	5.1	5.1

Source: Ali (1978).

Perhaps most interesting is the fact that during the first twelve weeks of the crop's growth, that is until approximately the end of the period of increasing temperature, nearly all the stations record a decline in relative humidity. Despite these wide climatic variations, wheat is cultivated successfully throughout Egypt.

Cotton is the most important cash crop grown in Egypt and, like wheat, is grown along the length of the Nile Valley. It is, however, a summer crop and is cultivated between early

March and the end of August. For cotton, the first week after sowing, when germination and emergence of seedling takes place is a critical time. This as it is the time when the khamsin winds which can do enormous damage to the crop by shrivelling up the tender shoots of cotton as they emerge. The vegetation stage covers the next six weeks, when maximum tillering, boll initiation and flowering takes place. Finally, there is the ripening phase over four or five weeks when the bolls attain maximum size.

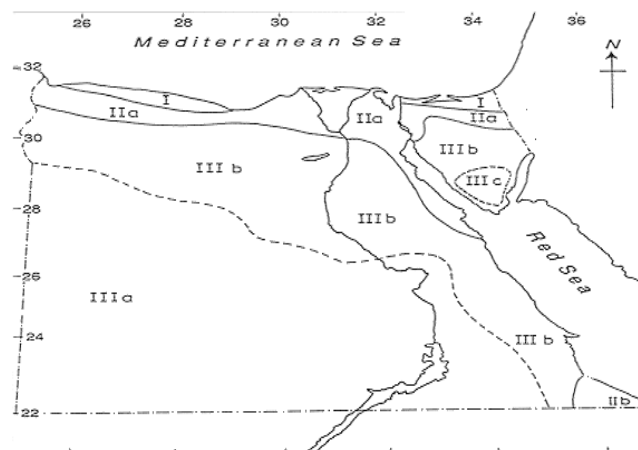
For the cotton crop, temperatures show a steady rise until the middle of the growth stage when boll initiation is taking place. Thereafter, temperatures remain remarkably steady. In contrast, relative humidity decreases at all inland sites during the same period. As for wheat, the largest temperature ranges experienced by cotton occur at inland sites. This data suggests that despite some unusual circumstances, climatic conditions in Egypt do not seem to impose very serious restrictions on the growth of the two most important crops.

### ■ Natural vegetation

Egypt is perhaps the most arid country North Africa. According to Ayyad and Ghabbour (1986), hot desert ecosystems cover all of Egypt and extend south to latitude 12 °N in Sudan. Such hot ecosystems are either arid or hyperarid and it is possible to distinguish between three main hyperarid and two arid provinces (Fig. below).

From a phytogeographical point of view, Egypt is the meeting point of floristic elements belonging to at least three phytogeographical regions: the African Sudano- Zambesian; the Asiatic Irano- Turanian; the Afro- Asiatic Saharo- sindian and the Euro- Afro- Asiatic Mediterranean. Considering climatic, geomorphological, and phytogeographical variations, El Hadidi (1980a) distinguished between eight main phytogeographical (ecological) territories, two of which have subdivisions. These are shown below.

The main features of the vegetation (plant names after Tackholm 1974) can be outlined as follows.



Egypt: hot desert ecosystems. I, semi-arid province; II, arid provinces; III, hyperarid provinces.

The Mediterranean coastal land of Egypt extends for about 970 km between Sallum eastwards to Rafah with an average width ranging between 15 and 20 km in a north- south direction. If the plateau of Sallum near the Libyan frontier is excluded, the remainder of the Mediterranean coastal strip has virtually no conspicuous highlands. According to Zahran et al. (1985), the Mediterranean coastal land can be divided into three sectors: western (the Mareotis, extending for 550 km between Sallum and Alexandria), middle (Deltaic, extending for 180 km between Alexandria and Port Said), and eastern (Sinaitic, extending for 220 km between Port Said and Rafah).

Boulos (1975) estimated a total of 1095 species in the Mediterranean coastal land of Egypt, which constitute about 53 percent of the native species in Egypt (2085 species : 130 families and 722 genera of angiosperms). Mashaly (1987) recorded 225 species from the Deltaic sector, while Gibaly (1988) recorded 382 species from the Sinaitic sector. At present, no exact estimate can raise up to 600 species.

According to Mashaly (1987), 50 percent of species in the Deltaic sector are from Mediterranean taxa, 32 percent are from pluri- regional taxa, and 8 percent are from Saharo- Sindian. The pluri- regional taxa of this sector are mainly common weeds of cultivation which exhibit a very similar spectrum to that known from the weed populations of the farmlands of the Nile Basin (Cosmopolitan taxa 12 percent, Pantropical taxa 12 percent, and Palaeotropical taxa 8 percent).

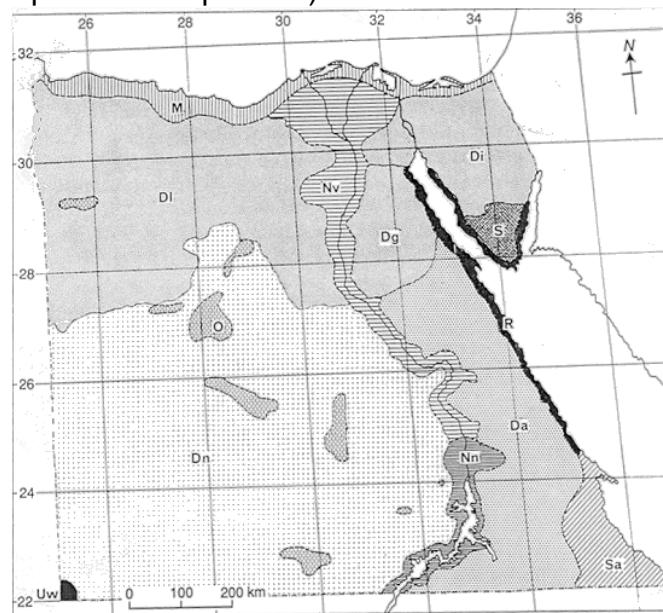


Fig. Egypt : phytogeographical territories.

M, Mediterranean coastal belt. D, Deserts including: DI, Libyan Desert; Dn, Nubian Desert; Di, Isthmic Desert; Dg, Galala Desert; Da, Arabian Desert. N, Nile land including: Nv, Nile Valley; Nn, Nubian Nile Oases, of DI and Dn, including the Kisseiba-Shabb area of the latter. S, Sinai mountainous region between the Gulfs of Suez and Aqaba. R, Red Sea coastal plains including those of Dg, Da as well as those along the Gulfs of Suez and Aqaba. Sa, Sahelian scrub in Gebel Elba mountainous block, its coastal plains along the Red Sea, and their extension westwards through Da, Uw, Massif of Gebel Uweinat and the intersecting wadis .

For the Sinaitic sector, Gibaly (1988) estimated that 45 percent of species are from Mediterranean taxa, 45 percent are from Saharo- Sindian taxa, and a lower fraction of 7 percent are from the pluri - regional taxa including Cosmopolitan, Pantropical, and Palaeotropical species. The similar proportions of 45 percent for both of the Mediterranean and Saharo - Sindian taxa in the Sinaitic sector can be attributed to its "bimodal nature" (Gibaly 1988, pp. 335 - 42). A western plain running for 160 km from El Qantara to El Arish is distinct from an eastern plain running for 60 km from El Arish to Rafah. Anthropogenic activities, demographic patterns, human settlements, and agriculture are all better developed in the humid eastern plain than the arid one. The western plain is characterized by the prevalence of internal desert flora (Isthmic element) while in the eastern plain Mediterranean elements predominate. The cultivated areas of the eastern plain are characterized by a weed assemblage which is similar in its structure to that of the fields of the Mareotis sector (Tadros and Atta 1958).

According to Mashaly (1987, pp. 180-93), seven habitat types are recognized in the Mediterranean coastal land. A synopsis of the studies are presented in the table below. In

their recent account of the Western Desert, Bornkamm and Kehl (1990, pp. 157-73) pointed out that, besides the plant communities of the littoral dunes, the other vegetation units recognized in the Mareotis sector (eventually Zone I of their account) belong to the *Atriplex halimus* - *Lycium europaeum* and *Thymelaea hirsuta* - *Plantago albicans* associations.

Littoral dunes are dominated by *Ammophila arenaria* and *Euphorbia paralias* on younger dunes, or by *Crucianella maritima* and *Ononis vaginalis* on older dunes.

The *Atriplex-Lycium* association is perhaps the most apparent association along the Mediterranean coastal land. It consists of perennial shrubby species at an average height of 100 cm or more. For comparison, the *Thymelaea-Plantago* association includes vegetation units with an average height of less than 100 cm. The *Atriplex-Lycium* association is found near the Mediterranean coast, while the *Thymelaea-Plantago* association is more widespread southwards.

Zahran et al. (1989) gave an account of the islands in Lake Manzala, one of a chain of five lakes extending along the Mediterranean coast of Egypt.

Lake Manzala (31° 00' - 31° 30' N, 31° 50' - 32° 20' E) is the largest lake in Egypt with an area of about 1400 km<sup>2</sup>. It includes about 1000 islands which consist of clay, sand, or mollusc shells. The larger islands range in area between 2.5 and 5.0 km<sup>2</sup>. The vegetation of these islands is essentially halophytic and seven community types were recognized. The dominant species were : *Phragmites australis*, *Juncus acutus*, *J. rigidus*, *Arthrocnemum macro-stachyum*, *Halimione (=Atriplex)* *Portulacoides*, *Halocnemon strobilaceum*, and *Zygophyllum aegyptium*.

Habitat type	Sector			Leading dominant species
	W	D	S	
Coastal dunes	+	+	+	<i>Pancratium maritimum</i>
				<i>Thymelaea hirsuta</i>
				<i>Moltkiopsis ciliata</i>
Salt marshes	+	+	+	<i>Arthrocnemum macrostachyum</i>
				<i>Halocnemon strobilaceum</i>
				<i>Phragmites australis</i>
				<i>Juncus rigidus</i>
Non-saline depressions (fertile non-cultivated land)				<i>Anabasis articulata</i>
				<i>Zygophyllum album</i>
				<i>Plantago albicans</i>
				<i>Thymelaea hirsuta</i>
	+	+	+	<i>Atriplex halimus</i>
				<i>Alhagi graecorum</i>
Rocky ridges	+	-	-	<i>Gymnocarpos decandrum</i>
				<i>Thymus capitatus</i>
				<i>Globularia arabica</i>
				<i>Asphodelus microcarpus</i>
Wadis	+	-	+	<i>Ephedra foeminea</i>
				<i>Lycium europaeum</i>
Inland siliceous deposits				<i>Moltkiopsis ciliata</i>
				<i>Artemisia monosperma</i>
	+	-	+	<i>Convolvulus lanatus</i>
				<i>Astenatherum forskalii</i>
Reed swamps	+	+	-	<i>Typha domingensis</i>
				<i>Phragmites australis</i>

Table: Habitat types and the leading dominant species in the different sectors of the Mediterranean coastal land of Egypt. (W: western, Mareotis sector; D: middle, Deltaic sector; S: eastern, Sinaitic sector)

## LAND RESOURCES

### ■ Soils

The most comprehensive review of Egyptian soils is provided in the FAO map of the world (FAO/UNESCO 1977). It is based on detailed soil maps (Elgabaly 1969; Veenenbos 193), and work by Ghaith (1959). It provides a comprehensive review of the distribution of Egyptian soils up to the mid- 1970s. The soil terminology used in this chapter is based on the FAO System of Soil Classification, excellent summaries of which appear in (FAO/UNESCO 1974) and Young (1976).

