NILE VALLEY REGIONAL PROGRAM PHASE II

Resource Management Series

Volume 11

INVENTORY STUDIES

Rainfed Areas of Egypt
Northwest Coast

Editors
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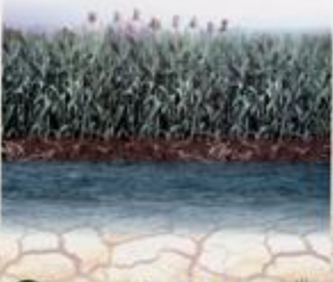

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ICARDA

Volume 11

Resource Management in the Rainfed Areas of Egypt: Northwest Coast

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Foreword

Limited soil and water resources and threatened sustainability of agricultural production call for an effective resource management strategy and farming systems approach in agricultural research. Implementing a long-term research program where more emphasis would be on systems-oriented rather than commodity-oriented agricultural research would represent such a strategy. Therefore, the Resource Management Component of the Nile Valley Regional Program (NVRP) of the International Center for Agricultural Research in the Dry Areas (ICARDA) was developed. The Component, which started in 1994 in one of the Nile Valley countries, Egypt, and is expected to be extended to the others, aims at achieving sustainable production at a high level, based upon the need to protect the resource base (land and water) through good management. This would be achieved through basic intensive technical research (long-term on-station trials) and on-farm extensive monitoring of resources in farmers' fields and farmers' decision making logic.

Preparatory studies were carried out prior to conducting the trials and monitoring activities. The objectives of these studies were to define and characterize the major farming systems of the main agroecological environments; to identify and prioritize—with respect to the natural resources—the constraints to optimum utilization and the threats to sustainable production; and to provide an outline for the strategy, design and implementation of the long-term research activities.

The preparatory studies involved three procedures for information collection: **Inventory Studies**, in which existing information and details of the ongoing research and development, related to soil and water management, agronomy and cropping systems, and socioeconomics were collected; **Rapid Rural Appraisals**, which included qualitative sampling of farmers and extension views concerning current limitations, constraints, dangers, and opportunities in the utilization of soil, water, and inputs; and **Multidisciplinary Surveys**, which employed short-focused questionnaires to fill some important information gaps. In general, information collected in the preparatory studies dealt with resource description, resource utilization and management, productivity, and threats to sustainability. This knowledge was used in planning the long-term research activities at selected locations by identifying high-priority researchable resource management problems, in the context of realistic cropping sequences and farm level economics.

The outcome of these studies is hence presented in what is called the **Resource Management Series**. The series includes a total of 18 volumes on Inventory Studies, Rapid Rural Appraisals, and Multidisciplinary Surveys in the Old Irrigated Lands, New Lands, and Rainfed Areas. In the Inventory Studies, five volumes on the research and development activities and findings in each of the Old and New Lands were compiled. These volumes were on Agronomy, Soil Fertility and Management, Water Management, Socioeconomic Studies, and a Synthesis of all the latter. The Inventory Studies of the Rainfed Areas included two volumes, one on the Northwest Coast and the other on North Sinai.

These studies were conducted in Egypt with the involvement of the Agricultural Research Center (ARC), Desert Research Center (DRC), National Water Research Center (NWRC), National Research Center (NRC), Ain Shams University and ICARDA within the NVRP with financial support from the European Commission. Appreciation is expressed to all those who contributed to these important reviews and studies.

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Weights and Measures

1 feddan (fed) = 0.42 hectare = 1.037 acres

1 hectare (ha) = 2.38 feddans

1 ardab wheat = 150 kg

1 ardab barley = 120 kg

Acronyms

ARC = Agricultural Research Center

BDAC = Bank of Development and Commerce

CAPMAS = Central Agency for Public Mobilization and Statistics

CEC = Cation Exchange Capacity

DRC = Desert Research Center

EU = European Union

FAO = Food and Agriculture Organization

FCRI = Field Crops Research Institute

GARPAD = General Authority for Reclamation Projects and Agricultural Development

GDDA = General Desert Development Authority

GOE = Government of Egypt

GTZ = Gesellschaft für technische Zusammenarbeit (German Agency for Technical Cooperation)

IAV = Inter-annual Variability

ICARDA = International Center for Agricultural Research in the Dry Areas

LE = Egyptian Pound

MALR = Ministry of Agriculture and Land Reclamation

MARS = Matrouh Agricultural Research Station

mcm = Million Cubic Meters

MDNCHPU = Ministry of Development, New Communities, Housing and Public Utilities

MDRS = Matrouh Development and Reconstruction Sector

NRC = National Research Center

NVRP = Nile Valley Regional Program

RAMDENE = Regional Environmental Management of Mediterranean Desert Ecosystems of Northern Egypt

SAMDENE = Systems Analysis of Mediterranean Desert Ecosystems of Northern Egypt

TDS = Total Dissolved Salts

UNDP = United Nations Development Program

UNESCO = United Nations Educational, Scientific and Cultural Organization

WFP = World Food Program

WUE = Water-Use Efficiency

Introduction

The northern coast of Egypt is unique in its historical and environmental background. The area represents a gateway to the east, west, and north to Europe across the Mediterranean. Historically, the area rumbles with the echoes of war machinery and the tramp of the many troops that have passed that way from ancient to modern times. It has also been the pathway for profits, apostles and missionaries.

Both the Northwest Coast and North Sinai have been the subject of various investigations, starting in the 1920s. The number of investigations has grown during the last 20 years. This intensive study has varied in objective, scale, and subject matter. Studies and research projects have been sponsored and carried out by various national institutes and authorities as well as regional and international organizations. Foremost among the national institutes are the Desert Research Center (formerly Desert Research Institute), the Agricultural Research Center, the National Research Center, the Academy of Scientific Research and Technology, the General Authority for Reclamation, Projects and Agricultural Development (GARPAD), and the Universities of Alexandria and Suez Canal.

The World Food Program (WFP):

This program was carried out in the project area and in the entire Northwest Coast during 1963–1973. It was revived in 1979 and continues today. The project focuses on the improvement of soil and water resources and socioeconomic conditions, hence contributing to Bedouin sedentarization. Activities are:

- Cleaning of old cisterns and excavation of new ones.
- Construction of dikes.
- Building of houses and animal sheds.
- Planting fruit trees.

The Food and Agriculture Organization (FAO):

FAO was active in the Northwest Coast in 1965–1970, and again from 1988 to the present. The current project aims to develop agricultural production by using modern agricultural methods, irrigation systems, and plastic greenhouses. The project is more active in specific sites such as El Qasr, Om El Rakham, Sidi Barrani, and Abu-Laho. It includes trials on soil and water conservation works in Wadi Mostagema, Wadi Shaiab, and Wadi Taweila.

The Australian Dryland Farming System:

In 1980–1983, McGowan International Ltd investigated the feasibility of introducing the Australian dryland farming system in the Northwest Coast. In the course of their work, they planted crops and established pasture on some 3,800 fed (1,357 ha) at seven trial sites.

The German Agency for Technical Cooperation (GTZ):

In 1988, GTZ began operations in El Qasr on an area of 40 × 70 km. It established agro-climate stations and land use planning and environmental monitoring stations. The project focuses on rural development. GTZ started a technical cooperation project, "Rural Development of North Sinai," in 1991. The aim of the project is to provide a general overview of the soils and land suitability in the North Sinai governorate.

The World Bank and the Government of Egypt (Ministry of Agriculture and Land Reclamation):

A feasibility study entitled "Matrouh Resource Management Project" was conducted in 1992 in the Western Province, from Matrouh westward almost to the Libyan border. The aim of the study was to make the best use of the limited resources available to the local population through the analysis of the natural resource base and the assessment of sustainable development possibilities.

Location and Physiography

Location

The Northwest Coast of Egypt forms a belt about 20 km deep, which extends for about 500 km between Amria (20 km west of Alexandria) and El Salloum near the borders with Libya (Fig. 1).

Physiography

The region can be subdivided into five physiographic areas (Fig. 2), each with its own particular topographical features (Pavlov 1962; La Moreaux and Hyde 1966; FAO/UNDP 1970; Ayyad *et al.* 1990):

- **Alexandria to El Alamein**: The coastal plain is wide, and includes three main ridges running parallel to the coast—a recent coastal ridge covered by sand dunes, and two old consolidated ridges—with flat depressions in between. The coastal plain leads to the Mariut Plateau at an elevation of 5–40 m asl.
- **El Alamein to Ras El Hekma**: This is an irregular succession of alternating low hills and closed depressions, sloping from south (60 m asl) to north (the coastline). There is an almost continuous range of dunes along the coast.
- **Ras El Hekma to Ras Abu-Laho**: The cliffs of the Libyan Plateau run parallel to the coast. A discontinuous series of dunes develops at a distance varying from 200 m to 3 km from the coast. There are some saline depressions in the lower part of the plain, some with outlets to the sea. The escarpment of the plateau is deeply cut by *wadis*.
- **Ras Abu-Laho to Sidi Barrani:** This region is characterized by a uniform topography. The coastal belt of alluvial soils is narrow and intermittent. South of the coastal belt, a large area of gentle uniform slopes extends up to the Libyan Plateau.
- **Sidi Barrani to El Salloum**: A flat coastal band 2–4 km wide, is found behind the dunes, starting some 10 km east of El Salloum. A few large depressions occur along the edge of the Libyan Plateau at 200 m asl. Some important *wadis* dissect the escarpment, especially southwest of Sidi Barrani.

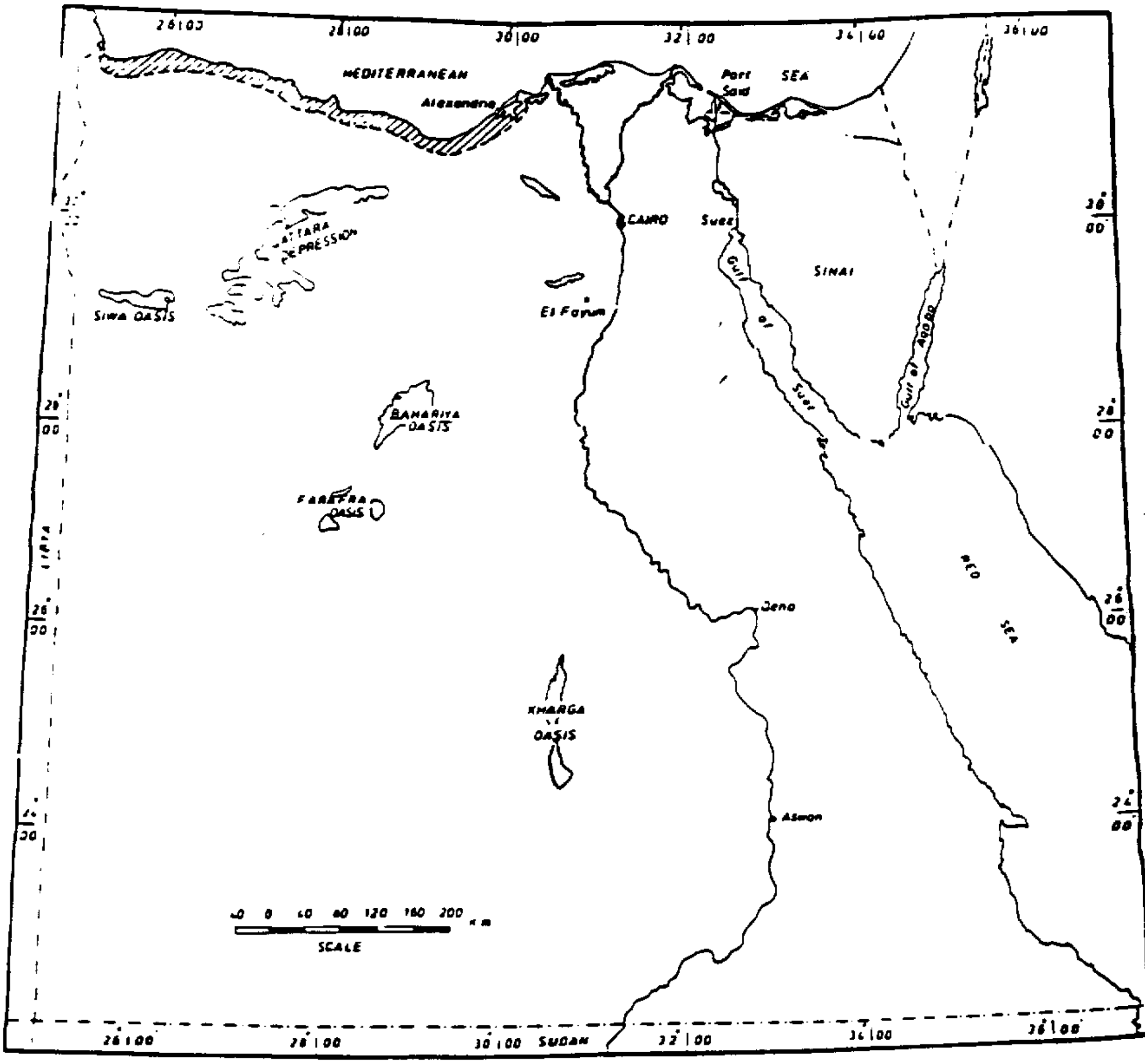


Fig. 1. Map showing the location of the Northwest Coast.

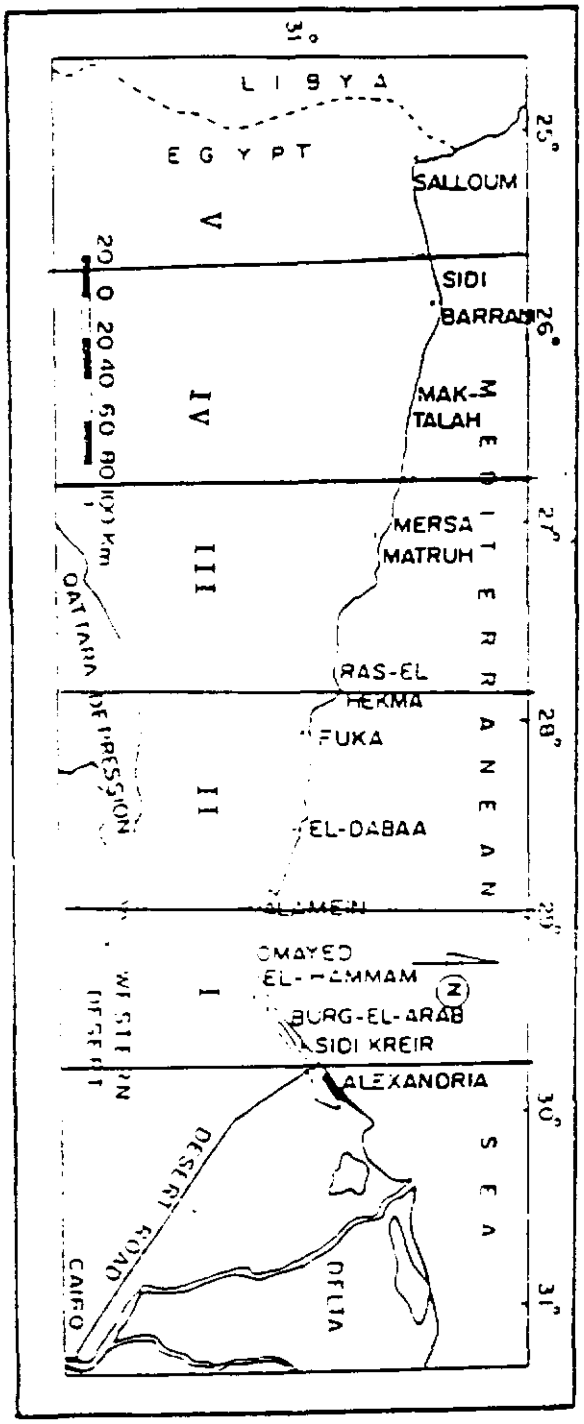


Fig. 2. The five physiographic zones of the Northwest Coast.

Meteorological Data

General Features

The Mediterranean coastal area of Egypt belongs to the dry arid climatic zone of Kopen's 1931 classification system (as quoted by Trewartha 1954), the arid mesothermal province of Thornthwaite (1948), and the Mediterranean arid bioclimatic zone of Emberger (1956). The region lies in Meig's "warm coastal deserts" (Meig 1973). According to the map of the world distribution of arid regions (UNESCO 1977) the climatic conditions are: warm summer (20–30°C), mild winter (10–20°C), and P/E + P less than 0.03 (where P is annual precipitation and E is annual evaporation).

Three factors contribute to the climate of the western Mediterranean region of Egypt: (i) the situation with regard to general circulation of the atmosphere; (ii) the proximity of the Mediterranean Sea; and (iii) the orientation of the coast (FAO/UNDP 1970).

The first factor is undoubtedly the most important. At the latitudes of this region, weather is controlled in summer by a subtropical high pressure belt and in winter by the cyclones moving eastwards with the westerlies. The summer (May to September) is characterized by a clear sky, no rain, high radiation, and a relatively weak wind. The situation changes in the winter, when cyclones found in the western region of the Mediterranean (Gulf of Genoa and Cyprus) penetrate eastward with the westerlies. These westerly cyclones account for practically all the winter rainfall in the region.

The proximity of the sea has a direct effect on air temperature and humidity, and consequently on evaporation and condensation, but does not affect rainfall.

The orientation of the coast with regard to the prevailing wind probably explains the differences in the distribution of rainfall along the coast. The parts of the coast directly exposed to the northwest winds, such as the region from Alexandria to Burg El Arab, receive more rain than those facing the northeast (Fuka and El Salloum).

Average Rainfall

Rainfall in the Northwest Coast ranges between 105.0 mm/yr at El Salloum and 199.6 mm/yr at Alexandria (Table 1). Data from eight stations situated near the coastline show that most of the rainfall (70% or more) occurs within the winter months (November to February), mostly during December and January. Two sets of data on Marsa Matrouh and Sidi Barrani are available, each representing the monthly averages for more than 15 years. The average annual means as well as the monthly means were very similar in magnitude, showing no significant shift in rainfall values over a period of more than 50 years.

Table 1 shows significant variation from one location to another, which is attributed mainly to the orientation of the coast at these locations. The data show that Alexandria has the highest annual mean while El Salloum and Fuka the lowest. El Dabaa, Marsa Matrouh and Sidi Barrani show intermediate means of a similar order of magnitude.

The prevailing rainfall gradient from north to south is shown in Fig. 3. The average mean decreases sharply from 150 mm near the coast to 80 mm at 20–70 km inland.

Table 1. Average monthly rainfall (mm) at eight stations (Northwest Coast).

Station / Period	July	Aug.	Sept	Oct	Nov	Dec.	Jan	Feb	March	April	May	June	Annual mean
Alexandria													
1946-1975	T	0.3	1.0	9.3	33.1	55.6	54.9	26.6	12.9	4.2	1.5	T	199.4
Burg El Arab													
1925-1965	0.0	0.0	0.4	13.7	31.4	35.5	42.1	22.1	4.7	4.1	0.6	0.0	156.6
El Hammam													
1925-1965	0.0	0.0	3.1	8.9	25.1	28.3	28.5	18.7	5.3	1.5	0.5	0.0	119.9
El Dabaa													
1925-1965	0.0	0.3	1.0	8.1	29.3	36.8	32.6	18.1	9.2	2.6	2.6	0.0	140.6
Fuka													
1925-1965	0.0	0.0	0.8	11.7	19.1	29.2	21.8	18.5	4.8	1.0	1.5	0.0	108.4
Mersa Matruh													
1948-1975	0.0	0.6	1.1	15.6	22.5	30.2	33.2	15.1	12.0	2.8	2.6	2.0	137.7
1960-1988	0.0	0.5	1.1	13.4	22.4	33.5	32.3	18.5	11.0	3.3	2.5	1.1	139.6
Sidi Barani													
1925-1965	0.0	0.1	0.3	14.4	21.9	35.0	38.1	19.4	10.2	1.6	2.8	0.1	143.9
1975.1992	0.0	0.0	2.1	10.8	15.4	41.4	41.4	25.6	7.9	2.2	1.4	0.0	148.2
Sallum													
1948-1975	0.0	0.0	1.5	15.9	23.9	17.2	20.6	9.6	8.8	3.7	3.5	0.0	105.0

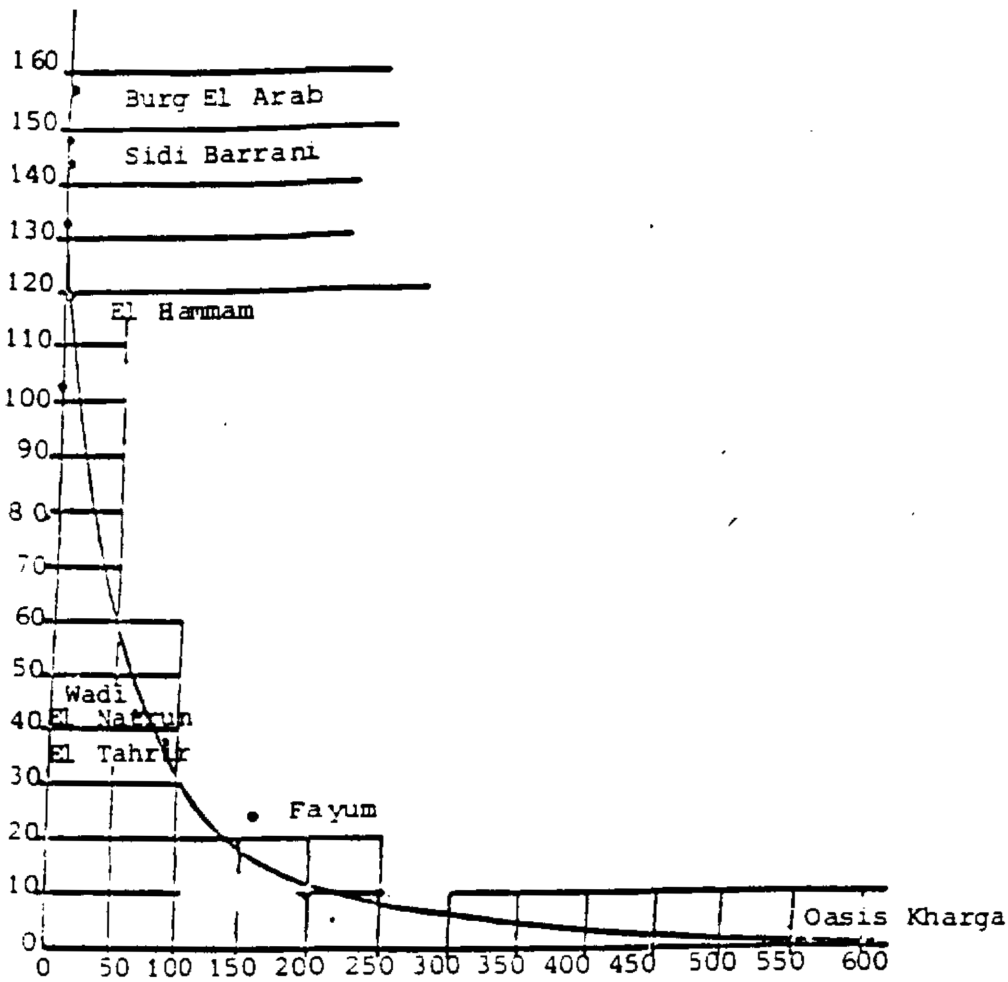


Fig. 3. Relation between rainfall (mm/yr) and distance (km) inland (Ismail *et al.* 1976).

Annual Distribution of Rainfall

The rainy season begins during the second half of October, and in this month the whole Northwest Coast receives at least 10% of its annual precipitation. Seventy-five percent of the total rainfall falls from November to February, with December and January the rainiest months. Some showers occur in March, but the spring in general is dry and receives only 10% of the total amount. The dry season lasts six to seven months without precipitation, except for a few stormy rains in April, May and September.

The mean number of rainy days is given in Table 2 and Fig. 4 for four levels of precipitation. Of 42 rainy days per year, only a few bring enough water to moisten the soil. On 25 days there is rainfall greater than 1 mm. A rainfall of more than 5 mm is observed seven days per year. Rainfall of more than 10 mm/day, generally falling with an intensity high enough to fill the *wadis*, occurs only three or four times per year. The total number of rainy days decreases from 95 in Alexandria to 53 in El Salloum.

Rainfall Intensity

The rainfall intensity is a very important factor, which affects runoff rate to a great extent and consequently soil erosion. Probability analysis of the annual rainfall in the region shows that rainfall of more than 98 mm/day is observed only once in 50 years; 75–98 mm/day only twice and 50–75 mm/day only five times (FAO/UNDP 1970).

The highest rainfall recorded during the last 15 days of October was 50 mm in one day. On that day 34 mm fell in the first hour, 45 mm by the end of 6 hours, and 50 mm by the end of 12 hours. In December 1990, the weather station installed by the GTZ project in El Qasr area registered 104 mm of rain in 6 hours.

The probable of occurrence of rainfall according to El Naggar and Perrier (1989) is:

- More than 2 mm/hr: 100%.
- More than 5 mm/hr: 85%.
- More than 10 mm/hr: 30%.
- More than 20 mm/hr: 15%.

This shows that 45% of the time, runoff storms occur (El Naggar and Perrier 1989).

Annual Rainfall Variation

The variation of rainfall from one year to another has a direct and significant impact on dry farming in the Northwest Coast. Fig. 5 shows the variation in annual rainfall at Marsa Matrouh over more than 65 years (Ergenzinger 1990). The minimum total annual rainfall was 34 mm (1950/51) and the maximum was 311 mm (1929/30). Table 3 illustrates the probability of certain levels of annual rainfall in Marsa Matrouh.

Table 2. Mean number of rainy days for four levels of precipitation (FAO/UNDP 1970).

Storm level/station	Jan.	Feb.	Mar	Apr	May	Sept.	Oct.	Nov	Dec.	Annual Mean
At least 0.1 mm										
Alexandria	10.1	7.3	5.3	1.6	1.1	0.3	3.9	7.2	10.9	47.7
El-Dabaa	5.6	3.7	1.9	0.5	0.5	0.2	3.1	3.7	5.3	24.6
Marsa Matruh	8.0	6.3	4.7	2.7	1.2	0.4	3.7	6.3	8.4	41.9
Sidi Barrani	9.0	5.7	4.8	0.4	1.8	0.3	3.8	4.8	9.3	40.2
El-Sallum	7.3	4.8	3.7	1.8	1.9	0.5	3.2	2.9	5.4	31.7
Greater than 1.0 mm										
Alexandria	6.7	4.8	2.5	0.7	1.1	0.2	2.5	4.3	7.4	30.2
El-Dabaa	4.4	2.7	1.2	0.2	0.4	0.2	1.9	2.3	3.8	17.1
Marsa Matruh	4.9	3.7	1.8	0.6	0.5	0.2	2.2	3.4	5.7	23.1
Sidi Barrani	6.3	2.8	2.7	0.5	0.7	0.0	2.1	3.4	6.4	25.1
El-Sallum	3.6	2.1	1.4	0.3	0.7	0.0	1.8	1.0	3.2	14.1
Greater than 5.0 mm										
Alexandria	2.6	2.0	0.4	0.2	0.0	0.0	0.7	1.9	3.9	11.7
El-Dabaa	1.7	0.7	1.0	0.1	0.1	0.1	1.2	1.2	1.9	8.0
Marsa Matruh	1.7	0.9	0.6	0.1	0.0	0.1	0.7	1.3	1.9	7.3
Sidi Barrani	3.2	0.5	0.7	0.1	0.0	0.0	1.2	0.8	2.2	8.7
El-Sallum	0.0	1.0	0.5	0.0	0.2	0.0	1.3	0.0	1.2	5.2
Greater than 10.0 mm										
Alexandria	1.4	0.7	0.1	0.0	0.0	0.0	0.3	0.8	1.9	5.2
El-Dabaa	1.0	0.4	0.1	0.1	0.1	0.1	0.4	0.8	1.0	4.0
Marsa Matruh	0.8	0.3	0.0	0.0	0.0	0.0	0.5	0.5	0.9	3.1
Sidi Barrani	1.5	0.3	0.1	0.0	0.0	0.0	0.4	0.3	1.2	3.8
El-Sallum	0.5	0.5	0.2	0.0	0.1	0.0	0.6	0.0	0.6	2.2

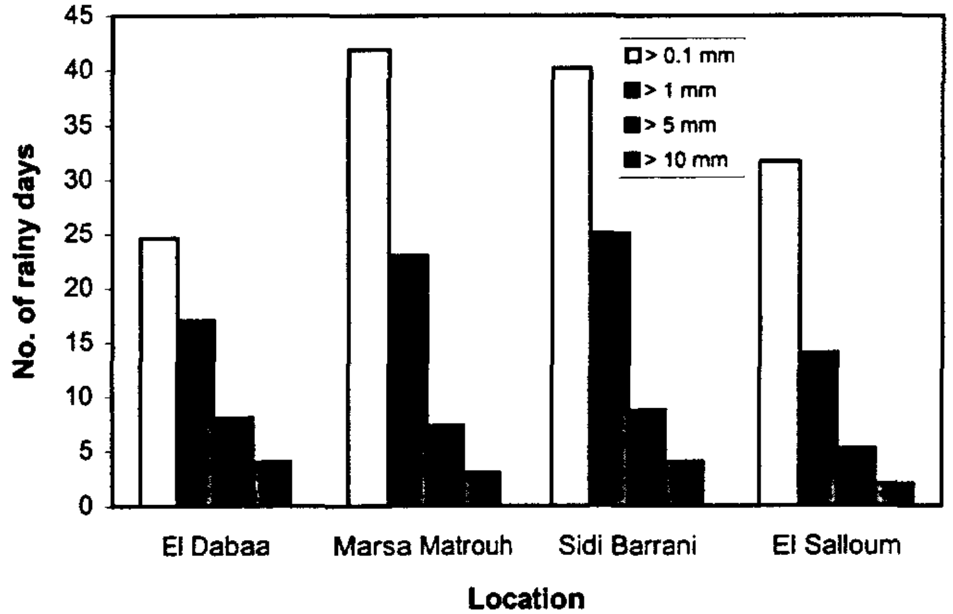


Fig. 4. Mean annual number of rainy days for four levels of precipitation (R) (FAO/UNDP 1970).

Table 3. Probability of occurrence of certain levels of annual rainfall in Marsa Matrouh.

Rainfall (mm) equal to or greater than	No. of years	Probability (%)
50	60	95.2
100	55	71.4
140	50	50.0
150	25	39.7
200	11	17.4
250	4	6.3
300	1	1.6

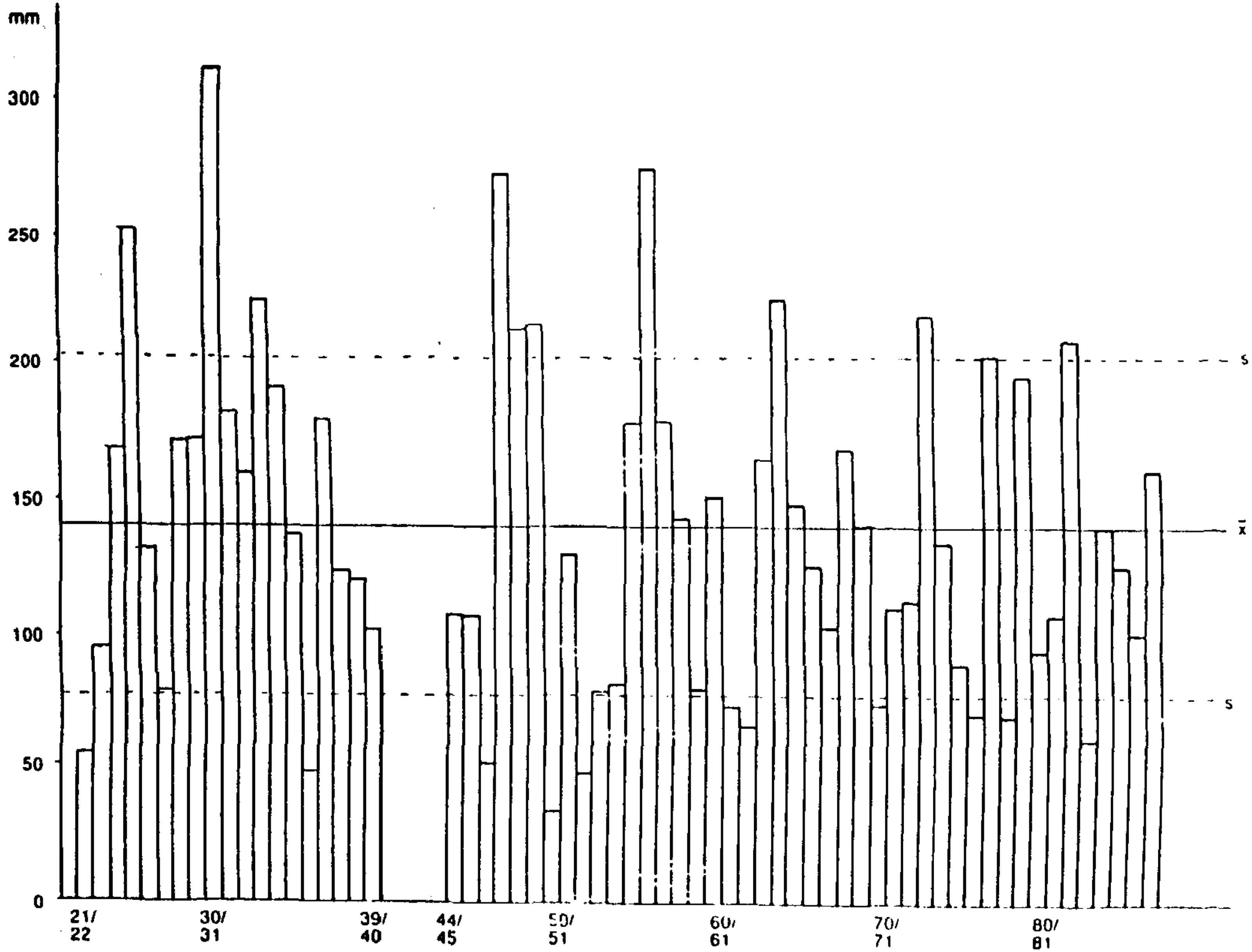


Fig. 5. Annual rainfall for Marsa Matrouh over a period of more than 65 years (Ergenzinger 1990).