In the late 1980s the legend for the FAO/UNESCO Soil map of the world was revised (FAO/UNESCO 1988). This revised legend affects many of the soils in Egypt.

Therefore, although (Fig.below) is based on (FAO/UNESCO 1977), the key to this figure has been revised, as has the table of different soil associations (Table below).

Mappable soils, those with even the slightest degree of horizonation, cover 79 599 km<sup>2</sup> , or 83.15 percent of Egypt (FAO/UNESCO 1977).

The main Egyptian soil associations, in order of decreasing area, are: calcisols and gypsisols; mixed leptosols and regosols; calcareic fluvisols; solonchaks; regosols; lithic leptosols and mixed lithic leptosols; and calcisols and gypsisols (Table below). In addition there are minor occurrences of gleysols, vertisols, and solonetz soils within the major associations.

### Egypt: Soil association distribution

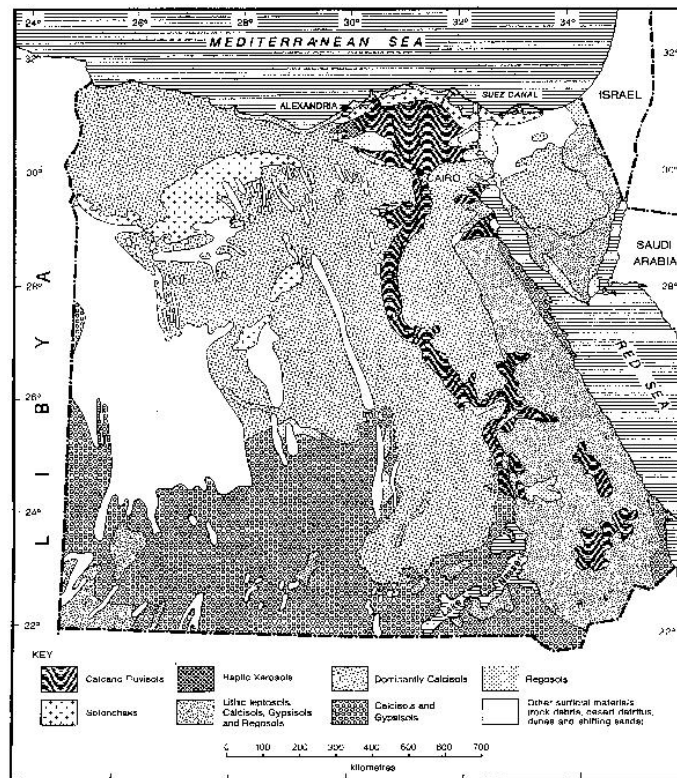
Major soil associations <sup>a</sup>	Area	
	km <sup>2</sup>	% land area
Calcaric fluvisols	5771	6.03
Solonchaks	3283	3.43
Gleyic	797	0.83
Haplic	2307	2.41
(Takyric) <sup>b</sup>	179	0.19
(Haplic xerosols) <sup>c</sup>	107	0.11
(Yermosols) <sup>c</sup>	53 351	55.71
(Not subdivided) <sup>c</sup>	19 695	20.57
(Calcic) <sup>c</sup>	32 335	33.76
(Haplic) <sup>c</sup>	1321	1.38
Regosols	2084	2.18
Calcaric	628	0.66
Eutric	1456	1.52
Lithic leptosols	1214	1.27
Lithic leptosols and (calcic yermosols) <sup>c</sup>	720	0.75
Lithic leptosols and regosols	13 069	13.65
Rock debris and desert detritus	86	0.09
Dunes and shifting sands	16 084	16.78

Source : FAO/UNESCO (1977) ; FAO/UNESCO (1988)

a. This table and the accompanying Map (Fig.below) were based originally on the major soil types in the FAO Soil map of the world (FAO/UNESCO 1977). Since then the legend for the FAO Soil map of the world has changed but a new map covering Egypt has not yet been produced. The overall calculations are therefore based on the original map and legend, although new soil types have been used whenever possible.

b. Takyric solonchaks have been deleted from the revised legend and these soils are now classified as takyric phases of other types of solonchaks.

c. Xerosols and yermosols were entirely deleted in the revised legend. Most soils originally classified as xerosols and yermosols are now classified as calcisols and gypsisols. These are subdivided into haplic, luvic, and petric calcisols and haplic, calcic, luvic, and petric gypsisols.



Egypt: Soils

### **Calcisols and gypsisols**

Large areas of calcisols and gypsisols are found in Egypt, especially in the Western Desert, on the Libyan Plateau, in the north-western and south-western parts of the Eastern Desert, long the southern Red Sea coast, and in Central Sinai (Fig. 2).

Calcisols are dominated by a calcium carbonate-rich horizon within 1.25 m of the soil surface. Their subsoil properties are variable, ranging from those with subsoil clay accumulation to those with no B-horizon development at all. The organic matter contents vary but they are never saline and neither do they exhibit evidence of gleying in the upper meter.

Gypsisols are similar to calcisols in terms of most diagnostic properties with the very important exception of the type of calcium accumulation in the upper 1.25m . In gypsisols this zone is dominated by gypsum (calcium sulphate). The lack of clay in many calcisols and gypsisols combined with the low amounts of organic matter means that most of these soils are characterized by inherently low fertility and poor water- holding capacity. Nevertheless, with irrigation and manuring or fertilizer application, they are being reclaimed on the desert land adjacent to the Nile Delta and in some of the Western Desert oases. The high calcium carbonate and calcium sulphate content of some calcisols and gypsisols can create further soil management problems. In many calcisols and gypsisols the calcium carbonate and sulphate has aggregated and hardened to form calcrete or gypcrete, respectively. These are rock-like materials which create severe problems for root penetration and ploughing, especially as they are usually found in the upper 1.25m of the soil. A further physical problem, which is particularly prevalent when these soils have a high silt content and are irrigated, is surface crusting which dramatically reduces the infiltration rate. Other management problems are concerned with soil chemistry. The levels of available phosphorus are low due to the high pH, and the micronutrients such as copper, iron , manganese, and zinc also have low availabilities. There are often potassium and magnesium supply problems due to the calcium imbalance, and the soils have very low levels of microorganisms.

### **Lithic leptosols**

Lithic leptosols have severe depth limitations. Continuous outcrops of consolidated rock can be found within 10 cm of the surface and consequently there is minimal profile development.

Lithic leptosols are restricted mainly to mountainous south-west Egypt. They are found in combination with calcisols and gypsisols in the most mountainous parts of the Eastern Desert and Red Sea Mountains, in a belt extending from the Sudanese border north to about 29°N, and on the southern tip of the Sinai Peninsula. Other isolated areas are found in the southern parts of the Western Desert, and a smaller area of lithic leptosols and regosols is restricted to the Egyptian - Israeli border in eastern Sinai (Fig. 2).

Cultivation is impossible on these soils due to their shallowness, limited nutrient supply, and very low water-holding capacity. Only localized land-use options, such as rough wet- season grazing, indigenous forestry, gathering plant products and hunting, or water catchment are available.

Calcaric fluvisols. Calcaric fluvisols are relatively young soils developed on recently deposited colluvial, fluvial, lacustrine, or marine sediments in the Nile Valley and Delta, and on some of the coastal plains. In addition, four isolated but extensive areas of calcaric fluvisols are found in the Red Sea Mountains (fig. 2).

Fluvisols still show some sedimentary stratification. Organic matter content decreases irregularly with depth (although it remains above 0.35 percent in the upper 1.25m) and the soils have sulphide-rich material within 125cm of the surface. Generally fluvisols exhibit little horizonation, except for a weakly developed A-horizon and peaty horizons. Calcaric fluvisols, however, are strongly calcareous, having significant amounts of free calcium carbonate at depths of 20-50 cm and pH 7. These are the most intensively farmed soils in Egypt and have a high development potential due to the ease of irrigation low water erosion potential, and their ability to be double- cropped. They do not, however, have very high nutrient levels, so the maintenance of fertility by traditional manuring practices or by high rates of fertilizer application is of particular importance in crop production. There are also potential wind erosion problems in silt - rich areas if the topsoil is allowed to dry out. The major management task is to control water supply and conserve soil moisture.

The Nile fluvisols are extensively irrigated and the management of irrigation scheduling and drainage is time- consuming. In addition, in areas with a high clay content, poor irrigation practices often lead to subsoil compaction and pan formation, secondary salinization, and gleying.

### **Solonchaks**

Solonchaks are the saline soils formed on recent alluvial and lacustrine material, often in closed basins, such as those found in the desert oases, or in the coastal sabkhas. They are commonly found in many of the major oases and depressions in the Western Desert, particularly in the Bahariya, Farafra, and Siwa Oases, the El Faiyum and Qattara Depressions, and in Wadi el Natrun. There is also a wide belt of solonchaks along the upper Nile Delta extending eastwards to the Sabkhat al Bardawil on the northern Sinai coast (Fig. 2).

A number of types of solonchaks are found in Egypt, but the main diagnostic feature of all solonchaks is their high soluble salt content. Gleyic solonchaks exhibit hydromorphic properties, such as waterlogging and reducing conditions, within 0.5 m of the surface. Some solonchaks lack hydromorphic properties but have extensive crystalline salt crusts with blisters, pressure is described as having a takyric phase. Orthic solonchaks lack salt crusts with either takyric or hydromorphic features in the top 50 cm of the soil, but do have a weakly developed organic A-horizon.

Solonchaks are extremely difficult soils to manage due to their severe salinity problems. The high soluble salt content affects crop growth in two ways. First the osmotic balance of the soil solution is altered, making it extremely difficult for roots to extract nutrients from the soil . This results in stunted growth and depressed yields unless salt- tolerant crop varieties are grown . Second, at soluble salt contents in excess of about 2 percent, toxic effects become important . In particular, accumulations of chloride and boron are important, while sodium only really affects the ionic

balance of the soil solution. Soil management is concerned with the amelioration of the high soluble salt contents in areas where there are no toxicity problems. Various strategies such as flushing out salts with irrigation water, the addition of less saline soil material, and the use of salt-tolerant crops are favourable measures for the less saline solonchaks, but where the salt contents are highest agriculture is impossible.

### **Regosols**

Regosols are developed on sandy substrates and, apart from a rudimentary A-horizon with less than 1 percent organic matter, show no horizonation. Two types of Regosols are found in Egypt - calcaric Regosols and eutric Regosols. The former have accumulations of calcareous material and the latter are not calcareous at depth of 20 - 50 cm, but have a base saturation in excess of 50 percent.

In Egypt, Regosols are important only locally in a small number of restricted areas. Pockets of calcaric Regosols are found in a narrow strip along the Mediterranean coast from Ras el Kanayis to the Damitta Branch of the Nile, to the east and west of the Nile Delta, on the western and southern shores of Sinai, in the Dakhla Oasis, and on the Sudanese border (Fig. 2).

Regosols have low available water capacities and low inherent fertility. Their management involves irrigation together with the addition of clay and manure. Irrigation alone provides only part of the answer, because without the addition of clay and organic material most of the water quickly enters the groundwater leaving little held in the rooting zone for plants. The clay and organic matter also provide nutrients and, in particular, provide sites to hold nutrients in the rooting zone.

### **Other surficial materials**

The non-soil units identified in Egypt, rock debris, desert detritus, dunes, and shifting sands, are found mainly in the inner Western Desert and the northern Sinai Peninsula. In these areas the soil management problems preclude any agriculture, apart from some desert nomadism.