The inter-annual variability (IAV) of the annual rainfall was calculated for five areas of the Northwest Coast (FAO/UNDP 1970) and reported in Table 4, together with the relative IAV showing the ratio of variation to the average annual rainfall. The data in this table show that Alexandria has the least relative variability while El Salloum has the highest. The data also show that though Sidi Barrani has an average annual rainfall similar to Matrouh, it has less inter-annual variability.

Table 4. Inter-annual variability (IAV) in the Northwest Coast of Egypt.

Station	Number of years of observation	Annual average (mm)	IAV (mm)	Relative IAV (%)
Alexandria	50	199	57	28.6
El Dabaa	38	141	57	40.4
Marsa Matrouh	40	140	67	47.8
Sidi Barrani	35	144	57	39.6
El Salloum	38	105	72	68.6

Frequency of Dry and Rainy Years

The values in Table 4, calculated on the basis of the hydrological year (June 1 to May 31) show that in Alexandria, rainy years with more than 250 mm occur once or twice in ten years, and dry years with less than 120 mm occur once in ten years. In Marsa Matrouh, El Dabaa and Sidi Barrani, annual rainfall of more than 250 mm is exceptional. A rainfall of more than 200 mm occurs twice in ten years. Dry years receiving less than 100 mm occur two or three years in ten. In El Salloum, the distribution is highly asymmetric. Despite the low annual average (105 mm), high annual amounts are sometimes observed, more often than would be predicted. On the other hand, drought conditions with rainfall less than 50 mm prevail about twice in ten years.

Ayyad (1973) calculated the number of occasions per 100 years that certain ranges of rainfall will occur (Table 5).

Table 5. Rainfall occurrence of certain ranges per 100 years at Burg El Arab.

Range of rainfall/year (mm)	Expectancies per 100 years
< 50	9.0
50–100	16.5
100–150	24.9
150–200	25.1
200–250	15.8
> 250	8.7

Dew

In arid and semi-arid regions, dew is a valuable source of moisture to plants. It has repeatedly been observed that some perennials, especially on sand dunes, produce ephemeral rootlets during the dry season, which are believed to absorb dew as it moistens the surface layers of the soil (Kassas 1955). Climatic conditions in the Mediterranean ecosystems of Egypt, such as considerable temperature gradients between different soil strata and overlying air, high relative humidity, and still wind, particularly during summer and autumn, are in some seasons favorable for water vapor condensation. The gain in moisture content due to water vapor condensation on the sand dunes was estimated by Migahid and Ayyad (1959) as ranging between 2.35 and 4.7% at Ras El Hekma, and a dew of 11.5 mm was recorded in 1955 at Burg El Arab. Abd El Rahman *et al.* (1966) recorded gains in soil moisture content due to water vapor condensation varying from 0.4 to 1.4%.

Temperature and Relative Humidity

The temperature varies from one location to another according to proximity to the sea and elevation above sea level. The monthly mean air temperature decreases from the west at El Salloum (20.5°C) to the east at El Dabaa (19.3°C), and then increases again towards Alexandria (20.2°C). The mean maximum air temperature (Table 6) varies form 16.7°C in January at Burg El Arab to 31.0°C in August at El Salloum, and the mean minimum varies from 6.4°C in January at Burg El Arab to 23.5°C in August at Dekheila, just west of Alexandria (Ayyad and El Ghareeb 1983). The mean annual air temperature differs within a narrow range from one station to another. The monthly mean relative humidity is usually higher in summer than in winter. It ranges from 51% in November at Dekheila to 75% in July at Sidi Barrani.

Wind

Wind is generally light, but violent dust storms and sand pillars are not rare. The prevailing winds are from the northwest. However, in spring hot *khamaseen* storms blow from the southeast. At Marsa Matrouh and Sidi Barrani, wind blows strongly during winter and early spring, with an average velocity of 20–23 km/hr (Ayyad and El Ghareeb 1983). The end of summer is characterized by many calm days, and the average wind speed drops to 15 km/hr. Wind speed at Alexandria, El Dabaa and El Salloum is 25% lower than in Marsa Matrouh and Sidi Barrani (Table 7). Maximum wind speeds of over 100 km/hr occur in the region an average of 2.2 times in ten years.

Sunshine

There is a little difference in sunshine from place to place along the Northwest Coast of Egypt. The monthly mean ranges between 201 hr in January and 272 hr in August.

Evapotranspiration

Evapotranspiration plays an important role in the soil/water relationship and affects the amount of recharge of groundwater aquifers as well as the groundwater quality. Mean annual potential evapotranspiration, estimated according to Thornthwaite's (1948) formula, is 995 mm in Burg El Arab (Ayyad 1973). Variations in potential evapotranspiration were calculated according to seven methods for Dekheila, El Dabaa and Marsa Matrouh (Mehanna 1981). The mean values were 945, 876, and 971 mm/year for the three stations, respectively, using Thornthwaite's method, and 1986, 2095, and 2146 mm/year using Penman's (1948) method.

Table 6. Monthly mean minimum (m) and maximum (M) air temperatures (°C) at five stations in the Northwest Coast.

Month	Station											
	Dekhella		Burg El-Arab		El-Dabaa		Mersa Matruh		Sidi-Barrani		El-Sallum	
	m	M	m	M	m	M	m	M	m	M	m	M
January	9.6	17.7	6.4	16.7	7.3	18.1	8.4	18.0	8.4	17.9	9.4	18.9
February	10.3	18.6	8.0	17.7	7.9	18.9	8.6	18.8	8.9	18.7	10.2	19.8
March	12.0	20.7	8.8	19.0	9.5	20.5	10.2	20.4	10.4	20.1	11.3	21.4
April	14.3	23.1	10.8	24.6	12.4	22.8	12.1	22.7	12.9	22.1	13.7	23.6
May	16.9	25.1	15.0	26.0	14.6	25.3	14.7	25.4	15.6	27.2	16.6	26.5
June	20.7	27.8	18.1	28.9	18.3	28.1	18.4	28.1	19.3	27.2	19.9	29.7
July	22.7	28.1	19.9	29.3	20.7	28.2	20.4	29.1	21.7	28.1	21.4	30.8
August	23.5	29.5	19.4	30.4	21.0	29.9	21.1	28.7	22.1	29.0	21.8	31.0
September	22.2	28.8	18.6	27.3	19.6	28.8	19.7	28.6	20.3	28.1	20.5	29.4
October	18.7	26.1	14.9	27.3	16.7	26.8	16.9	26.9	17.3	26.3	18.3	27.3
November	15.4	23.4	12.1	23.1	13.1	23.3	13.4	23.2	133.6	23.1	15.3	23.4
December	11.3	19.9	8.8	19.5	9.4	19.7	10.1	19.5	10.0	19.3	11.0	20.0

Table 7. Wind speed (km/hr) at five stations in the Northwest Coast.

Month	Stations				
	Alexandria	El-Dabaa	Mersa-Matrouh	Sidi-Barrani	El-Sallum
January	15.9	115	22.0	22.2	18.1
February	15.7	12.2	20.7	18.7	15.7
Marcy	16.8	11.6	21.3	21.4	16.6
April	15.3	13.5	19.8	22.6	14.9
May	14.6	13.3	17.2	18.5	13.5
June	15.0	13.9	18.5	17.0	15.5
July	15.7	15.3	18.3	20.7	16.6
August	15.2	15.3	18.7	15.5	16.1
September	12.6	13.5	15.9	14.8	13.9
October	11.3	10.9	15.2	15.5	12.2
November	12.2	9.8	18.4	19.4	14.1
December	13.9	10.5	20.5	21.5	16.6
Annual	14.4	12.6	18.7	19.1	15.3

Soil Resources

Geology

The geology and geomorphology of the Northwest Coast have been the subject of several investigations, including Shata (1955, 1971), Shukri *et al.* (1956), El Shazly (1964), El Shazly and Shata (1969), and Hammad (1966, 1972). According to the comprehensive review by Selim (1969), the entire northern region of the Egyptian Western Desert is covered by sedimentary formations that range in age from Lower Miocene to Holocene. The Holocene formation is formed of: (i) beach deposits; (ii) sand dune accumulations; (iii) *wadi* fillings; (iv) loamy deposits; (v) lagoon deposits; and (vi) limestone crusts. The beach deposits are composed of loose calcareous oolitic sands with quartz grains and shell fragments. The sand dune accumulations are either coastal or inland. The coastal dunes are composed of white, coarse calcareous oolitic sand, whereas the inland dunes are a reddish color with finer sand. The *wadi* fill comprises lime gravel and fine alluvium. The loamy deposits are fine sandy loam intermixed with gravel. Lagoonal deposits are present in the depressions between ridges and are composed of gypsum intermixed with sand and alluvium. The limestone crusts are developed on the exposed limestone surfaces.

The Pleistocene formation is formed of white and pink limestone. The white limestones are in the form of exposed ridges running parallel to the coast. They are composed of white calcareous oolitic sandy limestones, yielding Pleistocene microfossils, echinoid spines, calcareous algae, and shell fragments. The pink limestones are composed of pinkish white oolitic sand, yielding Pleistocene microfauna. The Pliocene formation is represented by creamy limestones that are marl and sand, found in the subsurface, or partly exposed in a few localities.

The Miocene formation includes middle and lower types. The middle type is represented by limestones and dolostones with intercalations of clays, sandstone, and siltstone, collectively known as the "Marmarica limestone." The lower Miocene type is formed of sandy limestones, shales, and marls, and is known as the "Moghra Formation" (Fig. 6).

Geomorphology

The region has two provinces (Selim 1969): an Eastern Province between Alexandria and Ras El Hekma (physiographic Zones I and II) and a Western Province between Ras El Hekma and El Salloum (Zones III, IV and V). The landscape is distinguished into a northern coastal plain and a southern tableland. In the Eastern Province, the coastal plain is wide, and is characterized by the presence of a number of alternating ridges (bars) and depressions (lagoons) running parallel to the coast. The ridges are formed of limestone with a hard crystallized crust, and vary in altitude and lithological features according to age. Nine ridges are recognized, the most prominent of which are the coastal Abu Sir and Gebel Mariut ridges. They are intersected by numerous shallow erosional valleys, some of which end in the Mediterranean Sea and others in depressions.

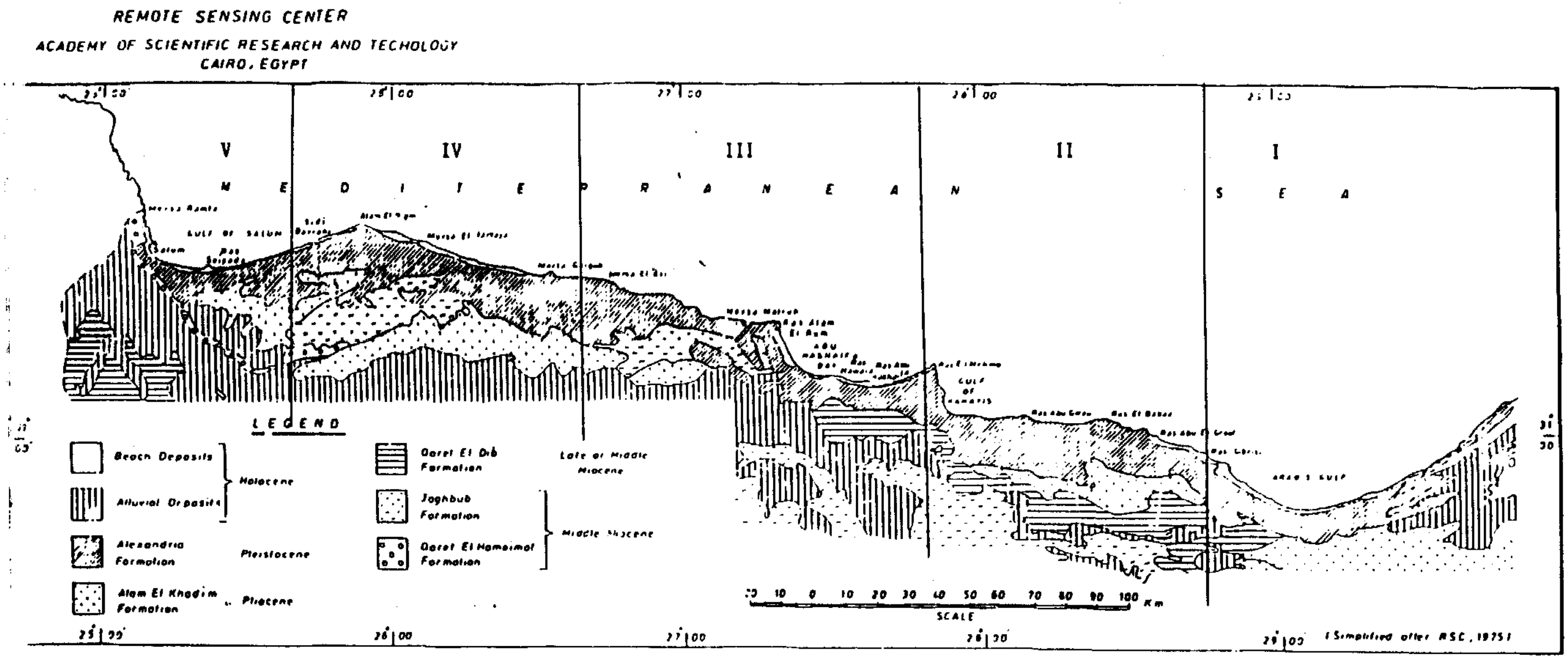


Fig. 6. Geological map of the northwestern coastal zone (from Landsat-1 satellite images).

The Abu Sir ridge is separated from the coastal ridge by a depression with a mean surface elevation of 5 m asl and a width which varies between 300 m and 1 km. It is filled with calcareous formations, highly saline in places and formed almost totally of oolitic grains in certain localities. The depression between Abu Sir and Gebel Mariut ridges is occupied by Mallahet Mariut depression. It is 2–5 km wide with the surface mostly below sea level, and is filled mainly with brackish water and saline calcareous deposits of weathered and down-wash material. Transitional areas adjacent to bordering ridges are covered with deep layers of down-wash material transported during the rainy seasons.

In the Western Province, the coastal plain is narrow or missing. the southern tableland extends southward till the Qattara Depression. It increases gradually in height westward, and attains a maximum elevation of 200 m asl near the shoreline at El Salloum, while at Sidi Barrani it slopes gently northward. Eastward, it decreases gradually until it loses its line of demarcation with the coastal plain (Ayyad and Hilmy 1974). The surface of this tableland is undulating and is covered by a hard crust of variable thickness.

Four major geomorphic areas are distinguished by Taha (1973) in the Northwest Coast: the coastal plain, piedmont plain, tableland, and drainage basins. Their morphological characteristics are summarized in Table 8.

Table 8. Morphological characteristics of the geomorphic areas in the Northwest Coast (after Taha 1973).

Geomorphic area	Eastern Province	Western Province
Coastal plain	Wide (about 6 km) with more than one oolitic limestone ridge; intersected by many drainage lines.	Narrow (a few meters to 1 km); one oolitic limestone ridge, occasionally intersected by drainage lines.
Piedmont plain	Facing the high cliff of the tableland; covered by a thick mantle of alluvial deposits; wide; intersected by many drainage lines.	Merging gradually with the tableland; covered by a relatively thin mantle of alluvial deposits; narrow; occasionally intersected by drainage lines.
Tableland	Abrupt tilting to the north; cliffs facing the Mediterranean; intersected by many drainage lines.	Gradual tilting to the north; no cliffs; facing the Mediterranean; occasionally intersected by drainage lines.
Drainage basins	Large difference in elevation relative to piedmont plain (+ 50 m); numerous structural noses; long, dense, deep, complex numerous meanders.	Small difference in elevation relative to piedmont plain (a few m); few structural noses; short, slight, shallow, simple, slight meanders.