### **Land cover**

For an arid country like Egypt, the prime factor which makes land productive is water. Thus an analysis of arable land can be best divided as pre- and post- High Aswan Dam periods.

Changing Patterns of Population and Arable Land in Egypt 1897 – 1999.

Year	Population	Arable Land	
		Total	Per Capita Land
		(million feddans)	(in feddans)
1897	9.7	4.9	0.51
1907	11.2	5.4	0.48
1917	12.8	5.3	0.41
1927	14.2	5.5	0.39
1937	15.9	5.3	0.33
1947	19	5.8	0.31
1960	26.1	5.9	0.23
1970	33.2	6	0.18
1980	42.1	6.1	0.14
1990	55	7.2	0.13
1999	65	7.8	0.12

Fortified by increased and more reliable water that was made possible by the construction of this dam, and assisted by technological developments, it has been possible both to intensify cultivation

in the old lands and to expand agricultural activities in the new lands. Construction of HAD basically confirmed the fact that the supply of arable land in Egypt is not necessarily inelastic, as was often assumed in the past. Nearly 650,000 acres out of a total of 805,000 acres of land reclaimed in the 1960s was made possible directly due to water from HAD.

The changes in Egypt's arable areas during the period 1897- 1999, are shown in Upper Table . It should be noted that between 1907 and 1999, the arable area increased by only about 2,400,000 acres, while the country's population increased nearly sixfold, from 11.2 to 65 million. The area of arable land available per person declined by 75 percent during this ninety-two year period.

The most detailed analysis of land resources of Egypt was completed in 1986 under the Land Master Plan (LMP). This plan concluded that 2.82 million acres of land could be reclaimed by using the Nile waters. In addition, another 570,000 acres could be reclaimed using the ground-water in Sinai and the New Valley. Thus the total land that could be reclaimed, subject to water availability, was estimated at 3.40 million acres. The LMP study considered land only for irrigated agriculture. Other uses of land like fisheries , forestry, and wildlife habitat were not considered. The LMP study divided the potentially reclaimable land into five categories depending on one or more land- use and management options. These options considered cropping patterns, irrigation and drainage systems, and farm types. More than half of the land proposed for reclamation is considered to be coarse to gravely sands.

The present estimate of cultivated area in Egypt is 7.8 million acres, of which 7.2 million acres are in the Nile Valley . It is essential that the government gives urgent attention to reduce the loss of arable land to urbanization for three important reasons. First, with increasing population, existing agricultural land areas should not be allowed to be lost. Second, land reclamation is an expensive process, hence it would be desirable not to lose any additional land that is already productive, and then try to compensate for that loss by reclamation. Third, often land lost due to urbanization is more productive than the reclaimed land. While the laws exist to prevent the loss of arable land due to urbanization, their enforcement is quite weak and erratic, as indeed is the case in many other countries.

Land reclamation in Egypt has been practised over several thousand years. For most of this period, reclamation was concentrated primarily in the Nile Valley and the Delta, since land in these areas could be reclaimed with low levels of technology and investment. Impressive progress was made in land reclamation in the nineteenth century, at the beginning of which the cultivated area was estimated at 2 million acres, of which 250,000 acres could be cultivated only in the summer. By 1848, the area cultivated had increased to 2.6 million acres; by 1880 to 4.7 million acres; and by 1900 to 5 million acres. Thus, during the nineteenth century, the arable land area increased by 150 percent, or 3 million acres. Construction of the High Aswan Dam significantly increased both the supply and reliability of irrigation water. Thus, between 1960 and 1971, a total of 912,000 acres of land was reclaimed, much of which was in the Western Delta. During the decade 1978- 1988, an additional 74,000 acres were reclaimed.

There has been a major policy shift during the 1980s. The government became disillusioned with the overall performance of the state farms because of their inefficiency, inability to adopt new farming practices quickly, and the general lack of development of new farming systems more applicable to desertlike conditions. A policy decision was taken to allocate new lands in a varying ratio of 60:40 -three- fifths to economically disadvantaged groups, unemployed graduates, and retired government personnel.

The total investment cost for land reclamation has been significant. For example, since the 1952 Revolution, over LE (Egyptian pound) 3 billion has been spent on land reclamation. The Land Master Plan study estimated that the investment cost for land reclamation varied from LE 3,000 to 7,000 per acre. In the remote areas, the high cost infrastructure increased the cost to LE 8,000. The government has pledged not to dictate cropping patterns in these areas, and many farmers are planting high- value crops, probably perennial fruit crops, to get attractive returns on their investments. The potential impact of this policy on market prices of fruits needs to be investigated.

In Egypt, land can be productive only if water is available for irrigation . As population grows and achieves a better standard of living and more industrialization, water demands for the municipal and industrial sectors will increase. Since these two sectors are most likely to have higher priority than the agricultural sector, the future of reliable water supply for the reclaimed areas should receive serious attention. Even so, the share of water available to agriculture will decline steadily. Accordingly, efficiency of water- use in Egypt has to be increased to ensure that all the reclaimed lands will continue to receive their share.

## **▣ Land use**

### **- Land use types**

→ Area percentage of the land use type

The total agriculture land of Egypt is about 7.8 million feddans which is almost entirely dependent on irrigation. In brief, 2 million feddans in Egypt suffer from salinization problems.

Sixty percent of the cultivated lands inof the northern Delta region are salt affected, while twenty percent of the Southern Delta and Middle region and twenty five percent of the soils of the Upper Egypt region are salt affected.

### **- Soil productivity**

45% of the cultivated area is highly or reasonably productive. The remaining 55% (third and fourth class soils).

## **▣ Physiography and agroecological systems**

### **- Geomorphology**

The physiography is closely related to the underlying geology; consequently these two aspects are dealt with together. Egypt can be divided into five main physiographic units (Fig. )

#### **(1) Western Desert;**

Like much of north-east Africa, the Western Desert is underlaid by level to gently dipping sedimentary rocks deposited on the Precambrian basement. These rocks consist of continental sandstones with thin beds of marine limestones, and marls . This sequence is known as the Nubian sandstone (Issawi 1973) and was deposited between the Lower Paleozoic and the Upper Cretaceous, the marine beds dating from the Carboniferous to Lower Cretaceous. The Nubian sandstone thickens northwards from about 50 m near Aswan to 600 m in Sinai (Furon 1963).

The Western Desert consists of five main physiographic units. Three of these (the Libyan Plateau, the Great Sand Sea, and the eastern and southern areas) are flat to undulating surfaces, dominated by wind actions. They vary in altitude from 100 to 500 m above sea level (m a.s.l.).

The Libyan or El-Diffa Plateau in north-western Egypt extends from the Libyan border to the Qattara Depression, north of 29 N, reaching a height of 215 m a.s.l.. It is a hamada, a level to gently sloping surface covered mainly by stones and gravel, formed by the deflation of fine-grained sediment over thousands of years leaving behind a lag deposit of coarse stones. Towards the Mediterranean coast the plateau ends in an escarpment and the coastal plain varies in width from a few kilometers to about 50 km. The groundwater conditions, proximity to moisture-bearing winds, and cooler temperatures lead to moderate winter vegetation cover on the coastal plain, making it an important grazing area.

The area to the south of the Libyan Plateau is dominated by the Great Sand Sea. It sweeps down the western half of the desert joining the Great Selima Sand Sea in Sudan (El-Baz and Issawi 1982). This part of the desert is dominated by mobile sand and has little agricultural potential.

The eastern and southern parts of the desert have areas of mobile sand and stony plateau surfaces, which characterize the arid desert environment in this area and are formed by aeolian geomorphological processes. The plateaux exceed 500 m a.s.l.. and usually terminate in marked escarpments. The areas of mobile sand are less common and are mainly orientated north-

west/south-east or north/south. The most significant of these is the Ghard Abu Muharik which exceeds 300 km in length.

The Western Desert is also characterized by a series of large depressions, the most famous being the Qattara which, at its lowest point is 134 m below sea level (m b.s.l.). It sweeps in an arc from approximately 50 km south of El Alamein on the Mediterranean coast to the Siwa Oasis, south of the Libyan Plateau; it extends further westwards into Libya. Other large depressions occur in the central and eastern parts of the Western Desert, and in areas adjacent to the Nile Valley and Delta (Table 1 and Fig. 1). All of these depressions have been formed by wind erosion and are termed deflation hollows; the areas of weaker rock in the Nubian sandstone sequence are preferentially eroded. The most important weakening factor is the geological structure (which is mainly faulted and jointed), but the surface expression of rocks such as chalk, shales, and marls, which are not resistant to wind erosion, is also important (El-Etr and Moustafa 1982). Depressions such as Moghara Oasis, Wadi el Natrun, and El Faiyum have thick sequences of Lower Miocene and Pliocene sandstones, limestones, and gypsiferous marls with occasional basalt flows; the latter depression contains a well documented sequence of gypsiferous clays, limestones, and clayey sand. One of the longest sequence, however, from Cretaceous to the Oligocene, is found in Farafra Oasis, where it exceeds 225 m in thickness. Many of the depressions are geologically related along lines of extensive jointing or faulting, and smaller depressions can be found along these alignments. For instance, the Qattara and Siwa Depressions are formed along the same structural trend; the Bahariya and Farafra Depressions, and the farafra, Dakhla, and Kharga Depressions, form other structurally related groups. The large areal extents of these depressions leads to the presence of a number of geomorphological environments. First, there are stony hamada surfaces similar to those in the surrounding desert; second, areas of mobile sand dunes; and third, closed depressions with saline lakes or playas. Playas from when the wind erodes the rocks in the depressions, exposing aquifers. In some cases the groundwater from these aquifers can be a valuable, although slightly saline, water resource; in other depressions the salts are extracted for their mineral content. The combination of local groundwater resources for irrigation, and soils developed on sediments that have washed down or have been blown in, makes these closed basins suitable for oasis cultivation. A number of depressions (especially Dakhla and Kharaga) are being developed by the Egyptian Government at the present time.

while there are isolated hills and low plateaux throughout the Western desert formed by erosion of the Nubian sandstone, the only extensive mountainous area is found in the extreme south-west. This area can be divided into the more northerly sandstone Gilf el Kebir Plateau, and the granite Gebel Uweinat Mountains on Egypt's border with Libya and Sudan. The latter mountains are higher, Gebel Uweinat itself reaching 1893 m a.s.l. The area has been the site of many scientific investigations since its discovery in 1923, the most comprehensive work being that of El-Baz et al. (1980) and El-Baz and Maxwell (1982). Although this is hyperarid region (with rainfall occurring only once in 10-20 years or more), the plateaux and mountains exhibit strong evidence of Quaternary fluvial erosion, particularly in the form of wadis and gorges (the latter being known as kankurs). The kankurs are so deep that groundwater-bearing rocks are often exposed and springs are present. The groundwater in the Gebel Uweinat kankurs supports a perennial savannah-like vegetation of grasses, sedges, small herbaceous shrubs, and small trees reaching 4-5 m in height (Boulos 1982). The occasional flash floods in the wadis give rise to blooms of ephemeral desert vegetation, which can last for up to three years, based on the moisture trapped in the wadi-floor flood sediments. These outposts of vegetation in the hyperarid desert are exploited by nomadic herdsmen for sheep, goat, and camel grazing.

## **(2) Nile Valley;**

The underlying geology of the Nile Valley is similar to the Nubian sandstone although it has been strongly eroded by the Nile, creating a deep valley with escarpments of the Eastern and Western Desert on either side in many places.