The features of the ridges and lagoons are not consistent throughout the coast. Lagoons have been filled by detrital deposits brought by streams from the drainage channels which descend from the tableland, eroding and intersecting the tableland, the escarpment and the ridges. Following are the main geomorphic processes in the Northwest Coast.

Fluvial processes

Water erosion is an active agent in carving the intricate pattern of drainage channels intersecting the northern part of the tableland, reaching the sea in some areas while creating fans at the foot of the tableland escarpment in the coastal plain.

Drainage of the coastal plain resulted in cutting the ridges, forming inter-ridge swales filled later by sediments deposited by the running water. The lagoonal deposits were covered later by deposits brought by streams from the upland *wadis*.

Littoral processes

The two dominant agencies determining the coastal morphology are shoreline erosion, which is the origin of wave-cut cliffs and platforms, and the constructive action of building ridges, beaches, and lagoons. The former is identified with the Arabic word *ras*, e.g. Ras Alam El Rum, Ras El Hekma, Ras El Dabaa and others. The latter is identified along the coastal littoral in the vicinity of bays (*marsa*), e.g. Arab Gulf, Marsa Matrouh and El Salloum.

Aeolian processes

In arid climates, aeolian processes become very active. Erosion and deposition have not been well evaluated. Apparently they play a great role in sorting materials that were laid down by streams or brought by waves along the coast. The aeolian deposits of this area are in the form of sand sheets, hummocks, and dunes.

Distribution and Types of Soil

The soils of the Northwest Coast have been studied many times, with studies varying greatly with respect to time, location, scope, and level of detail. Investigations from the last 40 years include: Abdel Samie *et al.* (1957), Abdel Hakim (1961), Hammad (1964), Harga (1967), Afifi (1968), Abdel-Salam *et al.* (1969), Hamdy *et al.* (1969), Metwally (1969), FAO (1970), Abdel-Rahman (1970), El Kady (1971), El Kady and Abdel-Salam (1972), Abdel-Salam *et al.* (1972), Harga and Rabie (1974), El Shazly (1978), Hammad *et al.* (1981), and GARPAD (1986).

Soil type and property are highly influenced by geomorphic and pedogenic factors. The main factors used to group the soils of the Northwest Coast are:

- Soil depth to hard rock or water table.
- Main characteristics of the soil (texture, structure, stoniness, etc.).
- Salinity of the saturated extract.
- Presence and depth of caliche and gypsic horizons.
- Calcium carbonate content.
- Location and topography.

The main soil units in the northwestern coastal zone are:

The coastal plain

- Coastal oolitic sand dunes.
- Soils of the lagoonal depressions.
- Consolidated dunes sloping and intersected.
- Deep sand to clay loam soils.
- Moderate to limited depths sandy to clay loam.
- Shallow soils of coarse textures with rock outcrops.
- Wind blown formations.
- Soils of the alluvial fans and outwash plains.

The piedmont-like plain

Plateau formations

- Shallow rocky soils.
- Alluvial deposits over the plateau.
- Rocky escarpment and drainage channels.

For the benefit of the present inventory study, the distribution of soil types and their main properties are presented below for the major five physiographic zones of the Northwest Coast.

Zone I: Burg El Arab; El Hammam; El Alamein (217,000 fed = 91,176 ha)

From north to south, the region contains three parallel ridges of dunes. The white sand dunes form a ridge about 500 meters wide. Two old consolidated ridges, 3 km apart with an altitude of 25–35 m, surround a depression extending from Lake Mariut in the east.

Further south, there is a marked relief line about 5 km from the third ridge of dunes, the height of which decreases from west to east. This change in contour, known as Gebel Sukkara in the vicinity of Burg El Arab, results from a series of limestone outcrops. Its regular alignment seems to be the result of a tectonic event, such as a fault or flexure.

South of these limestone outcrops, the relief shows a very slight general slope. Alternating ridges and depressions are typical of the western part of the region, whereas the eastern part is very regular, forming a wide basin at an altitude varying between 40 and 50 meters.

The soils of Zone I are classified on a morpho-pedological basis into the following sequence from north to south.

The soils of the foreshore plain (wind-blown soils).

1. Inland sand dunes and sand sheets.
2. Soils of the inland depression.
3. Soils of the front slopes
4. Soils of Mariut tableland.

Table 9 presents some of the main properties of these soils. Fig. 7 shows a schematic presentation of the sequence of land farms in Zone I (El Naggar *et al.* 1989).

Table 9. Some physical and chemical properties of soil types in Zone I.

Soil	Soil depth cm	Mechanical fraction (%)			$CaCO_3$ %	O.M. %	EC mmhos/cm 125°C	SP %	Moisture equiv. %	Wilting point %
		Sand	Silt	Clay						
The coastal plain	0-10	71.7	10.8	17.7	69.9	0.2	0.3	25.6	10.3	6.5
	10-40	73.8	6.8	20.6	74.1	0.2	0.4	23.8	9.2	5.8
	40-70	83.6	5.2	13.1	84.1	0.2	0.4	23.8	9.2	5.8
	70-120	86.7	2.7	13.1	87.6	0.2	0.8	23.8	11.5	6.8
The coastal oolitic sand dunes	0-20	100	-	-	95.8	0.2	0.07	26.4	4.1	4.2
	20-40	100	-	-	95.8	0.2	0.07	26.0	4.2	3.4
	40-120	100	-	-	95.0	0.2	0.10	27.0	4.1	3.8
The inland saline depression	0-10	52.5	23.6	27.2	33.6	0.2	7.8	32.4	19.2	8.9
	10-20	51.7	16.3	34.3	32.6	0.2	7.5	32.6	21.2	11.5
	20-50	48.8	16.7	37.6	48.6	0.2	7.1	32.6	19.2	10.2
	50-130	49.0	16.7	38.5	11.4	1.9	6.5	38.8	23.3	12.3
Soils of the footslopes	0-10	61.5	15.1	23.4	33.8	0.2	1.3	31.2	16.7	11.5
	10-40	46.0	28.6	29.3	37.7	0.2	2.4	35.4	23.4	11.8
	40-65	39.0	24.5	36.6	39.1	0.2	5.3	39.0	24.3	16.2
Soils of Mariut table land	0-30	54.6	17.3	30.2	37.7	0.2	1.6	25.6	10.3	1.5
	30-60	37.0	26.2	40.4	48.2	0.2	2.5	23.6	9.9	6.5

OM = Organic matter; EC = Electrical conductivity; SP = Saturation percentage.

Source: Harga *et al.* (1984).

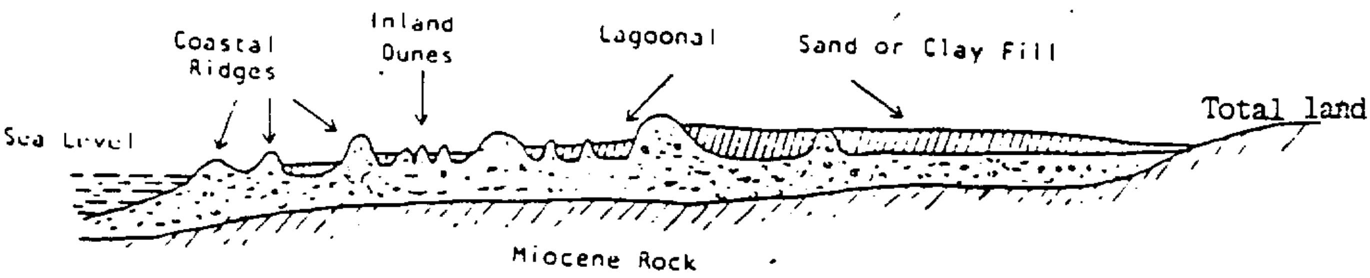


Fig. 7. Limestone ridges and inland sedimentary clay or sand in Zone I (El Naggar *et al.* 1989).

Zone II: El Dabaa; Ras El Hekma (400,000 fed = 168,067 ha).

East of Ras El Hekma, the relief line turns north–south. North of the railway it runs along the shore without a coastal plain, and with a few very short *wadis*. After Fuka, the cliff along the edge of the plateau becomes less pronounced towards the east, followed by a slope of 2–3%. Between Fuka and El Dabaa, the continuous coastal range of dunes is only crossed by two *wadis*. The 6–8 km wide belt between the coastal dunes and the 60 m contour line consists of an irregular succession of alternating limestone hills and closed depressions. The zone thus contains a string of small independent catchment areas varying from a few hundred to a thousand hectares in size.

Soil resource studies in this zone show that the area is characterized by four soil types related to the prevailing environmental conditions.

- The coastal dunes.
- The soils of the saline depressions.
- The soils of the cultivated depressions (cultivated mainly with barley—fruit trees are cultivated in limited areas depending on the groundwater).
- The soils of the ridge slopes.

These studies show that, in general, soil texture differs according to its position on the landform. Soils along hill slopes are sandy loam, while those of the saline depressions and cultivated depressions are silty loam to clay loam. $CaCO_3$ content is very high, varying between 50 and 90%, and is present in all size fractions, although most often found in sand and silt. Retention and distribution of soil water is related to the textural class and the degree of development of soil structure. Moisture curves show that the available water range is relatively narrow and the major portion is released before the soil moisture tension exceeds 1 atmosphere. Plant growth decreases in proportion to the decrease of moisture retention. The rate of growth decreases with the increase of soil osmotic pressure, which is a function of soil salinity.

The coastal dunes are formed mainly of oolitic sand with a very high $CaCO_3$ content.

Soils of the Western Province: Zones III, IV, and V

Zones III, IV, and V, representing the Western Province, have similar soils. The distribution, area and significance of each type of soil are closely related to the morphological features of each zone (Sogreah 1961).

Zone III: Marsa Matrouh to west of Ras Abu-Laho (525,000 fed = 220,588 ha)

Zone III can be subdivided into four sections from east to west as follows:

- **Wadi Kassaba to Ras El Hekma:** A cliff approximately 50 meters high rises sharply some 4 or 5 kilometers inland. It has been cut into by *wadis* which, though short, probably do not carry much water. The Baqqush development area, which is well supplied with water by four *wadis*, is in this zone.
- **Marsa Matrouh to Wadi Kassaba:** There is a lagoon system along the edge of the coastal plain. Upstream of these lagoons, the plain is only 2 to 3 kilometers wide. Both the coast and the escarpment turn northwest–southeast, which is not favorable in view of the prevailing rainfall.
- **Ras Um El Rakham to Marsa Matrouh:** The coastal plain widens out (up to 6 km south of Marsa Matrouh), and the ridge of dunes becomes more prominent. The *wadis* with the highest flows are situated in this region (*Wadis* Magid, Madwar, Ramla and Kharuba). In forming well-developed ramparts, they have substantially modified the appearance of the hills. *Wadi* Ramla, the largest, is about 15 km long and runs several times each year. It seems to be capable of a peak 10-year discharge of 50–100 cubic meters per second. These *wadis* do not reach the sea but spread out behind the ridge of dunes. The Ramla and Kharuba *wadis* occasionally reach the west lagoon at Marsa Matrouh. It is also noteworthy that most signs of former human activity are observed between Marsa Gargub and Marsa Matrouh, such as a large town, the remains of several dikes (4 km long along the banks of *Wadi* Mahqin), traces of dams and flow splitters, and a rather unusual underground aqueduct in the hills 6 km south of Marsa Matrouh.
- **West of Ras Abu-Laho to Ras Um El Rakham:** Going inland from the coast, there is a small coastal plain varying from 200 m to 3 km in width and from 5 to 20 m high. In a recent GTZ (1992) study, Marsa Matrouh was classified into three main geomorphological units. They are:
    - The coastal and escarpment unit, which lies from 0–50 m asl and extends to 9 km from the sea. The coastal basins consist of active coastal dunes of white sand on the sea, followed by interdunal depressions, the interdunal plain, ancient dune ridges, then alluvial plains sloping gently towards the sea. The escarpment zone is characterized by its numerous *wadis* and significant slopes which are up to 15% from base to ridge, rapidly decreasing to 2–5% on the flat lands on top of the escarpment.
    - The north plateau, extending 9–16 km inland, where the *wadis* and their catchment areas start. The northern part of the plateau is characterized by wide-branched *wadis* (including the *wadi* floor, slope and tableland) as well as some narrow deeply incised *wadis* to the west (including the *wadi* floor and tableland). The southern part consists of the tableland, which is intercepted by

numerous alluvial fans, ancient fields and some short shallow *wadis*. The plateau is relatively flat and inclined to the north, lying at 50–150 m asl.

- The south plateau starts about 20 km from the sea and lies at 150–200 m asl. It consists of very flat plain (less than 0.3% slope), including hummocky inland dunes, and scattered shallow depressions (*hatayas*) suitable for cultivation.

Zone IV: West of Abu-Laho to Sidi Barrani (650,000 fed = 273,109 ha)

The uniformity of this zone is its most distinctive feature. The coastal belt is virtually nonexistent, and the transition to the inland plateau is very gradual, with often only very minor steps.

The southern boundary of this zone is roughly formed by the extreme limit of cultivation, which occurs somewhere between the 100 and 150 m contour lines.

The line of cliffs in El Salloum peters out west of the meridian running through Sidi Barrani, where it merely assumes the form of a low ridge sometimes only a few meters high.

Wadi El Maqan and Wadi Kabsh, the longest *wadis* in the coastal zone, are between Marsa Gargub and Sidi Barrani. They fall between hills facing north-northwest, and thus receive rainwater relatively frequently. The network extends a fair distance into the plateau. At the roof of the hills, these *wadis* still carry sufficient water to enable them to dig a bed in very sandy ground where practically no tributaries join them. They then peter out in a depression south of the highway, after roughly 30 km. Water apparently flows in these *wadis* apparently two or three times a year.

The area west of Sidi Barrani is the only one in the coastal zone with a roughly uniform slope, which, however, becomes steeper near the sea. A few minor *wadis* exist near the coast. They vary between 2 and 4 km in length, some reaching the sea and others spreading out behind the dunes.

Zone V: El Salloum region (200,000 fed = 84,033 ha)

El Salloum plain is separated from the 200 m high Libyan Plateau by a line of sharp high cliffs, from 40 to 100 m (occasionally 150 m) high. These extend inland to the southeast from El Salloum to a point some 20 km from the sea, then gradually veer due east. Here, the transition between the plain and the plateau is marked by several tiered terraces, covering an increasingly large area further to the east. Fig. 8 shows a schematic presentation of the sequence of landforms and its effect on soil profile depth (El Naggar *et al.* 1989).

A line running almost due north–south some 30 km west of Sidi Barrani is considered the eastern boundary of this region. The separation between plain and plateau is much less distinct beyond this line, and the flow paths are more clearly visible in the plain.

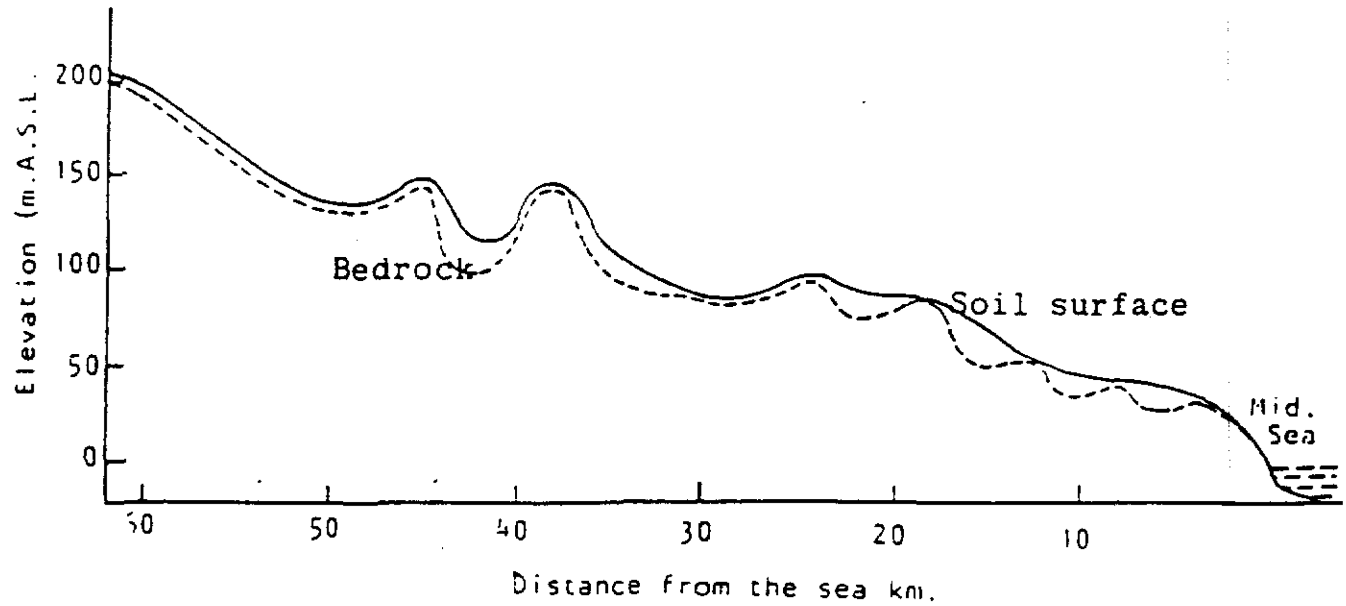


Fig. 8. Variation in soil depth according to distance from the sea in Zone V (El Naggar *et al.* 1989).

Soils common to the three zones of the Western Province

The soils of the three western zones (III, IV, and V) are encountered at varied extents in the three zones. The main soil units have been classified by several studies, including FAO/UNDP (1970), Hammad (1978), El Shazly (1978), and El Naggar *et al.* (1989):

Windblown soils: These include the coastal dunes and the inland dunes. The coastal dunes are found in a narrow strip along the sea and consist of oolitic sand that is very rich in $CaCO_3$ (more than 80%). These coastal dunes represent an estimated 12,485 fed (5,245 ha) in Marsa Matrouh, 14,762 fed (6,202 ha) in Sidi Barrani and 6,267 fed (2,633 ha) in El Salloum. The dunes are formed of white sand, coarse in texture of loose mobile grains. Some of the dunes are formed of cemented oolitic sand. The inland dunes are found in large areas southeast of Sidi Barrani. They are formed of quartz sand grains in the form of dunes or sand sheets.

Soils of the plain: These soils, between the coastal dunes and the escarpment, were formed by the action of water and wind. They are generally deep ranging from sand to loam. These soils occupy the lower slopes and deltas of small *wadis*, which receive significant runoff water and alluvial soil particles transported from eroded areas on the escarpment. Soil depth ranges from less than 30 cm to more than 90 cm. Many of the soils are classified as fine sandy loams, with 50% $CaCO_3$ content but without accumulation of a carbonate layer. These soils have good water holding capacity with an average field capacity of 19% by volume, an average wilting point of 7%, and soluble salts of less than 0.1%.

Deep sandy loam to loam or clay loam soils are found in large areas near Marsa Matrouh and Sidi Barrani. The topography is level and soils are well drained. A typical soil profile from near Sidi Barrani is:

- 0–30 cm. Sandy loam, friable, many roots, many pores.
- 30–60 cm. Loam, compact when dry, sub-angular, blocky, some small and big roots, some pores.
- 60–100 cm. Loam, compact when dry, compactness increases with depth, some small lime concretions, no roots, some small pores.

The soils are used exclusively for the cultivation of barley, but are suitable for most crops.

Soils of the alluvial fans and outwash plains: These are alluvial soils directly or indirectly derived form limestone, and have high levels of $CaCO_3$. They are composed of alluvial materials transported by runoff water from neighboring rock lands. They are deep, homogeneous soils without gravel or grit and even without concretions. No caliche layer has been detected within the top 1.2 m. These soils have been cultivated for a very long time.

Soils of the escarpment: Because of its elevation, escarpment soils are subject to the action of strong winds and rainfall runoff, causing severe erosion. Therefore, the soils are eroded and shallow (less than 30 cm). The inland rocky ridges have a thin layer of surface soil, brownish yellow in color and dry, which has been formed by sand carried by wind from other areas. This thin layer is covered with gravel and boulders.

In the depressions and protected flat lands of the escarpment there are typical dry desert soils formed of a mixture of residual alluvial and aeolian deposits. They are of medium-to-shallow depth, ranging from 30 to 100 cm, and have a sandy loam texture. The calcium carbonate content increases with depth, and pH ranges from 8.0 to 8.5.

Soil Fertility and Nutrient Status

Soil fertility and nutrient status in the soils of the Northwest Coast have been the subject of several investigations in the last 30 years, including El Laboudi *et al.* (1976), Sabet *et al.* (1976), Sawy *et al.* (1989), Abdel-Mottaleb *et al.* (1989) Abd El Hamid *et al.* (1984, 1991), Kassem (1987), El Demerdash *et al.* (1991), El Naggar *et al.* (1989), and El Bagouri (1994). The data show that both of the major soil categories in the Northwest Coast (calcareous and siliceous) are low in soil fertility. Soil pH is within the alkaline range, mainly 7.5–8.5. The organic carbon content is invariably low, generally between 0.05 to 1.00% in a non-saline habitat, increasing sharply to 3.0–3.5% in saline and marshy habitats. Cation exchange capacity (CEC) is related mainly to the soil texture, and given the dominance of the coarser loamy sands and sandy loams, it is generally in the lower range of 6–12 meq/100 g soil. For calcareous soils, $CaCO_3$ content varies from the lower limit of 10 to as high as 94.5% in the oolitic ridges. Moisture characteristics are related mainly to the textural variations of the soils.

Invariably, total N content is very low in the soils, with levels below 50 ppm. Phosphorus availability is quite low in calcareous soils as well as in the coarse textured non-calcareous soils—too low in almost for almost all crops. Potassium content is sufficient for most field crops, however, it is inadequate for vegetables and most fruit trees. Micronutrient studies suggest that the levels of iron and manganese in most soils are adequate for most crops, however, the effects of $CaCO_3$ content, level of bicarbonate, and soil reaction lead to growth-limiting deficiencies in Fe, Mn, and Zn for most grown crops and fruit trees.

Soil Potential

The total area of the Northwest Coast is estimated at 3.8 million fed (1.6 million ha). Of this, 390,700 fed (164,159 ha) are cultivable (FAO/UNDP 1970). These areas are subdivided into four categories:

- 204,875 fed (86,081 ha): deep soils suitable for all crops.
- 33,000 fed (13,865 ha): suitable for moderately deep-rooted crops.
- 96,125 fed (40,388 ha): suitable for shallow-rooted crops.
- 16,700 fed (7,016 ha): suitable soils found as small patches surrounded by unsuitable soils.

To evaluate the potential for agricultural purposes, the system of land capability delineated by FAO/UNDP (1970) is used. This system takes into consideration soil properties and the limitations affecting the agricultural potential of such soils. The Northwest Coast can be classified into four classes according to this system, presented below:

Class 2

The soils in this class have minor limitations that reduce the choice of crops and interfere with cultivation. Limitations may include, singly or in combination: the effects of inadequate or imperfect drainage; less than ideal rooting depth; slightly unfavorable soil structure and texture; moderate slope; and slight erosion. A wide range of crops can be grown.

These soils are in cultivated depressions in the coastal plains, marked by relatively heavy texture and deep alluvial fans. This land requires careful management, water conservation system, and adaptation of good farming methods. Most of these soils are presently under irrigation and others are rainfed (barley). Soil is deep enough to support olive and fruit plantations.

The main families which belong to this class are:

- Torriorthents, loamy (fine loamy), carbonaceous, thermic.
- Typic torriorthents, coarse loamy, gypsic, thermic.
- Typic torriorthents, loamy (fine silty) mixed calcareous, thermic.

Class 3

This soil class has moderate limitations that restrict the choice of crops or demand careful management or both. Limitations may result from one or more of the following: imperfect or poor drainage; restrictions on rooting depth; severely sloping ground; and slight erosion. These limitations affect the timing of cultivation and the range of crops. The soils corresponding to this class are those of the moderate to shallow soils, i.e. the coastal plain, alluvial fan, alluvial sheets over plateau, and the non-consolidated coastal sand dunes. These soils are suitable for all shallow-root crops and for fig orchards in coastal oolitic dunes, depending on the presence of shallow fresh groundwater.

The main soil families included in this class are:

- Typic calciorthids, loamy, coarse loamy, carbonaceous, thermic.
- Typic calciorthids, loamy, coarse loamy, gypsic, thermic.
- Typic calciorthids, loamy, fine silty, mixed, thermic.
- Typic gypsiorthids, loamy, calcareous, thermic.

Class 6

This land has very severe limitations that restrict its use to rough grazing and recreation. Limitations are due to one or more of the following characteristics: shallow soils; stones or boulders; very steep slopes; and severe erosion. These limitations are sufficiently severe to prevent the use of agricultural mechanization.

The soils of this class are those of the piedmont region, shallow coarse-textured soils with rock outcrops, and the inland dunes and sheets. None of these are suitable for agricultural uses, except for some areas, mostly in El Dabaa, that can only be used as rangeland for sheep grazing.

The main soil families related to Class 6 are:

- Typic torriorthents, loamy (coarse loamy), skeletal, carbonaceous, shallow, thermic.
- Lithic torriorthents, loamy (coarse loamy), skeletal, carbonaceous, thermic.

Class 7

This is land with extremely severe limitations than cannot be rectified. Limitations result from one or more of the following characteristics: very poorly drained boggy soils; extremely rocky soils; steep gradients; and severe erosion.

The soils corresponding to this class are extremely saline, shallow and/or rocky, and are located mostly at high elevations, i.e. consolidated coastal ridges, the Libyan Plateau and/or in the lagoonal depressions.

The main soil families which belong to this class are:

- Typic salorthids, loamy, mixed, calcareous, thermic.
- Typic calciorthids, loamy, fine silty, shallow, mixed, thermic.

Water Resources

Hydrographic Zones

Each physiographic zone has its own hydrographic characteristics. Fig. 9 depicts these zones and their catchment areas. The main characteristics of these zones are described below, following El Shazly *et al.* (1983).

Zone I

This zone is characterized by an uneven surface, more rugged to the east and generally sloping due north. The landforms are generally parallel to the Mediterranean seashore, with a general trend towards east–west elongation, and generally swinging to the northeast and the northwest. The landscape in this zone is distinguished by a northern coastal plain with modern beaches, coastal and inland sand dunes, coastal salt lakes and ephemeral lagoons, coastal salt marshes, elongated ridges and confined depressions, a transition piedmont plain developed to the south and southwest of El Alamein, and a southern tableland. This tableland has a prominent escarpment in the area southwest of El Alamein, while to the east the transition from the coastal plain to the tableland is gradual. The water divide is not well defined, but it is assumed to exist at an absolute altitude of 80 m to the west and 60 m to the east. Zone I lies between rainfall isohytes of 140–160 mm west of El Alamein and 160–180 mm east of El Alamein and 50 mm to the south. Average rainfall is 313.421 million m^3 annually.

Zone II: A. El Dabaa—Fuka Strip

This zone is characterized by a northern coastal plain which is dominated by a variety of landforms including modern beaches, foreshore dunes, foreshore lagoons and offshore bars, and a southern moderately elevated plain with a broad and moderately undulating surface which slopes generally to the north. The landscape in the latter area is strongly affected by a number of ridges rising from the surface. The hydrographic pattern dissecting the surface of the elevated plain is composed of typical insequent lines which are generally shallow and short and end in the inland hollows where they form disconnected alluvial fans. The pattern is represented by the Abu Samra, Gabir, and El Dabaa systems. The water divide is not well defined, but it is considered to exist at absolute altitudes of 110 to 120 m. The average rainfall ranges from 160 mm in the north to about 50 mm in the south. The strip receives an annual total rainfall of 85.544 million m^3.

Zone II: B. Fuka—Baqqush Strip

This zone has a monocline at Ras El Hekma where the tableland merges with the sea. It is dissected by several consequent *wadis*, following the northern slope of the tableland. South of Ras El Hekma, the *wadis* are short and shallow and end in the piedmont plain. To the east, some drain directly into the Mediterranean. At Fuka Basin, the dry *wadis* extend to the east, northeast, and north. Within this strip, 11 *wadis* are recognized with catchment areas ranging between 0.97 and 148.67 km^2. The water divide exists at an absolute altitude of about 130 m. The average annual rainfall ranges from 100 mm in the north to 50 mm in the south. Total rainfall is 44.618 million m^3 annually.

Zone III: A. Baqqush—Wadi Kassaba Strip

This strip is characterized by an intense fine dendritic hydrographic pattern draining both the tableland and the coastal plain. This strip is 23 km long, 19 km wide in the west, and 9.5 km wide in the east, where the tableland comes nearer to the Mediterranean. Within this strip, 16 *wadis* are distinguished with catchment areas ranging between 1.25 and 42.4 km^2. It receives rainfall ranging from 160 mm in the north to 60 mm in the south. The total rainfall is 26.223 million m^3 annually.

Zone III: B. Wadi Kassaba—Marsa Matrouh Strip

This zone is characterized by a very low relief and both gradual and abrupt slopes to the north and east towards the present coast of the Mediterranean. The landscape in this strip is characterized by shallow erosional *wadis* draining a part of the tableland and the coastal plain. Some of the erosional *wadis* take the shape of semi-isolated depressions.

Within this strip, seven *wadis* exist, with catchment areas ranging between 24 and 126 km^2. The water divide exists at an absolute altitude of about 170 m. The annual rainfall in the considered strip ranges from 160 mm in the north to about 50 mm in the south, constituting a total of 48.677 million m^3.

Zone III: C. Marsa Matrouh—Ras Abu-Laho Strip

This zone is characterized by low relief and mild topography and is differentiated into two different topographic areas: the southern tableland, which is dominated by about 12 deep consequent *wadis*, most of which drain the northern semi-closed depressions and the northern coastal plain where the landscape is characterized by the presence of alternating ridges and shallow depressions. The central portion of the coastal plain is occupied by a series of shallow salt lakes whereas due east and west it is affected by two structural monoclines. This region is about 30 km in length and about 25 km in width. The water divide exists at an absolute altitude of 170 m. The catchment areas of the *wadis* range from 4.5 to about 124 km^2, with a total catchment area of 514 km^2 for the whole strip. It is located between rainfall isohytes of 160 mm to the north and 50 mm to the south, receiving an annual rainfall of 42.633 million m^3.

Zone IV: A. Ras Abu-Laho—Marsa Hissi Ibrahim Strip

This zone is characterized by a southern high tableland, dissected by many drainage lines, which tilts abruptly to the north with cliffs facing the Mediterranean Sea, and a low wide coastal plain which is traversed by a series of limestone ridges and cut by the downstream portions of the drainage lines. The transition between two physiographic areas is marked by a wide piedmont plain, about 70 km long and 25 km wide, with its water divide existing at an absolute altitude of about 160 m. Forty-six *wadis* dissect the tableland with catchment areas ranging between 0.62 and 81 km^2. Rainfall steadily decreases from north (160 mm) to south (60 mm), with a total of 123.167 million m^3 annually.

Zone IV: B. Marsa Hissi Ibrahim—Sidi Barrani Strip

This strip slopes gradually to the north and is characterized by a low relief. It has a length of about 37 km and a width of 9 km, with a narrow coastal plain. It is traversed by 42 small *wadis* with a catchment area of 310.23 km^2. The water divide exists at an altitude of about 70 m asl. The annual rainfall ranges from 160 mm in the north to 100 mm in the south, totaling 39.327 million m^3 which drains to the coastal dunes to the north.