The Nile Valley extends from the Sudanese border in the south to Cairo in the north. To the south of the Aswan High Dam the upper valley is now flooded. The remaining valley follows the Nile swinging first east, and then west in an elongated flattened S- shape before reaching Cairo; the only major kink in this trend is a sharp eastward section around Qena in the upper valley. The valley length, from the High Dam to Cairo, is about 825 km and the valley is never more than 19 km wide. The valley floor has been extensively cultivated for thousands of years and little evidence of the backwaters, marshes, abandoned channels, and lakes typical of river floodplains can be seen; river terrace sequences, relicts of old valley floors have, however, been identified (Furon 1963). The valley sediments have been formed by the deposition of overbank deposits (sands, silts, and clays) when the Nile flooded. The sediments are the products of extensive erosion in the mountainous Nile headwaters in east Africa. River regulation has stopped this annual sediment influx, and the flood plain is now dissected by a network of irrigation canals.

The remained of the country is covered by dunes and shifting sands (16 084 km<sup>2</sup>) and rock debris and desert detritus (86 km<sup>2</sup>), which exhibit no evidence of soil formation. Although the picture seems favourable, many of the mappable soils have considerable management problems and present severe limitations to agricultural activity.

### (3) Nile Delta;

The Nile Delta has strong geological similarities with the desert to the west and the Nile Valley to the south. However, the Nile Delta is actively extending into the Mediterranean and much of the underlying sediment is modern and relates to this seaward extension.

The apex of the Nile Delta is the city of Cairo, and from here it extends north- westwards 160 km to Alexandria and north- eastwards 150 km to Port Said. There is complex pattern of distributary channels in the delta but two distributaries are dominant, the Rosetta Branch in the west and the Damietta Branch in the east. Many of the minor channels have been channellized and additional canals have been built. Waterway engineering works have been carried out to provide both irrigation water for the fertile delta farms and efficient drainage. Much of the delta is dominated by similar alluvial sediments to those found in the Nile Valley and it is an extremely important agricultural area. However, at the coast there is a series of saline lagoons and salt flats trapped behind coastal sand bars with little agricultural potential. The biggest of these are Bahra el Burullus, between the mouth of the Damietta and the Suez Canal. Two smaller lakes, Bahra Maryut and Bahra el Idku, occur in the north- western delta.

### (4) Eastern or Arabian Desert;

The northern and north-western parts of the Eastern Desert have a similar underlying geology to the Western Desert. In much of the desert, however, highly folded and faulted igneous and metamorphic Precambrian rocks are dominant. These form the Red Sea Mountains and are related to the tectonic sandstone, reaching a thickness of 600 m (Furon 1963) and exhibits substantial post-Cretaceous folding. Post- folding erosion has led to the formation of many resistant limestone cuestas with low- lying areas between them representing exposures of less resistant marls and sandstones. Tertiary rocks are found along the western coast and northern Sinai and are mainly covered with Quaternary sediments.

The mountains are restricted to the southern half of the peninsula. The highest range, which has nine peaks over 2000 m a.s.l., is found between the southern tip of the peninsula and 28 40'N . The highest peak in the range is Gebel Katherina (2642 m a.s.l.), which is also the highest mountain in Egypt; the more Gebel Musa (Mount Sinai) is only 2285m a.s.l. These mountains slope off steeply to the Gulfs of Aqaba and Suez with many short, steep ephemeral wadis flowing into the sea. To the north, the decline in relief is more steady, leading into the gently sloping Gebel el Igma and, further north in central Sinai, the Gebel el Tih. The physiography here is one of gently northward- sloping hills decreasing in height, from about 1600 m a.s.l. in the south to about 750 m a.s.l. in the north, over a distance of about 110 km. The area is dominated by drainage into northern Sinai. The

western coast of central Sinai is dominated by short wadis flowing into the Gulf of Suez and on the Egyptian- Israeli border a number of wadis flow into the Jordan Rift Valley.

In northern Sinai, the land is much lower than in the central and southern peninsula; it lies mainly between 200 and 300 m a.s.l. in height, although there are isolated hills reaching heights of between 800 and 1100 m a.s.l. Adjacent to the coast throughout northern Sinai the desert is dominated by extensive areas of mobile sand. Mediterranean coastline can be split into two parts. The western part is dominated by bars and saline coastal mudflats and lagoons known as sabkhas; the largest of these is the Sabkhat el Bardawil. The eastern part of the coastline sweeps up towards the Gaza Strip in a long curve.

#### (5) Sinai Peninsula.

The major units and their main subdivisions ( Table ) are discussed below.

##### - Agro-climatic zones

Egypt has permitted the cultivation of both winter and summer crops. Traditionally, before the advent of perennial irrigation in the nineteenth century, the Nile Valley was characterized by winter crops, of which the most important was wheat. With the development of summer cultivation, crops such as cotton, rice, sugar cane, and millet became important (Beaumont and McLachlan 1985).

The most widely grown winter crop is wheat, which is cultivated along the whole length of the Nile Valley. The seeds are usually sown in early November following fallow, maize, or cotton. Harvesting takes place in late April or early May.

The first four weeks after sowing are critical period for the wheat crop when the seeds germinate and the shoots emerge above ground level. This is followed by the main growth phase which includes maximum tillering (weeks 5-14), ear initiation (weeks 14-19), and flowering (weeks 19-22). Finally between weeks 22 and 26 the ripening of the wheat occurs.

Although sowing dates vary somewhat between different parts of the Nile Valley, it is interesting to compare the wide range of climatic conditions tolerated by the wheat crop during its growth. For example, around Alexandria the range of temperatures experienced is relatively small compared with elsewhere in Egypt, and in particular when compared with Aswan. Similarly, the Alexandria and Nile Delta regions enjoy much more humid conditions than, for example, Aswan, where for most of the year relative humidity values are about one-half of those found in the north. With wind speed it is the extremes of the country, at Alexandria and Aswan, where the highest values are recorded.

Penman potential evapotranspiration rates for selected stations in Egypt:

Month	Evaporation (mm day <sup>-1</sup> )			
	Alexandria	Giza	Aswan	Kharaga
January	1.2	2.0	2.2	2.2
February	1.7	2.7	3.2	3.1
March	2.5	3.5	4.1	4.2
April	3.1	4.9	5.5	5.8
May	4.1	6.2	6.8	7.0
June	4.6	6.7	7.8	7.9
July	4.7	6.8	7.6	7.5
August	4.5	6.3	7.5	7.6
September	3.5	5.3	6.4	6.5
October	2.4	4.0	4.4	4.6
November	1.4	2.3	3.0	3.1
December	1.1	1.6	2.2	2.2
Annual mean	2.5	4.4	5.1	5.1

Source: Ali (1978).

Perhaps most interesting is the fact that during the first twelve weeks of the crop's growth, that is until approximately the end of the period of increasing temperature nearly all the stations record a decline in relative humidity. Despite these wide climatic variations, wheat is cultivated successfully throughout Egypt.

Cotton is the most important cash crop grown in Egypt and, like wheat, is grown along the length of the Nile Valley. It is, however, a summer crop and is cultivated between early March and the end of August. For cotton, the first week after sowing, when germination and emergence of seedling takes place is critical time. This is the time the khamsin winds which can do enormous damage to the crop by shrivelling up the tender shoots of cotton as they emerge. The vegetation stage covers the next six weeks, when maximum tillering, boll initiation, and flowering takes place. Finally there is the ripening phase over four or five weeks when the bolls attain maximum size.

For the cotton crop, temperatures show a steady rise until the middle of the growth stage when boll initiation is taking place. Thereafter, temperatures remain remarkably steady. In contrast, relative humidity decreases at all inland sites during the same period. As for wheat, the largest temperature ranges experienced by cotton occur at inland sites. This data suggests that despite some unusual circumstances, climatic conditions in Egypt do not seem to impose very serious restrictions on the growth of the two most important crops.

#### Egypt : physiographic units

Major physiographic units	Main subdivisions
Western Desert	Libyan Plateau
	Great Sand Sea
	Southern and Eastern Desert
	Large depressions
	El Faiyum
	Bahariya
	Dakhla
	Kharga
	Qattara
	Siwa
	Wadi el Natrun
	South-Western Mountains
	Gilf el Kefir Plateau
	Gebel Uweinat
Eastern or Arabian Desert	Red Sea Coastal Plain
	Red Sea Mountains
	Northern Desert and Galala Plateaux
	Eastern Desert
Nile Valley	
Nile Delta	Upper and Central Delta
	Coastal Zone
Sinai Peninsula	Southern Mountains
	Gebels el Igma and el Tih
	Northern Sandy Desert
	Coastal Zone



## Water resources

Egypt's prosperity still depends largely on the agricultural sector and productivity. However, the fearful increase in population-growing at 2.6 percent annually- represents the greater challenge to Egypt's future.

The River Nile is the principal water resource and is expected to remain so for years to come, supplying Egypt with more than 95 percent of its present water requirements. With the limitation of Egypt's share and the complexity of developing its north-bound water inflow, the need for rationalizing the different uses of water acquires utmost importance, and to this end the Ministry of Public Works and Water Resources (MPWWR) has adopted several policies .

The High Aswan Dam (HAD) was established as a long-term storage reservoir to ensure a constant and regular inflow for both Egypt and Sudan. However, the drought period that prevailed in the region from 1979 and lasted for nine uninterrupted years has seriously affected the storage in the High Dam Lake Reservoir - a fact that motivated the country to develop various scenarios to face the probability of a recurrence of such a catastrophe. Some of the alternatives are to consider reducing, as much as possible, rice and sugarcane cultivation; to minimize the water duties for different applications; and to generate electricity during the winter closure period. The government is studying ways of storing fresh water, which is discharged to the sea during this period, and reusing it in agriculture. Linked to these proposals and plans are studies of the laws and regulations that govern water-use and coordination between ministries, organization, and water users. A supreme ministerial committee for water has been constituted, headed by the minister of public works and water resources and including representatives from concerned agencies, to discuss water policies.

### **Hydrography**

#### **- Water Resources**

Egypt is a very arid country. The average annual rainfall seldom exceeds 200mm along the northern coast. The rainfall declines very rapidly from the coast to inland areas, and is negligible south of Cairo. This meagre rainfall occurs in winter, in the form of scattered showers, and cannot be depended upon for extensive agricultural production. Thus, reliable availability of irrigation water is an absolute necessity for agricultural development.

#### **- Surface Water Supply**

The main and almost exclusive source of surface water is the River Nile. The Nile Water Agreement of 1959 with Sudan clearly defines the division of water traveling north between Egypt and the Sudan. Nearly 85 percent of the water to both countries originates in the Ethiopian Highlands. The 1959 Agreement was based on the average flow of the Nile during the 1900- 1959 period. The average flow at Aswan, Egypt, during this period was 84 billion m<sup>3</sup>. The average annual evaporation and other losses in the High Dam lake were estimated 10 billion m<sup>3</sup>, leaving a net usable annual flow of 74 billion m<sup>3</sup>. Under the 1959 treaty, 55.5 billion m<sup>3</sup> was allocated to Egypt and 18.5 to the Sudan.

The High Aswan Dam was constructed in 1964 to assure long-term availability of water for both countries. Its lake has a live storage capacity of 130 billion m<sup>3</sup>. The annualized Nile flow at Aswan for the past one hundred years indicates the average flow varies slightly if shorter durations are considered. The annual discharges from the High Dam lack during the period 1968 to 1990 show that there is a potential for increasing the Nile flow at Aswan.

The Joint Egyptian-Sudanese Committee has outlined several development programs, the first of which is the construction of the Jonglei Canal. The project was expected to canalize the river channel in the Sudd region of the Sudan and thus reduce the substantial evapotranspiration losses. The construction of phase one of the canal was started in 1976 but had to be abandoned in 1983 due

to security problems in southern Sudan. Initially, this phase was expected to be completed around the mid- 1980s, which would have provided an additional 4 billion m<sup>3</sup> of water at Aswan to be shared equally by the two countries. The total loss in the Machar swamps by evapotranspiration is about 10 billion m<sup>3</sup>. Conservation schemes in this sub-basin are expected to yield an average gain of 4.4 billion m<sup>3</sup> at the White Nile or about 4.0 billion m<sup>3</sup> at Aswan . The above estimates of water savings from the proposed conservation projects in the Upper Nile sub-basins adds to a minimum of 18 billion m<sup>3</sup>.

However, finalization of these schemes depends on agreements between the Nile basin countries and the investment requirements. A total of 7 billion m<sup>3</sup> was expected after the completion of phase two of the Jonglei Canal. Joint efforts are required to resume the work on the first phase of construction of the canal, in which over 70 percent of the work was completed.

The water discharge in the streams from Bahr El-Ghazal (another sub-basin of the equatorial plateau) is about 14.0 billion m<sup>3</sup> in a normal year, of which only 0.6 billion m<sup>3</sup> reaches the White Nile at Lake Noo and the rest is lost in the swamps.

Proposed schemes for conserving the water of Bahr El-Ghazal are expected to yield a saving of 12 billion m<sup>3</sup> annually at Malakal or roughly 10 billion m<sup>3</sup>/year at Aswan.

The water lost in the Sobat and tributaries basin reaches 5 billion m<sup>3</sup> each year. There are no definite plans for conserving this similar to those of Bahr El-Ghazal.

#### - **Groundwater Supply**

Groundwater in Egypt can be divided into two categories. The first comprises the Nile Valley and the Delta system. The total storage capacity of the Nile Valley aquifer is about 200 billion m<sup>3</sup>, with an average salinity of 800 ppm. Another 300 billion m<sup>3</sup> is the storage capacity in the Delta aquifer. The current annual rate of extraction of groundwater from the two aquifers is 2.6 billion m<sup>3</sup>. This can be increased to a safe annual extraction rate from the aquifer system, currently estimated at 4.99 billion m<sup>3</sup>.

Groundwater also exists in the Western Desert, generally at great depths. Most recent studies have indicated that this is not a renewable resource. Preliminary estimates indicate that the total groundwater storage in this area is of the order of 40,000 billion m<sup>3</sup>, with salinity varying between 200 and 700 ppm. Use of this fossil water depends on the cost of pumping, depletion of storage, and potential economic return over a fixed period. Investigations in the New Valley indicate that about 1 billion m<sup>3</sup> of groundwater can be used annually at an economic rate. This will allow irrigation of 150, 000 acres can be irrigated in the East Ewainat area (southern part of the Western Desert) by groundwater from the deep Nubian Sandstone aquifer. More studies are under way to investigate the groundwater potential within this regional aquifer. This work is being carried out in cooperation with Sudan and Libya.

Groundwater is available in Sinai in numerous aquifers of varying capacities and qualities, but it is generally believed that it is in limited quantities. Shallow aquifers in the northern coastal areas are replenished by the seasonal rainfall. The thickness of the aquifer varies between 30 and 150 m and its salinity increases from 2,000 ppm to 9,000 ppm near the coast. In the northern and central parts of Sinai, groundwater aquifers are formed due to recharge by the rain storms falling and collected in the valleys. Deep aquifers with nonrenewable water exist in Sinai, where wells are drilled to a depth of 1,000 m to supply water for domestic use. The El-Arish-Rafaa coastal area in north Sinai has always been of importance. The present extraction rate from the Quaternary aquifer in El-Arish is estimated at 52,000 m<sup>3</sup>/day. This area is now facing a state of quality deterioration in space and time. The system is being exploited and it needs to be safely managed. The groundwater investigation in South Sinai include several shallow and deep reservoirs which have a definite potential for development, but again of limited scale.

#### - **Water-Use**

Total water-use in Egypt in 1990 was estimated at 59.2 billion m<sup>3</sup>, of which 84 percent was used in agriculture. Industrial, municipal, and navigational use accounted for additional 8 percent, 5 percent, and 3 percent, respectively. Current estimates indicate that the total water-use will increase to 69.4 billion m<sup>3</sup> by the year 2000. The share of water-use by the agricultural and municipal sectors will remain almost similar to 1990, but the share of industry will increase by 50 percent, and the navigational use will decline very substantially.

#### - **Agricultural water-use**

While the amount of water used for agriculture has declined slowly during the past decade, it still accounts for the largest share (84 percent) or 49.7 billion m<sup>3</sup> per year. This amount does not include an annual estimated loss of 2 billion m<sup>3</sup> due to evaporation from the irrigation system. Annual evapotranspiration losses are estimated at 34.8 billion m<sup>3</sup>. The government has launched a national program for irrigation improvement and water management. Surface irrigation systems are used in most cultivated lands of the Nile Valley and Delta and their efficiency is considered to be low. Excess applications of water to crops contribute to problems of salinity and high water-tables. It must also be noted, however, that excess irrigation water contributes to groundwater, a good part of which is pumped or partially reused through cycling.

All of which increases overall water-use efficiency to a reasonable level. The measured drainage water out of the system amounted to about 11 billion m<sup>3</sup> during 1990. In the new lands, modern irrigation systems such as drip and sprinklers are used. The government does not give permits for new water to lands unless evidence is given of the use of new irrigation technologies.

#### - **Domestic water-use**

Annual domestic water-use for 1990 was estimated at 3.1 billion m<sup>3</sup>. It is also estimated that the level distribution losses is 50 percent. It is assumed that the domestic water-use could be held at 3.1 billion m<sup>3</sup> by the year 2000 by reducing distribution losses to 20 percent.

#### - **Industrial water-use**

It was estimated that industry used 4.6 billion m<sup>3</sup> in 1990. This estimate is based on the extrapolation of the 1980 survey carried out for the Water Plan.

#### - **Navigational water-use**

From February to September, water releases for irrigation are sufficient to maintain water levels in the Nile for navigation. Irrigation demands from October to January, however, are not enough to maintain a navigational level in the river. This period is the peak tourist season, Some 1.8 billion m<sup>3</sup> of water has to be released during this period to maintain the navigational level. The Esna Barrage is being rebuilt, which will provide better control of the Nile water level. By the year 2000, annual navigational water requirements could be reduced to only 0.3 billion m<sup>3</sup> through better control of water level and the establishment of storage in the northern lakes.

#### - **Re-use of treated water**

Wastewater has been re-used indirectly in Egypt for centuries, but the first formal use of wastewater was initiated in 1915 in the eastern desert area of Jabal El- Asfar, northeast of Cairo. After primary treatment, wastewater was used for desert agriculture, bringing into cultivation an area of 2,500 acres. As new wastewater treatment plants come on-line in Cairo and other urban areas, the amounts of treated wastewater available for agricultural activities will increase steadily during the next three decades. Total wastewater available from the Greater Cairo area will increase from 0.9 billion m<sup>3</sup> in 1990 to 1.7 billion m<sup>3</sup> in the year 2000 and 1.93 billion m<sup>3</sup> annually by the year 2010, according to estimates. It should be stressed that Egypt's experience with wastewater re-use is limited.

From a policy viewpoint, steps should be taken to establish major pilot projects for its use in agriculture. These projects would help to convince the general population that such practices, when properly carried out, impose no risk human and animal health.

Proper sewage treatment, in addition to providing treated wastewater, could make another major contribution to agriculture. Dried sludge can be effectively used as a soil conditioner. During 1988/89, 46,000 m<sup>3</sup> of dried sludge was produced and sold to farmers and other organizations at Jabal Al-Asfar and Abu-Rawash. It is estimated that at full development, the Greater Cairo wastewater project in the year 2010 would produce 3,410 tons per day of dry solids. A conservative estimate of the total annual market demand of sludge is 779,000 m<sup>3</sup>.

**- Re-use of agricultural drainage water**

Agricultural drainage water in Upper Egypt is discharged back into the Nile. This affects slightly the quality of the Nile water : its salinity increases from 250 ppm in Aswan to 350 ppm in Cairo. The drainage water in the Nile Delta is of lower quality, and accordingly is collected through an extensive drainage network for disposal into the Mediterranean Sea. The total amount of drainage water discharge to the sea depends on many factors, e.g., the amount of water released at Aswan, cropping patterns, and irrigation efficiency. The total amount of drainage water discharged annually has varied from 14 billion m<sup>3</sup> in 1984/85 to 11 billion m<sup>3</sup> in 1988/89 (Table below).

Nile Water-Flow Downstream of High Aswan Dam and Drainage Water Flowing to the Sea:

Year	Nile Water	Drainage Water	
	Downstream of HAD (billion m <sup>3</sup> )	Quantity (billion m <sup>3</sup> )	Saline (mmhos/cm)
1984-85	56.4	14.12	3.71
1985-86	55.52	13.86	3.68
1986-87	55.19	13.03	3.64
1987-88	52.86	11.82	6.15
1988-89	53.24	11.12	4.63

The salinity of this water ranges between 1,000 and 7,000 ppm: 25 percent of this water in 1984 and 70 percent in 1988 had a salinity level of less than 3,000 ppm. MPWWR is imposing strict policies for the releases of Nile water downstream from the High Aswan Dam . Further decrease in drainage water quantity and increase of its salinity will occur when the irrigation efficiency is improved both in the conveying system and at the farm level.