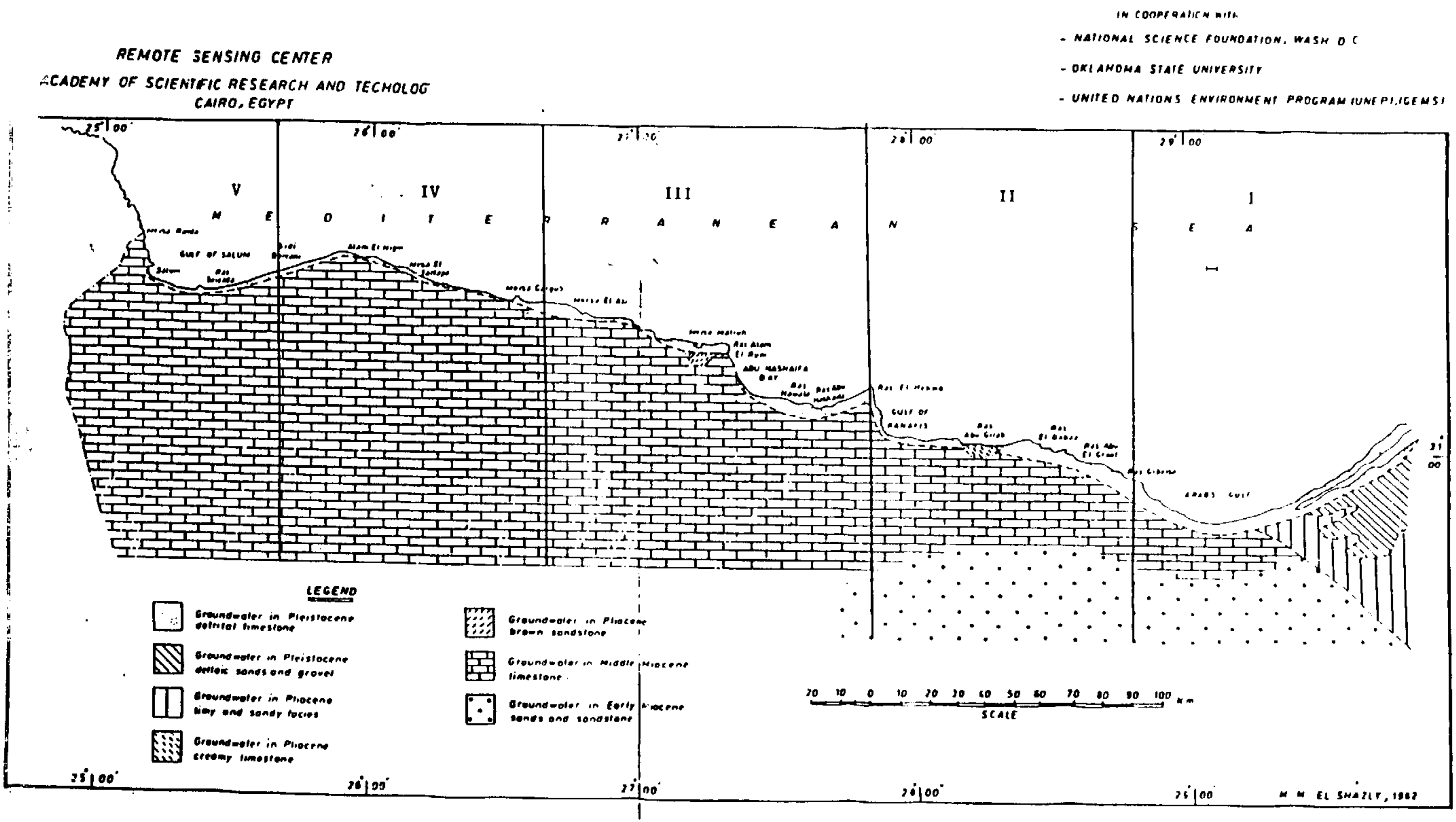


Fig. 9. Hydrographic strips of the Northwest Coast.

Zone V: Sidi Barrani—El Salloum Strip

This strip runs east–west for about 83 km. The tableland bounds the northern low-lying coastal plain by a prominent cliff which starts close to the sea at El Salloum, turning first to the southeast and then to the northeast. The northern portion of the coastal plain is marked by two elongated ridges and an extensive salt marsh. The water divide ranges between 40 to 8 km south of the coast, at an absolute level of 200 m. The edge of the tableland is dissected by numerous short dendritic drainage lines, extending north and northeast and ending in the piedmont plain. The total catchment area of the strip is about 2707 km^2, receiving a total annual rainfall of 187 million m^3.

Groundwater Resources

In the Northwest Coast, strata of hydrogeologic interest are found in both the Quaternary and the Tertiary succession. These strata occur in different lithologic forms which include: loose dune sand accumulation and unsorted gravel filling of the *wadi* (Holocene); detrital limestone and brown sandstone (Pliocene) and clayey limestone (Miocene), etc. (El Shazly *et al.* 1983). The thickness of these strata rarely exceeds 100 m, which allows a limited water supply of varying quality which is used for civic purposes, and for local cultivation, particularly in the area to the west of El Dabaa.

With the exception of the highly saline water found in the pre-Tertiary strata in the Northwest Coast, which belongs totally or partly to the extension of the great Nubian sandstone and related aquifers, the groundwater in the area depends totally on local precipitation. Annual rainfall is, on the average, about 150 mm. In brief, the groundwater resources in the coastal zone are classified according to their position in the geologic column as well as their lithologic characteristics into units, among which the following are of significance.

Groundwater in Holocene Dune Sands

Coastal dune sands dominate along the northern strip of the coastal plain, covering parts of the near-shore ridge, and accumulating mostly on its slopes. They are prominent at Sidi Kreir, western El Alamein, Ras El Hekma, Baqqush, Burbeita, El Qasr, El Neguila, and Zawyet Shammas. These dune sands—composed of loose carbonate sand mostly of medium grain size—are water-bearing in local areas where their base is low relative to the level of the prevailing water table. This phenomenon has been detected at Baqqush and El Qasr where the contact between the base of the dune sands and the underlying geological area is below the water table. In some cases, this contact (the lower boundary) is higher, and the dune sands act as a passage for the infiltrated rainfall water to the underlying aquifer. Wherever groundwater exists, acting as aquifer, under a free water table above the main saline water body, the latter results from the steady intrusion of seawater. Groundwater in this aquifer is recharged essentially from the direct infiltration of the rainwater (infiltration rate = 12.8 m/day). Recharge through lateral subsurface seepage from the main water table when it is higher than in the dune is possible. This latter phenomenon probably occurs to the extreme north, where the water table declines to drain the Mediterranean Sea.

Groundwater in this aquifer is discharged via collecting galleries as in Baqqush, wells, subsurface seepage to the sea, evaporation, and evapotranspiration. The water in this aquifer is limited and has a relatively low salinity with total dissolved salt (TDS) less than 1000 ppm. The quality deteriorates with excessive pumping due to the contamination with seawater.

The hydraulic parameters of this aquifer, determined from pumping tests at Baqqush, are as follows (Ezzat 1976):

$$T = 15\ m^3/d/m$$

$$K = 17\ m^3/d/m^2$$

where T = Transmissivity coefficient and K = Hydraulic conductivity.

Groundwater in Holocene Wadi Alluvium

Groundwater in this aquifer is of very limited potential and distribution in the coastal area, where it is detected in the downstream portion of *wadis* in the western part of the area, e.g. Wadi Um Ashtan, Wadi Abdya, and Wadi Unthili. The aquifer is composed of loose pebbles, cobbles, and gravel mixed together with fine sand and silt. The main recharge source is surface runoff water running in the *wadi* channels. The water has a relatively low TDS in the order of 1000 ppm. Alluvial deposits of a loamy nature have been identified as an aquifer in the Mallahet Mariut depression. The water produced has a TDS of 2,846 ppm. The hydraulic parameters of this aquifer show wide variation from one location to another, which is attributed to variations in the nature of the constituting material, its source, as well as the topographic position within the *wadis*. The average hydraulic parameters of this aquifer, given by Ezzat (1976), are as follows:

$$T = 12.8\ m^3/d/m$$

$$K = 16.41\ m^3/d/m^2$$

where T = Transmissivity coefficient and K = Hydraulic conductivity.

Groundwater in Pleistocene Detrital Limestone (Alexandria Formation)

This large aquifer is the most important one in the coastal areas. The detrital limestone forming this aquifer exists either in the form of a series of elongated ridges running parallel to the present coast, or as a layer of variable thickness underlying the loamy deposits in the low-lying shallow depressions. It is composed of detrital limestone with an oolitic texture which is friable to moderately hard, with micritic cement, and an estimated porosity of about 45%.

Groundwater in this aquifer is in a free water table resting on the existing main water table. It is recharged from the infiltration of rainfall or from surface water inflow from the catchment to the south through active drainage lines. Groundwater recharge inflow contributed from the fissured limestone aquifer of the Neogene is also possible. In the Burg El Arab–El Hammam stretch, the El Nahda Canal constitutes a new important factor of recharge. The amount of infiltration from rainwater varies between 10 and 40%. In Sidi Kreir site, this amount has been estimated to be around 7.4%. Groundwater in this aquifer is discharged through collecting galleries as in El Qasr and many wells, as well as through subsurface outflow to the sea and lakes. Vertical discharge of water from this aquifer into the underlying Neogene aquifers occurs. The fluctuation of the water table in the detrital limestone aquifer is affected by the seasonal rainfall and daily by tides. In an experiment conducted at Sidi Kreir, the response to the tidal effect was about 100 m inland from the sea, where the water table in the aquifer shows a marked fluctuation of 15 cm (positive and negative) in a well located 75 m from the shoreline. In another well, located 120 m from the shore, the water level remains steady. The water table shows gentle undulations, but generally declines to the north, i.e., towards the sea. In some localities, especially in the eastern portion of the area where low water divide areas dominate to the south, the water table declines to the south.

The water table is 1–25 m from the surface, depending on the topography. This water table exists at different absolute levels, ranging from +5 m to -3 m. In most cases where the water table is below sea level, the declination of the water table is associated with a natural drain existing below sea level or with the a connection to the main water table mostly below sea level, which extends to the south.

Groundwater exhibits variable chemical salinity both vertically and horizontally. Horizontally, chemical salinity increases from north to south, which is related to the variation of the petro-physical properties of the rock constituting the aquifer, the type of soil cover, the upper boundary of the aquifer, whether it is exposed or hidden underneath younger deposits, and the rate of infiltration. Vertically, the water column shows marked variations in chemical salinity. In the upper freshwater layer, reaching sometimes 14 m in thickness as in Sidi Kreir site, the TDS content is just less than 1000 ppm, belonging to the bicarbonate type. The TDS content shows successive increase with depth, reaching at the lower portion of the aquifer about 40,000 ppm (in this case a chloride type of water prevails).

The average hydraulic parameters given by Ezzat (1976) are as follows:

$$T = 36.1 \ m^3/d/m$$

$$K = 32.6 \ m^3/d/m^2$$

where T = Transmissivity coefficient and K = Hydraulic conductivity.

Groundwater in Pliocene Creamy Limestone (Alam El Khadem Formation)

Creamy limestone is rare as a water-bearing geological substance in the coastal area, although it has been identified in the synclinal area between El Sira and Abu Samra monoclines in El Dabaa area. It is a medium hard limestone with a thickness of about 38 m. The water in this aquifer exists in a free water table and is recharged either directly from infiltration of rainwater or by downward leakage from the overlying detrital limestone, while discharge of water occurs through a small number of wells and through water percolation into the underlying Middle Miocene aquifer. The water produced from this aquifer belongs to the sodium chloride type, and has a brackish nature with a TDS content varying between 2,880 and 3,320 ppm.

Groundwater in Pliocene Sandstone

This water-bearing substance has been reported only at Hatawa in the eastern portion of Marsa Matrouh, at a thickness of about 17 m. The water is considered as perched water, a phenomenon related to an upfold structure. The aquifer in question is recharged from the vertical infiltration of accumulated surface runoff from a number of drainage lines directed to the low-lying topographic basin in Hatawa. Within this aquifer two water types are detected, reflecting the chemical nature of the water. In the northern upfold area, freshwater of a bicarbonate type exists, with a TDS varying from 715 to 875 ppm, while saline water dominates the aquifer to the south, with a TDS as high as 39,000 ppm where the water table comes below sea level and joins the normal saline water table.

Groundwater in Middle Miocene Cavernous Limestone (Jaghbub Formation)

This aquifer dominates in the western portion of the coastal plain and in the tableland. It constitutes mainly limestone beds alternating with thin beds of clay and marl. This type of succession favors the occurrence of several water levels, having different degrees of salinity depending on their absolute level relative to the sea. This condition is reported in the northern extremity of the tableland of Marsa Matrouh, where three water horizons exist in the limestone beds. TDS ranges from 700 ppm in the upper horizon to more than 25,000 ppm in the lower. The latter exists below sea level and dominates the coastal plain.

Groundwater is found in the normal water table and as perched water. The latter represents a local extension, is related to structural features and/or lithology and is characterized by its separate water table. The groundwater here has relatively low salinity, while under the normal water table, high salinity predominates.

The perched water reflects the presence of Middle Miocene limestone in the coastal plain in Fuka Basin and at El Qutaf in El Dabaa area. In Fuka Basin groundwater exists at about 15 m above sea level, with TDS content less than 2,000 ppm. The aquifer has transmissibility and storage coefficients of 2,400 m^3/d/m and 15%, respectively.

In El Dabaa, perched groundwater exists at varying absolute levels between +15 and +50 m and is generally of low salinity, with TDS values ranging between 126 and 512 ppm.

The perched water in the aquifer is recharged directly from infiltrated rainwater as well as from surface water runoff, while discharge takes place through pumping from wells. Under normal water table conditions, recharge from seawater intrusion is probable.

Surface Runoff

This occurs during and immediately after rainy periods. Surface runoff represents a definite percentage of the rainfall, which differs from one location to another depending on factors such as the slope, nature of the cap rock, field water capacity, extent of the catchment area, and the altitude. The general relation between rainfall and surface water runoff is represented by the following equation:

$$R = P \times Rc$$

where R = Surface water runoff; P = Precipitation (rainfall); and Rc = Surface water runoff coefficient.

Rc depends on the water field capacity, the topography of the area and the nature of the ground surface cover. The relation according to these factors may be of the first, second or third order.

An attempt was made (FAO/UNDP 1970) to establish the relation between rainfall and runoff. The frequency curve of annual runoff in six selected *wadis* located between Ras El Hekma and El Salloum has been constructed. On the basis of this data and the results of detailed hydrogeological investigations in four *wadis* at Ras El Hekma, El Qasr, Um El Rakham and El Neguila, a rough estimation of the total runoff for the Mediterranean Coast was determined by Ezzat (1976):

- Catchment area = 10264 km^2.
- Total runoff along the coast between Burg El Arab and El Salloum = 34.57 million m^3/year.

In other words, the surface water runoff constitutes about 3.8% of the total annual rainfall. Table 10 shows the estimated annual runoff in the various zones of the Northwest Coast (after Ezzat 1976). The amount of rainwater recharging the groundwater supply (910.638 million m^3) was estimated by the same author to constitute about 13.6% of the total annual rainfall.

Table 10. Estimated annual runoff in the Northwest Coast.

Locality	Catchment area (km^2)	Average rainfall (mm)	Annual rainfall (mm^3/yr)	Runoff (mm^3/yr)
Zone I: El Alamein to Burg El Arab	1962.00	92	182	4.7
Zone II: Fuka basin	448.93	70	32	1.7
	112.30	114	13	0.7
Fuka to Dabaa	1001.00	84	86	2.2
Dabaa to El Alamein	1172.00	112	131	3.4
Zone III: Ras Abu-Laho to Matrouh	514.45	82	43	2.3
Matrouh to Wadi Kassaba	557.88	85	49	2.6
Wadi Kassaba to Baqqush	262.25	99	26	1.4
Zone IV: Sidi Barrani	1315.25	82	108	2.8
Sidi Barrani to Hissi Ibrahim	310.23	126	39	2.1
Hissi Ibrahim to Abu-Laho	1195.10	108	123	6.5
Zone V: El Salloum	1391.08	56	79	4.2
Total	10264.00	89	911	34.6

El Nahda Canal

This canal, according to El Shazly *et al.* (1983), is an artificial irrigation canal, which has been excavated in the area in the last 10 years. It starts at Pumping Station No. 5 at the Mariut Canal and extends along the depression located to the south of Gebel Mariut ridge to El Hammam village. The absolute levels of the surface water in the canal range between +26 and +24 m. The canal is 57.5 km long, with an average width of about 5 m. In the eastern portion, the bottom and both banks of the canal are constituted of loamy deposits which are underlain, at varying depths, by detrital limestone. To the east of Burg El Arab and further westwards to El Hammam the bottom cuts through fissured detrital limestone, which is overlain, especially opposite El Gharbaniyat gypsum quarry, by Pleistocene lagoonal deposits 11.5 m thick and loamy deposits 50–80 cm thick. The canal affects the hydrogeological situation over the Burg El Arab–El Hammam stretch, where the water table has risen to 8 m from the surface due to water seepage, as well as from irrigation. This effect ends at Mallahet Mariut, which acts as a drain for groundwater. Opposite this canal the water level in the wells to the north of Mallahet Mariut fluctuates normally, i.e. there is no response to the high water level to the south.

Hydrologic Data of the Northwest Coast

- Number of *wadis*: 218
- Catchment areas: 10264 km^2
- Average rainfall: 88.72 mm
- Annual rainfall: 910.638 mcm/yr
- Runoff: 34.56 mcm/yr
- Infiltration: 248.366 mcm/yr
- Groundwater recharge: 124.18 mcm/yr

Farming Systems in the Northwest Coast

Main Components of the Farming Systems

Farming systems in the Northwest Coast are related to the availability and characteristics of the water and soil resources as well as financial considerations. With the exception of Zone I, which receives Nile water for irrigation, the rest of the four zones are rainfed areas with limited supplemental irrigation from groundwater sources. The rainfed areas are principally used for range grazing; opportunistic barley cultivation is practiced when rains permit, both to meet human needs and for supplementary livestock feed in the form of straw and stubble. The combination of rangeland grazing and barley cultivation therefore represents a well-established integrated livestock and crop production system.

Over the last 20 years, considerable pressure on range resources has caused an increased reliance on crop production to supplement feed. As recently as 20 years ago, the rangeland met the majority of animal feed needs. However, it is estimated that, depending upon rainfall availability, only 30–45% of feed requirements are currently being met by range vegetation (World Bank and MALR 1992). Cereal production has thus become increasingly important as a source of animal feed and now represents a more permanent element in the Bedouin production system. As a further adaptation to the changing demands and potentials resulting from sedentarization, the Bedouins in the Western Province have tended to diversify farming practices to include horticultural crops (principally olive and fig). By the beginning of the 1960s, the introduction of fruit trees gained momentum, based on the availability of suitable water and soil resources and incentives from international organizations, including WFP and other development projects.

The basic traditional production system in the Western Province is best described as a mixed, rainfed farming operation, which includes the raising of animals (principally sheep and goats), cereal production, and horticultural production.

According to the Matrouh Resources Management Project, which started in 1992 in the Western Province of the Northwest Coast, tree crops make a proportionately higher contribution to the farm enterprise in areas closest to the coast. Generally, the farther from the coast, the greater is the reliance on range grazing and cereal (mainly barley) cultivation, with the establishment of tree crops limited to smaller, more scattered areas in particularly favored localities.

On this basis, three zones may be identified:

- A coastal strip with a maximum width of about 5 km and alluvial soils, derived from *wadis*, which are suitable for tree crop and vegetable production as well as the small ruminant/barley combination.
- A mixed production strip ranging from 5 to 15 km inland, with low rainfall and relatively low soil permeability, with tree crops usually confined to *wadi* beds.
- A predominately rangeland strip, 15–70 km inland with 50–100 mm rainfall, consisting of scattered areas suitable for barley cultivation and occasional tree crop cultivation where cistern availability and soil suitability permit.

Further inland, in what may be called a fourth strip, grazing is even sparser. The strip is used mainly for camel grazing.

In the coastal strip, tree crops (and to a lesser extent vegetables) are associated with *wadis* or depressions in plains, where more fertile soils have accumulated and runoff collects. In the mixed production strip, there is a tendency for tree crops to be associated with dikes in *wadis* and for vegetables to be restricted to very small plots served by domestic cisterns located close to the settlement.

The major crops grown in Northwest Coast are cereals (barley and wheat), tree crops (olive, fig and, to a limited extent, almond, and grape), watermelon, and small areas of vegetables mainly in the coastal strip. Based on statistics published by CAPMAS (1992), farms may be categorized into three sizes on the basis of land area and livestock holding. Farm size is closely linked to social status and relative affluence. About 50% of farming households fall into the small farm category, with less than 10 fed (4.2 ha) of land and less than 20 head of small ruminants. Forty percent of farms are 10–50 fed (4.2–21 ha) with 20–100 head of small ruminants, and 10% of farming households have access to over 50 fed and own over 100 head of small ruminants. Fig. 10 compares registered land ownership for the years 1981 and 1991. The data show a sharp increase in registered land ownership over ten years in all the five zones of the Northwest Coast.

Crops

Barley. Barley is the main crop cultivated in the region. It is well adapted to the short growing season, relatively tolerant to drought stress, and a key element in the feeding regime of small ruminants.

The area sown to barley varies with land availability under traditional rights of access, the perceived reliability of rain and, for the majority of farmers who do not own tractors, access to funds for tractor rental. Within the limits of these resources, farmers sow as large an area as possible in the expectation of taking maximum advantage of subsequent rainfall. However, the final area harvested generally represents some 50–70% of the area sown, estimated in 1991 at 73,000 fed (30,672 ha). Table 11 shows the estimated areas planted to barley and wheat (1990/91), and their distribution in the zones of the Northwest Coast.

The estimated area of barley may be too high, since CAPMAS (1992) figures for the following year reports areas of 43,972 and 40,858 fed (18,468 and 17,160 ha) for barley and wheat, respectively (Table 12 and Fig. 11).

The areas sown to barley as well as the area harvested vary considerably from one year to another. Table 13 shows the potential influence of a more reliable water supply, both in terms of yield and the proportions of sown and harvested area.

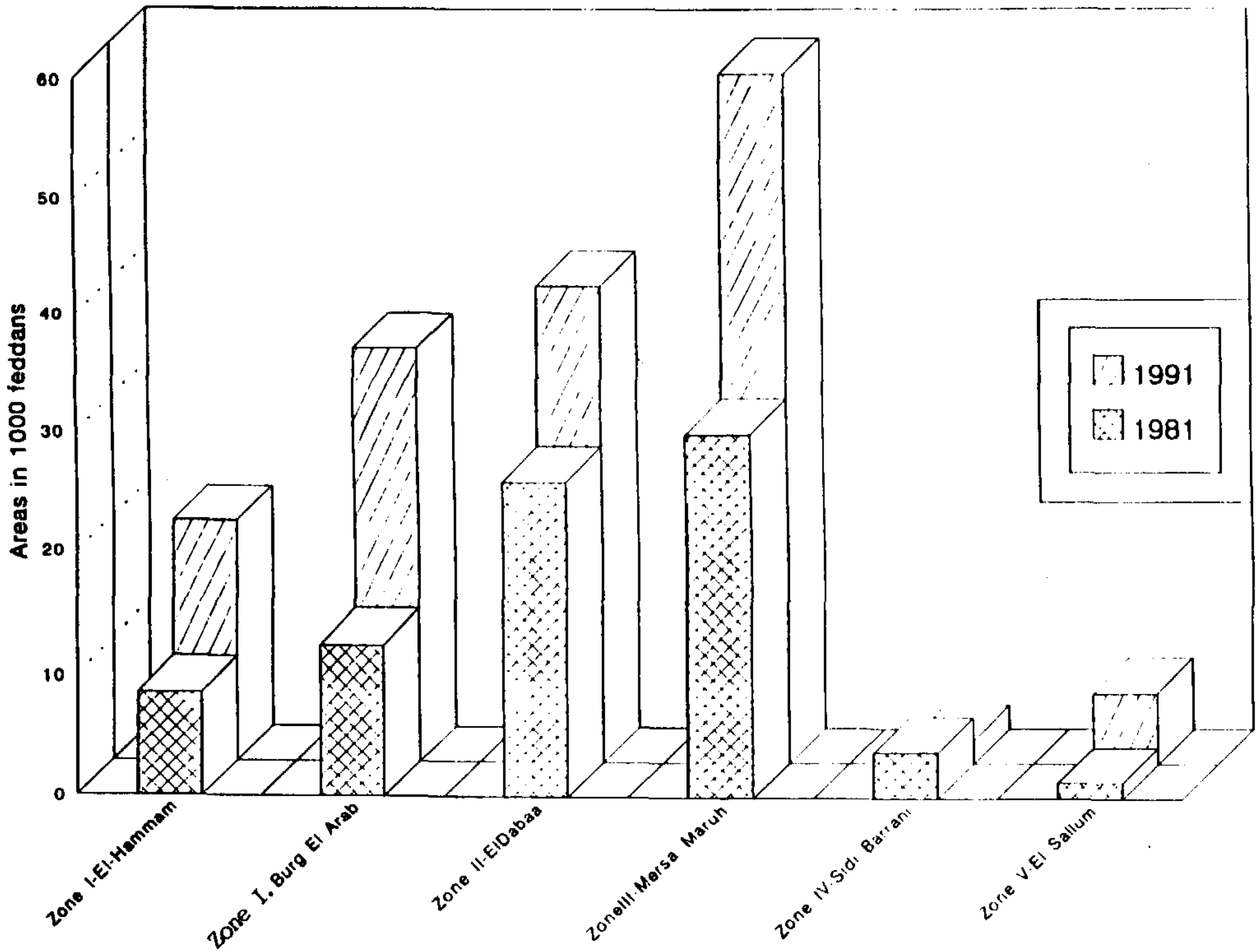


Fig. 10. Registered land ownership in the five zones (1981 and 1991).

Table 11. Cereal cultivation (in feddan) in Matrouh governorate, 1990/91.

Zone	Barley	Wheat
I: Bug El Arab and El Hammam	1,812†	5,524
II: El Dabaa	9,000	6,434
III: East Matrouh	45,804	6,500
West Matrouh	25,150	20,412
IV: Sidi Barrani	23,400	5,000
V : El Salloum	925	2,567
Total	106,091	46,327

† Plus 460 fed irrigated barley.
1 ha = 2.38 fed.
Source: MALR, Marsa Matrouh and mission estimates.

Table 12. Barley and wheat areas (fed) in the five zones, 1991/92.

Zone	Barley	Wheat
I†: Burg El Arab	5,497	10,430
El Hammam	4,529	2,084
II: El Dabaa	6,975	8,526
III: Marsa Matrouh	21,715	11,966
IV: Sidi Barrani	4,331	5,295
V: El Salloum	925	2,557
Total	43,972	40,858

† Mainly irrigated with Nile water.
1 ha = 2.38 fed.
Source: CAPMAS (1992).

Table 13. Relationship between barley area, yield and production, and rainfall.

Rainfall condition	Seed availability at planting	Area planted (fed)	Area harvested (fed)	Estimated yield (kg/fed)	Estimated production (t)
Drought year	good	80,000	20,000	200	4,000
Below-average year	poor	90,000	90,000	200	14,000
Average year	fair	100,000	73,999	300	22,000
Average year	good	120,000	110,000	400	30,000
Above-average year	good	120,000	110,000	400	44,000
Average					23,000

1 ha = 2.38 fed.
Source: FAO/UNDP (1970).

Wheat. Barley has long been the traditional source of flour for the Bedouins of the area. However, Bedouin familiarity with wheat flour has increased during the process of sedentarization, through allocations of wheat flour under the food-for-work programs established by World Food Program grants.

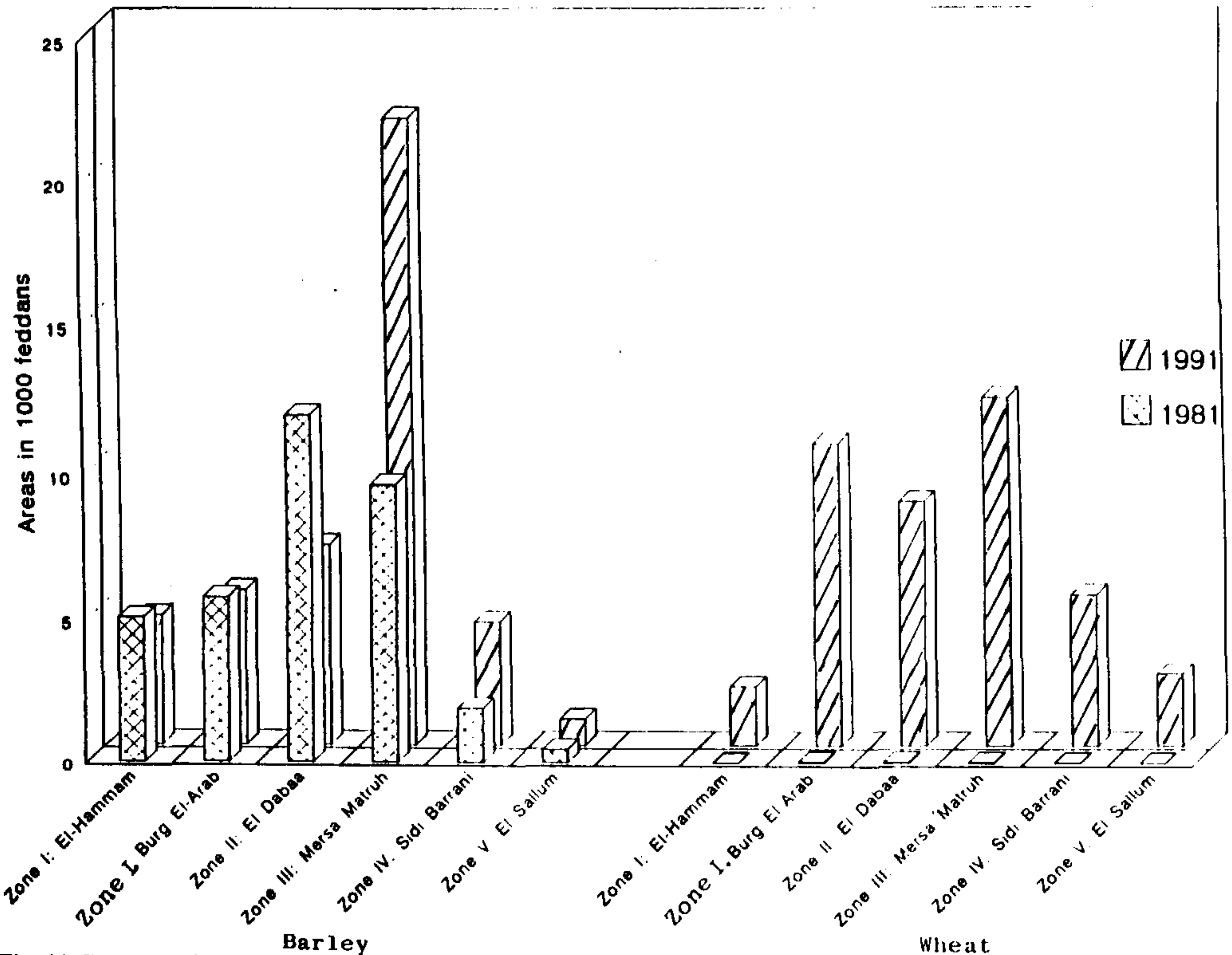


Fig. 11. Barely and wheat areas in the five zones (1981 and 1991).

As a national policy, the Government has promoted wheat production in an effort to achieve higher levels of self-sufficiency in wheat flour. Through adaptive research programs conducted in the Northwest Coast by the Field Crops Research Institute of the Agricultural Research Center over the last 10 to 15 years, the potential and requirements for wheat cultivation under rainfed conditions have been assessed. Following promising results, wheat cultivation has been promoted over the last seven years to farmers in the zone.

To encourage wheat cultivation, seed (cv. Giza 155) has been supplied at a 75% price subsidy, which is being gradually lifted. Wheat has now been incorporated into the production system, mainly at the expense of barley, as wheat in 1990/91 represented about a third of the annual cereal acreage sown in the Northwest Coast.

Wheat has a higher moisture requirement than barley. To promote wheat cultivation, the recommendation has been made to farmers to plant wheat on land which has a relatively stable water supply, i.e. land immediately upstream of water harvesting structures. This has tended to displace barley to the more marginal cultivable land. Clearly, this may have an adverse effect on barley yield from the point of view of water availability, and yield may also be limited in such areas by lower soil fertility.

In 1988/89, the wheat area in the Northwest Coast was about 6,200 fed (2,605 ha), rising to 13,987 fed (5,876 ha) in 1989/90 (of which 1,019 and 2,000 fed were grown in West Matrouh and Sidi Barrani, respectively), and further increasing to the present level of 67,000 fed (28,151 ha), including 20,400 fed (8,571 ha) in West Matrouh and 5,000 fed (2,100 ha) in Sidi Barrani (World Bank and MALR 1992).

The government price subsidy on wheat flour is gradually being lifted, making wheat flour an increasingly expensive commodity. Since wheat flour has increased in importance for local bread making, it is probable that the wheat area will continue to expand at the expense of barley in order that the Bedouins may secure their own production rather than rely on purchases.

Other winter crops. Table 14 presents the areas of other winter crops in the Northwest Coast. The data in this table point out the sharp increase in irrigated legumes (berseem and alfalfa) and onions in Zone I for the 1990/91 season. However, the data clearly show that the area of rainfed legumes in Zones II, III, IV, and V has been drastically reduced, from 698 fed in 1981 to only 30 fed in 1991.

Table 14. Areas of other winter crops in the five zones for 1981 and 1991 (fed).

Zone	Legumes		Onion and garlic	
	1981	1991	1981	1991
I†: El Hammam	458	1,798	-	33
Burg El Arab	881	9,170	-	573
II: El Dabaa	509	-	-	1
III: Marsa Matrouh	167	22	-	10
IV: Sidi Barrani	3	8	4	657
V: El Salloum	19	-	-	125
Total	2,037	10,998	4	1,399

† Irrigated with Nile water.

1 ha = 2.38 fed.

Orchards

Orchards are associated with *wadis* or depressions where the limited rainfall can be supplemented by collected runoff water. In the first three years after planting, supplementary summer watering is provided from cisterns. Although similar water applications would be advantageous after the establishment phase, the practice is only followed to a very limited extent in view of the restricted availability of cistern water and the difficulties of transporting stored water between the often widely separated water storage facility and orchards. *Wadi* orchards are planted in areas of water and soil accumulation created by low stone or cemented dikes, whilst plantings in more open depressions are frequently in basins surrounded by earth dikes built to retain sheet runoff and promote increased water infiltration.