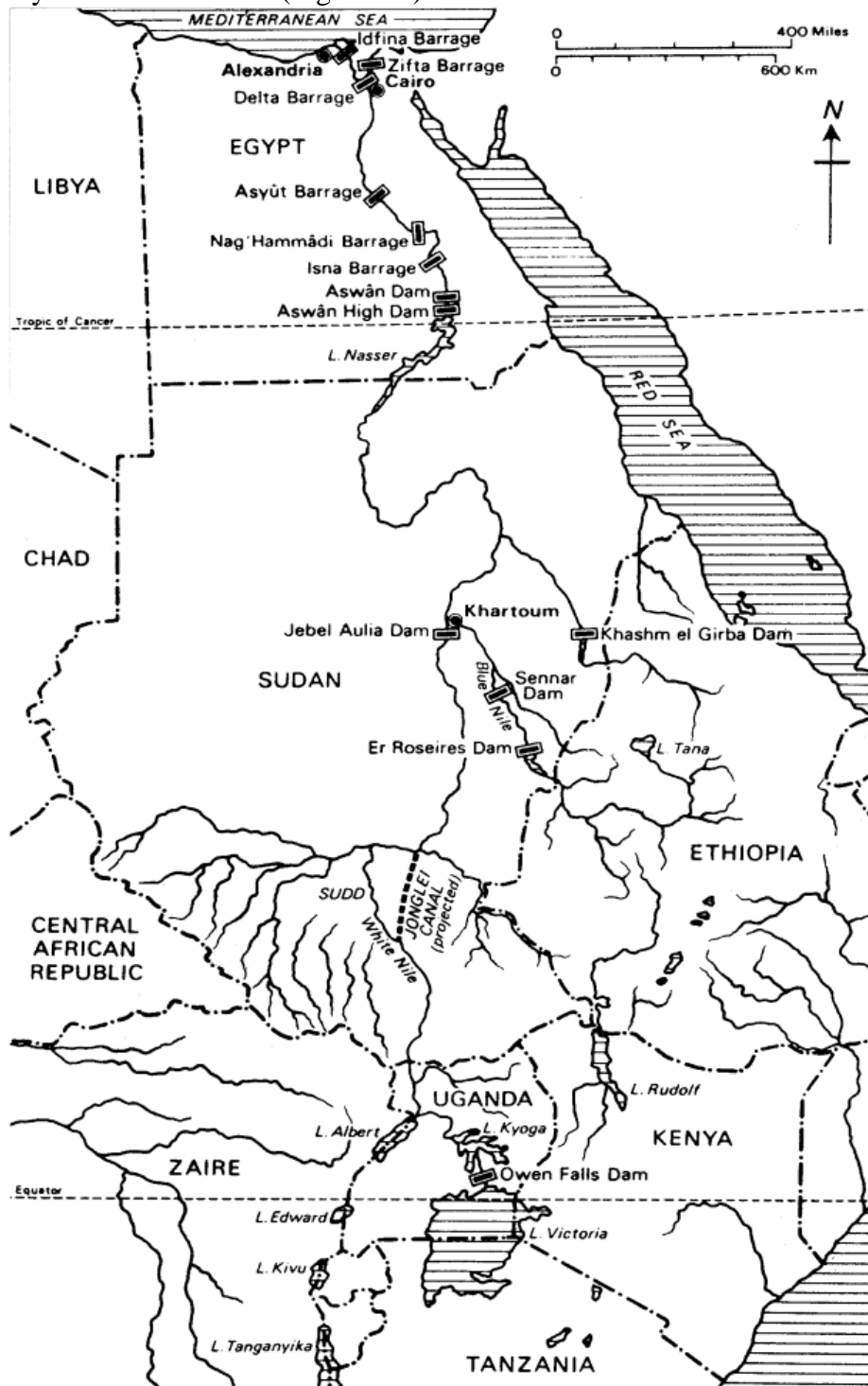
Surveys and monitoring of the quality and quantity of the agricultural drainage water in the Nile Delta have shown that it is possible to re-use part of this water in irrigation. When salinity is low, the water is used directly . When it is high , it is mixed with fresh canal water. Water with higher salinity and water contaminated by municipal and industrial wastes cannot be used in irrigation. Under most circumstances a substantial portion of drainage water must be discharged into the sea to maintain the salt balance in the Nile Delta.

The amount of drainage water presently re-used in irrigation is 4.7 billion m<sup>3</sup> annually, of which 2.6 billion m<sup>3</sup> is in the Nile Delta ,0.95 billion m<sup>3</sup> in Fayoum, and 1,015 billion m<sup>3</sup> returned to the Nile in Upper Egypt. This is expected to be increased gradually to reach 7.0 billion m<sup>3</sup> by the year 2000. It should be noted that potential savings from improved water management (greater efficiency and reduced outflows to the sea as practiced in 1987/88 and 1988/89) and increased re-use of drainage water are not mutually exclusive. However, there is a real danger that salinity could increase steadily over the years. A cautious approach to increasing the use of drainage water is likely to be in Egypt's long-term interest.

## Hydrology

### - River flow

To a large extent, the hydrology of Egypt is determined by factors outside the country. The very low annual rainfall means that no perennial rivers exist within the country with the Nile. Despite the huge size of the Nile basin in Africa, the Nile Valley in Egypt consists of a narrow north to south strip between the Red Sea Hills and the Western Desert. In all the region to the west of the Nile, surface runoff takes place only following severe storms and then it is always short-lived. The waters of the Nile have always been the only water source available to Egyptian farmers for their irrigation requirements. However, they have rarely been disappointed as the Nile has one the largest discharges of any river in the world. (Fig below).



## **Irrigation and drainage**

### **- The irrigation - drainage system**

The farmland of the Nile Basin is dissected by a complicated network of irrigation canals and drains. Major irrigation canals originate from the Nile or its Damietta and Rosetta branches. They divide repeatedly to bring fresh water to every plot of farmland. Smaller drains collect excess irrigation water from farm plots and bring it to larger drains which release their water into depressions such as Wadi Rayan in the Western Desert , or into the brackish lakes of the northern Delta.

In areas of fresh (irrigation system) , brackish, or saline (drainage system ) water, communities of phanerogamic water plants can cause serious blockages.

Most of the water plants of the Nile basin are from Cosmopolitan or palaeotropical taxa which can grow in fresh or brackish water. Some species such as *Nymphaea lotus* and *Nymphaea coerulea* are confined to drains, where slow water currents the favourable habitat for their growth. Others with local distribution include *Vallisneria spiralis* confined to Aswan Province, *Potamogeton trichoides* in Asyut and Minya Provinces and *P. perfoliatus* at Sadd El Rawafaa in Sinai as well as the Aswan area. The introduction of these species in such places can be attributed to migratory birds (El hadidi 1965, 1968). *Potamogeton schweinfurthii* and *Najas armata* are tropical species which are associated with the waters south of the Aswan Dams ; these act natural barriers for its spread northwards. The establishment of the Aswan High Dam in 1960-5 led to changes in environmental conditions which favoured the vigorous growth of some rare species such as *Myriophyllum spicatum* and *Eichhornia crassipes* which serious problems for irrigation and navigation.

The muddy banks of the Nile, irrigation canals and drains support the growth of populations of hygrophyllic species including the tall reeds *Cyperus alopecroides*, *Typha domingensis*, *Saccharum spontaneum*, and *Phragmites australis*. Shrubby species include *Pluchea dioscorides*, *Ambrosia maritima*, and *Sesbania sesban*. Herbaceous species include, *Mentha longifolia* subsp. *typhoides*, *Cotula anthemoides*, *Ageratum conyzoides*, *Coronopus niloticus*, and *Gnaphalium luteo-album*. *Ceruana pratensis* used to be rather abundant especially in Upper Egypt. After the construction of the Aswan High Dam, less silt was deposited in the Nile Basin north of the dam. This created unfavourable plant habitat and led to the disappearance of most of the populations. *Aster squamatus* was recently introduced to Egypt , is now completely naturalized, being one of the most widespread species in the country.

## Plant nutrient resources

Egypt has a long tradition of using mineral fertilizers, its first use of Chilean nitrates dating back to 1902. For over thirty years all mineral fertilizers were imported, until the local production of phosphate fertilizers started in 1936 and later the production of nitrogen fertilizers in 1951. The great demand for food, highly productive soil, availability of good quality irrigation water, optimum climatic conditions, and the use of new technology have contributed to a continuous increase in fertilizer production and thus, in fertilizer use. The increase in fertilizers use is influenced mainly by the following factors: cropping index and rotation, use of high yielding cultivars, degree of cultivation of newly reclaimed areas, requirements for subsidized fertilizers determined by the Ministry of Agriculture each season, amount of subsidies available for fertilizers, local production and availability of fertilizers when they are needed. Tables 1 and 2 show the quantities of fertilizers distributed to farmers by the Principal Bank for Development and Agricultural Credit (PBDAC) between 1970 and 1990, together with the official fertilizer requirements (an amount fixed by Ministerial Decree each season) for the years 1981/2 until 1988/9.

Table (1): Amounts of NPK fertilizers, distributed by PBDAC during the period 1970 - 1990 ('000 t)

Year	Fertilizer		
	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
1970	317	55	1.4
1971	308	59	1.9
1972	332	61	1.4
1973	322	57	2.4
1974	360	50	1.9
1975	403	78	2.4
1976	408	83	3.4
1977	418	68	2.9
1978	474	87	3.8
1979	483	98	6.7
1980	490	99	11.5
1981	626	134	12
1982	660	143	10
1983	746	150	17
1984	639	164	25
1985	775	184	25
1986	750	177	29
1987	791	184	29
1988	805	190	33
1989	790	180	27.5
1990	793	165	21

source: dSata for 1970-80, MOA (1986); 1981- 90, PBDAC (1991, personal communication).

Table (2) shows an interesting comparison between official fertilizer requirements, fixed by Ministerial Decree each season (an estimation of fertilizer need), and the actual quantities of fertilizer distributed to farmers. Fertilizer need estimation and distribution during the period, 1981-9

Year	Fertilizer	Fertilizer requirement a (need estimation) ( '000 t )	Fertilizer distributed by PBDAC ('000 t)	Fertilizer distributed relative to fertilizer requirement (%)
1981/2	N	692	626	90.5
	P <sub>2</sub> O <sub>5</sub>	158	134	85
	K <sub>2</sub> O	----	12	----
1982/3	N	701	660	94
	P <sub>2</sub> O <sub>5</sub>	165	143	86.7
	K <sub>2</sub> O	----	10	----
1983/4	N	617	746	121
	P <sub>2</sub> O <sub>5</sub>	168	150	89.3
	K <sub>2</sub> O	----	17	----
1985/6	N	752	775	103.1
	P <sub>2</sub> O <sub>5</sub>	180	184	102
	K <sub>2</sub> O	29	25	86.2
1986/7	N	781	750	101.3
	P <sub>2</sub> O <sub>5</sub>	189	177	97.4
	K <sub>2</sub> O	27	29	107.4
1987/8	N	786	791	102.4
	P <sub>2</sub> O <sub>5</sub>	187	190	101.6
	K <sub>2</sub> O	34	29	97.1
1988/9	N	801	772	98.6
	P <sub>2</sub> O <sub>5</sub>	192	181	93.8
	K <sub>2</sub> O	38	27	71.1

a An official rate fixed by Ministerial Decree each season, which can be purchased by all farmers. *Source: data for 1970 - 80, MOA (1986), 1981 - 90, PBDAC (1991, personal communication).*

Until recently, fertilizers have been used mainly in the form of straight fertilizers (Table 3). The major forms of nitrogen fertilizers used are calcium nitrate, ammonium sulphate, ammonium nitrate, and urea, while phosphate fertilizers are superphosphate, improved or double superphosphate and triple superphosphate. Only one potassium fertilizer is used, namely potassium sulphate. Straight fertilizers are still the major fertilizers used in traditional agriculture. Compound soil fertilizers were once imported for trial purposes (Table 4). Very small amounts of imported soluble compound fertilizers (Table 5) are used mainly in the new agricultural areas with unconventional irrigation systems - drip, pivot, and sprinkler-irrigation.

Table (3): Distribution of fertilizers through PBDAC during the period, 1981/2 - 1989/90 ('000 t)

	1981/2	1982/3	1983/4	1984/5	1985/6	1986/7	1987/8	1988/9	1989/90
Calcium nitrate (15.5 % N)	36.5	39.6	41.9	34.7	22.4	38.2	35.6	38.2	37.9
Ammonium sulphate (20.6 % N)	25.5	31.9	37.3	43.7	75.3	72.3	68.9	66.8	82.3
Ammonium nitrate (33.5 % N)	246.1	233.4	233.9	234.5	269.5	254.1	300.1	291.9	272
Urea (46 %N)	315.9	372.0	455.9	339.8	314.1	440.5	385.8	396.4	348.6
Superphosphate (15 % P <sub>2</sub> O <sub>5</sub> )	74.3	86.1	110.1	129.3	160.6	151.8	142.7	140.4	154.1
Double superphosphate (37 % P <sub>2</sub> O <sub>5</sub> )	–	–	–	–	11.8	38.1	37.1	24.5	30.1
Triple superphosphate (45 % P <sub>2</sub> O <sub>5</sub> )	59.6	56.8	49.5	34.8	10.9	–	–	–	–
Potassium sulphate (48 % K <sub>2</sub> O)	12.4	10.4	18.9	26.3	26.4	32.7	27	21.2	27.7

Source : El-Khashab (1987); PBDAC (1991, personal communication).

Table (4): Compound fertilizers (for soil application) imported during the year 1973/4

Fertilizer	t
Complex 15/5/5	4000
Complex 30/10/0	5000
Diammonium phosphate 16/48	5000

Source : EL-Khashab (1987)

Table (5): Compound fertilizers for drip irrigation , imported in the years 1986-9

Fertilizer	1986/7(t)	1988/9 (t)
13/40/13 (Kristalon 66)	261	100
15/5/30 + 3 Mg (Kristalon White)	306	1606
19/6/20 + 4 Mg (Kristalon Blue)	329	1000
19/19/19 + 2 Mg (Kristalon Special)	627	200

Source: El - Khashab (1987).

From 1970 until 1973 the use of N, and until 1974 the use of P<sub>2</sub>O<sub>5</sub> was more or less stagnated; since then in general, there has been a gradual increase. The use of K<sub>2</sub>O has remained very low compared with that of N and P<sub>2</sub>O<sub>5</sub> because it was believed that the high exchangeable-K content of the soil was adequate for most crops except those with a high starch content, as well as some vegetables and fruits (Serry 1980). However, as the research on potassium has increased (Faizy 1980) and, taking modern concepts of plant nutrition into consideration, it has been found that the K<sub>2</sub>O requirement of crops is much greater than was previously estimated (El- Fouly 1984, 1989; Abdel- Hadi 1989). Since 1975, a gradual increase in K<sub>2</sub>O consumption has been recorded (PBDAC 1986). This trend is leading to a more balanced ratio of fertilizers applied, instead of favouring only N; it also reflects the real needs of crops more accurately.

It shows that farmers are becoming more convinced of the need for potash. In 1985, the first official estimation of the K<sub>2</sub>O requirement was carried out.

The difference between the actual distribution of fertilizers by PBDAC and the estimated need is due mainly to the unavailability of fertilizers at certain times rather than the unwillingness of the farmers to use them.

### Production and importation of fertilizers

- local production of nitrogen and superphosphate

The fertilizer industry in Egypt started in 1936 by producing superphosphate from locally available raw material. In 1951 the first locally produced N fertilizer, namely calcium nitrate, came on to the market. Since then, the capacity of existing production plants has increased and new plants have been built (Aglan 1987; NSC 1981). Details of Egyptian companies producing mineral fertilizers are given in Table 6. No potash fertilizers are produced in Egypt due to the lack of raw material, but it was reported recently that some local potash deposits had been found. The production of N and P<sub>2</sub>O<sub>5</sub> fertilizers has increased markedly over the last decade. In the late 1980s, production exceeded 600 000 t N and 128000 t P<sub>2</sub>O<sub>5</sub> compared with 118 000 t N and 59 000 t P in 1970. Detailed data on the production, consumption, and trade in N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O since 1962 is given in Appendix Tables (1, 2, and 3).

TABLE (6): Companies producing chemical fertilizers in Egypt

Company / location	Product	Start of production
El_Malia Weal Senaiaa (EFIC)	Superphosphate	1936
Kafr El-Zayat branch	Superphosphate (15% P <sub>2</sub> O <sub>5</sub> )	1936
Asyut branch	Superphosphate (15% P <sub>2</sub> O <sub>5</sub> )	1969
Abu Zaabal Company	Superphosphate (15% P <sub>2</sub> O <sub>5</sub> )	1948
( fertilizers and chemicals )	Double superphosphate (37% P <sub>2</sub> O <sub>5</sub> )	1984
El Nasr Company for Fertilizers and	Calcium nitrate (15.5% N)	1951
Chemicals (SEMADCO)	Ammonium sulphate (20.6% N)	1963
	Calcium ammonium nitrate (26% N)	1975
	Calcium ammonium nitrate (31% N)	1976
	Urea (46% N)	1980
	Ammonium nitrate (33.5% N)	1988
Egyptian Chemical Industries (KIMA)	Calcium ammonium nitrate (20.5% N)	1960
	Calcium ammonium nitrate (26% N)	1964/5
	Calcium ammonium nitrate (31% N)	1968/9
	Ammonium nitrate (33.5% N)	1988
El Nasr Company	Ammonium sulphate (20.6% N)	1964
(coke industries and basic chemicals)	Calcium ammonium nitrate (20.5% N)	1971
	Calcium ammonium nitrate (33.5% N)	1973
Abu-Qir Company	Urea (46% N)	1980
(fertilizers)	Ammonium nitrate (33.5% N projected)	1991

Source : NSC ( 1981 ).

Appendix table 1 : Production, imports, exports, and consumption of nitrogen (' 000 t N)

Data source / Year	Production	Imports	Exports	Consumption
<b>FAO <sup>a</sup></b>				
1962	106.5	85.4	0	191.9
1963	111.2	85.0	0	196.1
1964	114.2	85.8	2.2	227.1
1965	128.1	120.3	2.6	260.6
1966	149.1	136.5	0	284.8
1967	163.3	84.0	0	243.8
1968	146.1	145.0	0	244.1
1969	139.8	134.0	0	281.4
1970	117.8	158.0	0	310.1
1971	118.3	148.1	0	330.8
1972	120.0	238.1	0.3	324.5
1973	151.8	290.0	0	360.9
1974	150.7	260.0	0	358.2
1975	100.2	263.5	0	360.0
1976	150.5	227.4	0	415.0
1977	169.9	227.3	0	427.7
1978	195.2	258.2	0	459.5
1979	216.5	333.1	0	490.5
1980	263.9	208.1	0	500.0
1981	400.5	164.4	1	554.0
1982	482.0	162.6	1.6	585.0
1983	622.8	36.0	0.4	667.8
1984	639.2	26.0	82.0	722.2
1985	625.9	143.5	138.0	649.2
1986	575.5	146.9	9.2	640.3
1987	601.8	53.6	0	655.4
<b>PBDAC <sup>a</sup></b>				
1984	572.0	14.1	82.0	743.3
1985	701.0	45.6	138.0	638.0
1986	690.0	199.2	9.2	775.8
1987	662.3	63.5	0	776.0
1988	663.6	80.5	0	791.7

<sup>a</sup> Note the difference in figures between the different source, FAO, Rome and the PBDAC (Principal Bank for Development and Agriculture Credit), Cairo. Source: *El-Khashab (1989)*.

Appendix table 2 : Production, imports, exports, and consumption of phosphorus (' 000 t P<sub>2</sub>O<sub>5</sub>)

Data source / Year	Production	Imports	Exports	Consumption
FAO <sup>a</sup>				
1962	25.6	19.7	1.0	48.4
1963	29.4	20.0	5.0	41.6
1964	31.6	20.0	4.6	47.9
1965	46.4	19.3	3.6	43.1
1966	42.5	9.8	4.4	52.2
1967	46.3	4.4	5.4	43.4
1968	52.2	3.7	4.3	35.5
1969	56.8	0	7.2	38.6
1970	59.4	0	9.0	36.2
1971	74.3	0	12.1	40.2
1972	73.8	0	11.8	46.3
1973	115.5	0	18.2	55.7
1974	81.0	3.1	9.2	44.4
1975	95.0	2.0	5.1	65.0
1976	77.0	1.5	4.3	83.0
1977	73.7	4.8	4.7	66.4
1978	88.4	9.0	10.1	80.8
1979	97.8	1.0	15.3	86.9
1980	93.0	11.6	18.2	97.5
1981	106.0	10.5	13.2	102.0
1982	116.6	32.0	23.2	110.0
1983	145.8	32.0	30.5	149.6
1984	122.8	64.4	11.9	159.6
1985	112.0	69.0	9.7	181.0
1986	149.1	59.8	10.7	198.2
1987	128.1	0	6.5	121.6
PBDAC <sup>a</sup>				
1984	139.9	31.6	0	158.5
1985	150.1	21.7	0	163.3
1986	184.1	0	0	183.2
1987	186.6	0	0	185.4
1988	189.4	0	0	190.8

<sup>a</sup> Note the difference in figures between the different source, FAO, Rome and the PBDAC (Principal Bank for Development and Agriculture Credit), Cairo. Source: *El-Khashab* (1989).

Appendix table 3 : Production, imports, exports, and consumption of potash (' 000 t K<sub>2</sub>O)

Data source / Year	Production	Imports	Exports	Consumption
<b>FAO <sup>a</sup></b>				
1962	0	2.00	0	2.00
1963	0	1.25	0	1.25
1964	0	1.02	0	1.03
1965	0	0.92	0	0.92
1966	0	0.59	0	0.59
1967	0	0.69	0	0.69
1968	0	1.20	0	1.20
1969	0	1.96	0	1.10
1970	0	1.74	0	1.52
1971	0	3.09	0	1.91
1972	0	3.72	0	1.64
1973	0	4.00	0	2.12
1974	0	0.75	0	1.92
1975	0	5.30	0	3.60
1976	0	5.33	0	3.19
1977	0	2.50	0	2.84
1978	0	0	0	2.94
1979	0	5.00	0	3.80
1980	0	5.00	0	6.70
1981	0	7.50	0	7.50
1982	0	12.91	0	12.91
1983	0	8.32	0	9.20
1984	0	16.90	0	17.50
1985	0	34.40	0	21.00
1986	0	14.27	0	25.00
1987	0	37.20	0	30.10
<b>PBDAC <sup>a</sup></b>				
1984	0	26.5	0	17.5
1985	0	16.9	0	24.2
1986	0	24.0	0	24.4
1987	0	28.9	0	28.9
1988	0	33.5	0	29.5
1989	0	38.4	0	31.2

<sup>a</sup> Note the difference in figures between the different source, FAO, Rome and the PBDAC (Principal Bank for Development and Agriculture Credit), Cairo. *Source: El-Khashab (1989).*

Rock phosphate for production of phosphatic fertilizers is available , but sulphur is mainly imported and partially produced by the Red Sea oil industry .Another major constraint in the fertilizer industry is the subsidy policy, for fertilizers are delivered to the PBDAC at a price far below the production cost (CAPMAS 1982).

A private fertilizer company in Egypt is now providing farmers with a variety of different NPK formulations, using local sources of N and P<sub>2</sub>O<sub>5</sub> and imported K<sub>2</sub>O.

## Importation of fertilizers

Despite the increasing local production of N and P fertilizers, their imports are considerable. The value of imports has reached two maxima in excess of LE 80 million, the first in 1974-5, followed by a decrease, followed by a second peak in 1985/6 (Table 7 and 9). The main countries exporting fertilizers to Egypt are given in Table 8, and Table 9 shows public sector imports until 1987/8. Since 1988, the private sector has also been allowed to import fertilizers.

Subsidized NPK fertilizers are currently distributed by the PBDAC, through its stores which are distributed all over the country (Table 10). These stores can accommodate up to about three million tonnes of fertilizers (El- Khashab 1989). Fertilizers are distributed to farmers according to a Ministerial Decree issued each agricultural season. This indicates fertilizer rates for each crop (Keleg et al. 1987). Appropriate amounts of fertilizer to meet the statutory rates of application are given to farmers all over the country with very limited differentiation. They are considered a compromise between different factors including real crop needs in different locations, availability, price policy, and subsidy.

Farmers are entitled to purchase specific quantities of fertilizers, by credit, according to the decree and their acreage. The PBDAC finance the whole purchase and allocates the required funds (Table 11). The value of fertilizers purchased by credit during the years 1983/4 - 1989/90 is shown in Table 12. Until 1986, only about 20-25 percent of the total volume of fertilizers distributed were purchased with cash. There are no figures to show the private sector's share of fertilizer distribution since 1989. Since 1990, companies producing fertilizers are also allowed to distribute their products directly to farmers or through channels other than the PBDAC.

Table (7) Quantity and value of imports of chemical fertilizers (1970/1 - 1982/3)

Year	N fertilizers ( 15.5 % N )		P fertilizers ( 15 % P <sub>2</sub> O <sub>5</sub> )		K fertilizers ( 48 % K <sub>2</sub> O )	
	000 t	LE '000	000 t	LE '000	000 t	LE '000
1970/1	1385	10 792	—	—	1.6	32
1971	1524	10 146	—	—	1.6	38
July/Dec. 1972	955	8 246	—	—	—	—
1973	1250	16 800	—	—	8.0	221
1974	2094	81 854	—	—	15.0	611
1975	1928	97 557	—	—	6.1	316
1976	824	13 890	—	—	5.0	291
1977	1957	32 291	20	302	10.0	615
1978	1930	41 302	39	651	10.0	644
1979	1400	29 661	41	970	20.0	1296
1980	1021	45 159	80	3912	15.5	2082
Jan./June 1981	1241	74 584	85	8432	15.5	2596
1981/2	520	31 320	145	29 102	25.0	5018
1982/3	160	10 261	160	23 248	25.0	4838

Source : MOA ( 1986 ).

Table (8) Major countries exporting fertilizers to Egypt

Fertilizer		Imported from
Type	Content	
N	Ammonium sulphate	France, Italy, Belgium, Bulgaria
	Ammonium nitrate	USSR, Romania, Czechoslovakia
	Urea	The Netherlands
P	Triple superphosphate	Tunisia, Lebanon, Belgium, France, USA
K	Potassium sulphate	Switzerland, USA

Source: MOA (1986)

TABLE (9) Impotrs of fertilizers by the public sector

	1982/3	1983/4	1984/5	1985/6	1986/7	1987/8
Fertilizer ( t )						
Urea (46 % N)	—	—	—	78 659	—	—
Ammonium nitrate (33.5 % N)	—	—	52 306	183 214	70 366	119 230
Ammonium sulphate (20.6 % N)	131 237	68 474	136 410	493 376	193 687	196 952
Triple superphosphate (44 % P <sub>2</sub> O <sub>5</sub> )	160 421	71 725	49 387	—	—	—
Potassium sulphate (48 % K <sub>2</sub> O)	24 961	55 211	35 175	50 011	60 301	69 872
Nutrient (t)						
N	27 035	14 106	45 623	199 195	63 472	80 514
P <sub>2</sub> O <sub>5</sub>	70 585	31 559	21 730	—	—	—
K <sub>2</sub> O	11 981	26 501	16 884	24 005	28 944	33 539

Source : El-Khashab ( 1989 ).

Table (10): Storage areas in different regions in Egypt ( June 1986 )

Region	Closed stores		open stores		Free storage area	
	Number	Area ( '000 m <sup>2</sup> )	Number	Area ( '000 m <sup>2</sup> )	Number	Area ( '000 m <sup>2</sup> )
Alexandria	31	4.26	—	—	5	41.8
Cairo	—	—	—	—	1	70.0
East Delta	59	26.9	27	54.2	123	983.9
West Delta	26	22.13	11	14.02	117	854.6
Middle Delta	19	27	5	22.75	53	389.3
Suez Canal	14	5.82	—	—	12	62.8
Middle Egypt	47	34	7	17.03	133	929
Upper Egypt	63	51.18	27	30.8	77	558

Source : El-Khashab (1987).

Table (11): Funds allocated by the PBDAC for the purchase of different quantities of fertilizers (1981/2 - 1990/91)

Year	Quantity of fertilizer ( '000 t )	Value of fertilizer ( LE million )
1981/2	2798	244
1982/3	2675	178
1983/4	2493	143
1984/5	2814	170
1985/6	3711	270
1986/7	3197	244
1987/8	3342	263
1988/9	3660	600
1989/90	3430	611
1990/1	3227	782

Source : El- Khashab (1987); PBDAC (1991, personal communication).

### Foliar fertilizers and micronutrients

It has already been mentioned that only small quantities of compound fertilizers are imported. The Abu-Qir Company is producing urea fortified with micronutrients in experimental quantities (Massoud 1983). Zinc sulphate is used extensively as a soil fertilizer in rice production. Some is produced locally, the rest is imported from different sources.

Foliar fertilizers have been registered in Egypt since 1976. In the 1960s and early 1970s characterized by the lack of NPK soil fertilizers, foliar NPK fertilizers showed positive effects on most crops. However, this is not the case now.

The trend has been towards micronutrient foliar fertilizers (El-Fouly 1987). New regulations for fertilizer registration issued in 1986 resulted in 121 foliar fertilizers being registered until the end of March 1988, and it is estimated that the number will increase with time. Of these foliar fertilizers, 11 are produced locally, but the majority are imported. No data is available for the quantities of foliar fertilizers produced locally and those utilized all over the country. These fertilizers are not subsidized and can be handled freely in the market place, which makes data collection very difficult. Most of these fertilizers are used for cotton, where no distinction is made between NPK and micronutrient foliar fertilizers. It was estimated that in 1982, 2400 t of fertilizers were used in cotton (El-Gala 1987). In 1982-3, the PBDAC distributed about 2000 t of foliar fertilizers (Table 13), but the amount has decreased since then. The decrease is due mainly to the stopping of NPK foliar fertilizer use in cotton. Attempts were made to rationalize the use of foliar fertilizers by categorizing them (Abdel-Hadi 1987; El-Fouly 1987) and identifying crop needs in different regions (El-Fouly 1987). An estimation of foliar usage is given in Table 14, while Table 15 shows preliminary estimations of the need for foliar micronutrient fertilizers.

The use of micronutrient foliar is likely to show a gradual increase in the future. In the meantime, and with the increasing availability of NPK soil fertilizers, the use of foliar NPK fertilizers will decrease.

Table (13): Distribution of foliar fertilizers by the PBDAC, 1981/2 - 1985/6 a

Year	Distribution (t)
1980/1	1159
1981/2	2147
1982/3	2112
1983/4	2065
1984/5	1588
1985/6	1506
1986/7	938
1987/8	926
1988/9	749
1989/90	397

a Excludes quantities distributed by other organizations and agents.

Source : *El-Khashab (1987)*.

Table (14): Total imported and locally produced foliar fertilizers for the period 1981- 8

	1981-5 <sup>b</sup>	1986	1987	1988	Total
Macronutrient compounds <sup>a</sup>	4784	432	442	2280	7938
Macro- and micronutrient compounds <sup>b</sup>	900	157	127	54	1238
Single micronutrient chelated compounds	312	35	52	47	446
Complex micronutrient compounds	962	25	160	160	1307

In addition to approximately 900 t Zinc sulphate per year for rice.

a With less than 2% micronutrient (Mn + Fe + Zn) in chelated form.

b With higher than 2% micronutrient (Mn + Fe + Zn) in chelated form.  
 Source : *El-Fouly (1989)*.

Table (15): Estimated crop requirements for zinc , manganese, iron, and copper, used as foliar fertilizers in chelated form.

Crop	Micronutrient requirement (g feddan 1)			
	Zn	Mn	Fe	Cu
Wheat	40	30	15	22.5
	80%	70%	60%	5%
Maize	50	45	20	22.5
	80%	30%	60%	5%
Sorghum	50	40	20	20
	80%	30%	10%	5%
Cotton	35	22	15	10
	85%	70%	70%	5%
Sugarcane	60	45	25	20
	80%	80%	25%	5%
Rice	50	40	20	20
	90%	60%	30%	5%
Vegetables	75	60	50	10
	100%	100%	50%	5%
Orchards	150	100	100	20
	100%	100%	100%	15%
Legumes	50	40	40	20
	100%	100%	100%	15%

Source : *El-Fouly (1989)*.

### **Future outlook**

Estimations of fertilizer requirements and availability until the year 2000 (Appendix Tables 4 and 5) (Aglan 1987; Mazen 1987; NSC 1981) show that for N and P a negative balance will exist, provided that the production capacity does not increase during this period. Needs for potash will double between 1985 and 2000 (NSC 1981), and this is a low estimation in view of new trends in potash research (El-Fouly 1989). There are, as yet , only preliminary estimations of the need for micronutrient fertilizers, in spite of the general recognition of their value and the increasing information on the increased needs of micronutrients for different crops. Furthermore, the whole fertilizer sector will face drastic changes in the 1990s as a result of changing production and trade policies, e.g. the removal of the price control and subsidy, production of new types of fertilizers, the increased role of the private sector, and the use of modern methods for determining crop fertilizer requirements according to varieties, location, and farming system , using soil testing and leaf analysis. In view of these changes, research institutions and agricultural extension will also have to change their policies , viewpoint, and methodology, in order to give the best advice to farmers, and to inform the industry about farmers' needs. The economics of fertilizer use in different crops will also be changed, and the environmental aspects of using fertilizers will play a greater part than at present. In view of these changes, two major projects are in progress to co-ordinate industrial and agricultural activities. One project is the work of the Egyptian Fertilizer Development Center (UNIDO/UNDP) in collaboration with IFDC, USA (Klada 1989). The second is the NRC/GTZ project on micronutrient and other plant nutrition problems in Egypt ( El-Fouly 1989).

Appendix table 4 : Nitrogeneous fertilizers: current situation and expectations until the year 2010 (' 000 t N)

Year	Production of existing plants <sup>a</sup>	Demand <sup>b</sup>	Deficit in production
1991/2	660	874	214
1992/3	653	893	240
1993/4	647	911	262
1994/5	640	930	290
1995/6	634	949	315
1996/7	627	967	340
1997/8	621	985	364
1998/9	615	1004	389
1999/2000	609	1023	414
2000/1	603	1042	439
2001/2	597	1060	463
2002/3	591	1078	487
2003/4	585	1097	512
2004/5	579	1116	537
2005/6	573	1135	562
2006/7	567	1153	586
2007/8	562	1172	610
2008/9	556	1190	634
2009/10	551	1209	658

<sup>a</sup> Based on the actual production in 1987/8, then decreased by a rate of 1% yearly because of the very old factories.

<sup>b</sup> Based on the estimates of the Ministry of the Agriculture. *Source: Dawoud (1989).*

Appendix table 5 : Phosphorous fertilizers :current situation and expectations until the year 2010 (' 000 t P<sub>2</sub>O<sub>5</sub>)

Year	Production of existing plants a	Demand b	Deficit in production
1991/2	181	203	22
1992/3	179	208	29
1993/4	177	212	35
1994/5	175	217	42
1995/6	173	221	48
1996/7	171	226	55
1997/8	169	230	61
1998/9	167	235	68
1999/2000	165	239	67
2000/1	163	244	81
2001/2	161	248	87
2002/3	159	253	94
2003/4	157	257	100
2004/5	155	262	107
2005/6	153	266	114
2006/7	151	271	120
2007/8	149	275	126
2008/9	147	280	133
2009/10	145	284	139

<sup>a</sup> Based on the actual production in 1987/8, then decreased by a rate of 1% yearly because of the very old factories.

<sup>b</sup> Based on the estimates of the Ministry of the Agriculture. *Source: Dawoud (1989).*