For new orchards established in formerly uncultivated *wadis*, scrub clearance, and land preparation have recently been carried out using a combination of bulldozer and tractor under government/WFP assistance programs. In such cases, watermelon is planted initially, followed after two to three seasons by tree crops, or are intercropped with tree crops during the first few seasons of tree establishment. This practice permits revenue to be generated prior to fruit tree bearing.

Table 15 and Fig. 12 show the areas cultivated to the main fruit trees and their distribution in the five zones of the Northwest Coast according to CAPMAS (1992). In association with the installation of water harvesting and storage structures essential for fruit tree cultivation, the data show considerable expansion in the area allocated to fruit trees over a ten year period (1981–1991). The area planted to olive increased from 10,187 to 14,854 fed (4,280 to 6,241 ha), a 46% increase. Marsa Matrouh is the largest area for olive.

Table 15. Area (fed) of fruit trees in the five zones in 1981 and 1991.

Zone	Olive			Fig			Grape		
	1981	1991	Rate of change (%)	1981	1991	Rate of change (%)	1981	1991	Rate of change (%)
I: El Hammam	632	930	47	5,752	8,504	48	289	154	-135
Burg El Arab	2,455	1,535	-37	2,252	2,519	12	434	54	-380
II: El Dabaa	1,321	4,314	226	5,457	10,424	91	60	-	
III: Marsa Matrouh	4,750	6,954	46	5,905	13,242	124	19	34	
IV: Sidi Barrani	749	638	-15	1,251	1,272	2	38	169	
V: El Salloum	280	483	73	573	467	-18	33	222	
Total	10,187	14,824	46	21,190	36,428	72	873	633	-27

Source: CAPMAS 1992.
1 ha = 2.38 fed.

Figs occupy the largest fruit area, 36,427 fed (15,305 ha) in 1991, a 72% increase over 1981. The Matrouh zone has the largest area planted to fig. According to CAPMAS, other fruit trees covered 6,479 and 8,251 fed (2,722 and 3,466 ha) for 1981 and 1991, respectively. The other fruit orchards include grape, guava, and pomegranate.

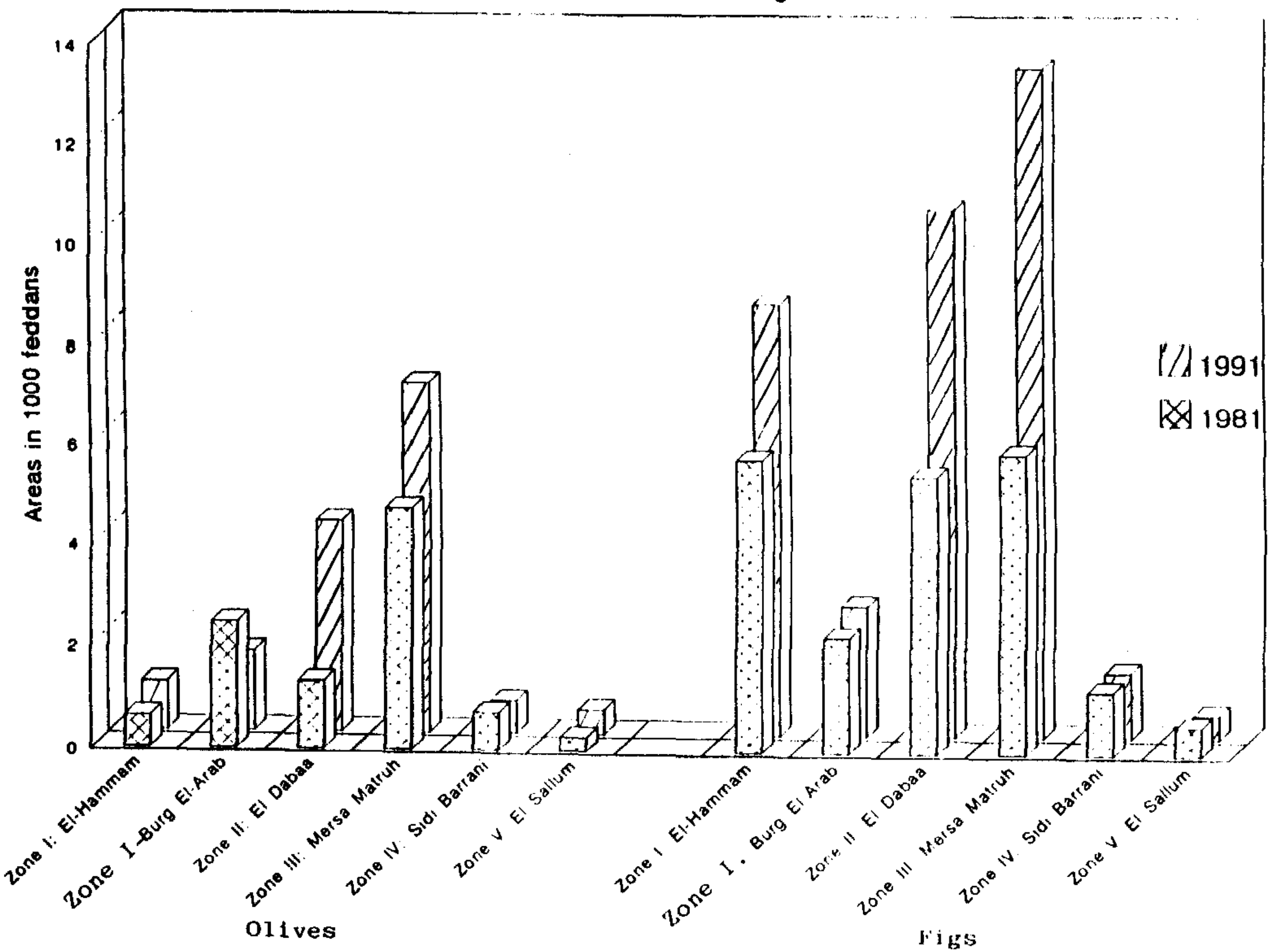


Fig. 12. Areas of fruit trees in the five zones (1981 and 1991).

Protected agriculture

Protected agriculture, or plasticulture, as it is frequently referred to in the area, has been introduced as a means of income generation linked to the expansion of tourism in the Northwest Coast and its associated demand for vegetable crops. Up to 1992, about 90 plastic tunnel units had been established, mainly to grow tomato and cucumber.

The units cover a standard area of 540 m^2. Units have been established for larger farmers as turnkey operations including the tunnel, water reservoir and pumping system, drip irrigation equipment and fertilizer tanks, at a total cost of LE 8,500. Two short-cycle vegetable crops can be produced each year, equivalent in a mixed system to about 10.8 tons of tomato plus 8.1 tons of cucumber in successive cycles.

Environmental Systems of Production

Six environmental systems of production can be distinguished in the region (El Naggar *et al.* 1989). These systems can be identified by ecological characteristics: (i) coastal production system, 0–5 km inland from the sea; (ii) inland production system, 5–15 km; (iii) livestock grazing/barley cropping system, 15–50 km inland; (iv) communal grazing system, especially camels, 50–100 km inland; (v) severe desert system, 100–200 km inland; and (vi) oases system (Siwa), more than 200 km inland from the seacoast.

For purposes of agricultural classification, Moustapha (1993) reported that the edaphic nature of the region, in combination with variability in climate and physiographic features, can be considered as three production strips: a coastal strip, a mixed production strip, and a rangeland strip.

Coastal strip. The first production strip extends from the seashore 5–10 km inland. It includes the beach and the coastal plain. The southern boundary of the coastal plain is composed of ridges running parallel to the sea at a distance of 200 m south of Ras El Hekma and 3 km south of the town of Marsa Matrouh. West of Marsa Matrouh, the coastal plain is narrow, intermittent or absent. Between Sidi Barrani and El Salloum, there is a flat coastal band 2–4 kilometers wide, behind a ridge of dunes about 10 km east of El Salloum. Trees and vegetables are cultivated with *wadi* runoff water as well as water from *sanias*, galleries, and some cisterns. The farmers collect runoff water for horticultural production.

Mixed production strip. The second production strip is located between 10 and 20 km inland. Rainfall is the main water resource, with use of runoff and no lateral movement of water. There are a few non-artesian wells, but the farmers consider them as a secondary water supply. This area is comprised of ridges, *wadis*, and depressions and is located just behind the ridges of the coastal system. Generally, the topography is uniform with a gradual slope from south to north. Stream beds (218 *wadis*) flow south to north in a hydrographic network of distinct organization with narrow, elongated plains and closed depressions. Some lands are suitable for rainfall runoff to improve barley cultivation and tree production. Flocks of sheep and goats are raised in this strip.

Rangeland strip. The third production strip is situated 20–50 km inland. This land system extends southward to the bluffs of the Libyan Plateau. Within this strip are two sub-areas: the northern area, used for the grazing of sheep and goats in addition to limited barley cropping, and the interior area, with a natural vegetative cover of shrubs, sub-shrubs, spiny bushes, and low quality grasses used for communal grazing. The area has a gentle to gradual slope from south to north. The rainfall varies from 50 to 100 mm, which constitutes the main water supply. However, a few wells are used in the area. Soil type influences the distribution and growth of natural plant life, infiltration rate, and water holding capacity. Access to grazing is governed by tribal membership.

Rangeland Resources

Current situation

Previous studies. The flora and vegetation of the Northwest Coast of Egypt have been well studied. Recent floristic and phytosociological studies conducted detailed local investigations, including Tadros (1956), Migahid and Ayyad (1959), El Sharkawy (1961), and Ayyad (1973, 1982). A regional vegetation map was produced on the basis of air photo interpretation and field surveys by a team of the UN Special Fund Project headed by J. Calembert and Abou Guendia (1966/67). This map established the framework for later regional range evaluation. Another vegetation map was prepared based on interpretation of soil information and Landsat imagery (El Shazly 1978).

The Systems Analysis of Mediterranean Desert Ecosystems of Northern Egypt (SAMDENE) (Ayyad 1979) and the Regional Environmental Management of Mediterranean Desert Ecosystems of Northern Egypt (REMDENE) (Ayyad 1982) projects contributed significantly to our knowledge of the rangeland ecosystem of the region. Of particular importance is the comprehensive evaluation of the various biotic and abiotic components of the rangeland ecosystem in relation to grazing. The latter project included a socioeconomic component dealing with the prevailing tribal systems and their effects on land use and grazing practices.

Range sites. The range vegetation in the Northwest Coast is a shrub type characterized by stands of shrubs and semi-shrubs, with a cover of short-lived annual forbs and grasses. The density of the dominant shrubs varies according to soil type and location, generally decreasing with increasing distance from the coast. Perennial forbs and grasses are present, but are considered of significance only in case of a few types (e.g. the *Plantago albicans* type).

Although the density of annuals varies from one vegetative type to another, rainfall amount and distribution through the season appear to strongly influence the actual density and yield. However, other factors such as the availability of propagules, surface soil condition, and the perennial vegetation cover condition are of importance in determining the density of the annuals.

In a study carried out by Abou Guendia (1985), emphasis was placed on relating the natural vegetation to the landform characteristics (their form and structure) according to the commonly used range site concepts. The following is a brief description of the main range sites identified in the area:

The salt-marsh site. This type is characterized by a high density of salt-tolerant shrubs. In general, the amount of grazing obtained from this site is small and is generally restricted to early autumn. This is due to the low palatability of the dominant shrubs, presumably due to their high salt content.

The rockland site. This type is dominated by the semi-shrub *Gymnocarpos decandrum* and is found on rocky ridges and crowded slopes in the northern half of the coastal strip.

Although plant density is generally low, the palatability of most species is high. This site is utilized mainly in the summer and autumn.

The sub-desert site. This type is similar to the preceding type in that *Gymnocarpos* is present, but has a greater species diversity and productivity due to the more favorable soil conditions. It is found mainly south of Sidi Barrani and is grazed mainly in winter and spring.

The coastal plain. Artemisia herba-alba is dominant in this site. It occupies areas with relatively deep, medium-textured soils in the northern half of the zone. The density of shrubs and herbs is high.

The eroded coastal plain. The eroded plain type is characterized by open stands of the low shrub *Haloxylon articulatum* and occupies degraded sites in the northern plains. Species diversity is low, as is the density of annuals. This site provides some summer and autumn grazing.

The inland dunes. This site represents the stabilized and semi-stabilized inland sand dunes, mainly near Sidi Barrani. The characteristic species is the perennial forb *Plantago albicans*. Numerous shrubs and perennial forbs and grasses are associated with this species. The density of both perennial and annual species is high in stabilized areas. Grazing takes place mainly in spring and early summer.

The saline upland site. The salt-tolerant, semi-shrub *Suaeda purinosa* is the characteristic species of this range site. This site represents saline, dry upland areas. Species diversity and density in this site are low throughout the region. Grazing takes place mainly in early summer and in the autumn.

The desert range site. This is the main range site in the southern half of the project area. The soil is often shallow or covered with a thin sheet of sand. The dominant species here is the desert shrub *Anabasis articulata*. Plant density is very low, with the exception of low areas receiving additional moisture from runoff. This type is grazed all year-round by camels. Sheep and goats sometimes graze on this type, mainly in winter.

Table 16 summarizes the common species in the Northwest Coast and those common in each of the five physiographic zones. This table includes the life cycle, general description, ranking of range importance, ranking of feed composition, ranking of palatability, and possibilities of seed production.

Rangeland use

The main types of land use in the area are:

- Grazing by sheep, goats and camels.
- Dryland farming (mainly barley cultivation).
- Irrigated agriculture (mainly in the eastern part of the area).
- Horticulture (mainly fruit production in selected valleys with deep soils and available supplemental water).
- Fuel collection (uprooting of shrubs by local inhabitants for cooking and lighting purposes).
- Recreational activities (e.g. summer camps, tourist villages).

Table 16. Natural range species of the Northwest Coast.

Scientific name	Common name	Family	Life cycle		Description			Range importance			Feed composition			Palatability			Seed production				Remarks
			Per	Ann	Her	Shr	Tre	Hi	Me	Po	Hi	Me	Po	Hi	Me	Po	Ab	Go	Me	Ro	
A. Species common to the region as a whole :																					
Acacia farnesiana	Fotna	Leguminosae	+			+	+		+			+			+				+		
Acacia nilotica	Taih	Leguminosae	+			+	+	+	+			+			+		+				
Acacia saligna	Sayaal	Leguminosae	+			+	+		+			+			+		+				Sand dune
Achillea santalina	Bishreen	Compositae	+		+				+			+			+				+		
Anacyclus alexandrinum	Sorret-el-Kabsh	Compositae		+	+				+			+			+			+			
Asphodelus microcarpus	Basal-el-Onsol	Liliaceae	+		+					+			+			+					
Astragalus boeticus	Kreisha or Mahallas	Leguminusae		+	+			+			+			+					+		
A.hamosus var. brachyceras		Leguminosae		+	+			+			+			+					+		
Astrogolus peregrinus	Kreisha	Leguminosae		+	+				+			+			+			+			
Atriplex halimus	Roghaata	Chenopodiceae	+			+			+			+			+		+				
Panicum turgidum	Thommaam Abu rokba	Gramineae	+		+			+				+			+			+			
Pituranthos tortuosus	Qozzaah	Umbelliferae		+	+			+			+			+				+			
Trigonella hamosa	Eshb-el-malik	Leguminosae		+	+				+				+			+			+		
Trigonella martima	Helba	Leguminosae		+	+				+				+			+			+		
Vicia sativa sp. cardata	Deorag or El-gromboush	Leguminosae		+	+			+			+			+			+				
Vicia sativa sp. nigra	Dehorag or El-gromboush	Leguminosae		+	+			+			+			+			+				

Table 16. (Cont'd)

Scientific name	Common name	Family	Life cycle		Description			Range importance			Feed composition			Palatability			Seed production				Remarks
			Per	Ann	Her	Shr	Tre	Hi	Me	Po	Hi	Me	Po	Hi	Me	Po	Ab	Go	Me	Ro	
Lolium perenne	Gazzon	Gramineae	+		+			+			+			+				+			
Lotus corniculatus	Qorn-el-ghazaal or Abou-Qarn	Leguminosae		+	+				+			+			+			+			
Lotus creticus	Oshb	Leguminosa	+						+			+			+			+			
Melilotus sicylus	Handayoog helow	Leguminosae		+	+				+			+			+						
Cutandia memphitica	Khasfoor	Gramineae		+	+				+				+		+						
Cynodon dactylon	Nigem	Gramineae	+		+			+			+				+						
Gymmocarpos decanderum	Garad	Garyophyllac eve	+			+			+			+			+						
Y. cyclocarpa var. leiocarpa	Koreset-el-arnab	Leguminosae		+	+				+		+				+			+			
Hippocrepis bocontorta	Doreis	Leguminosae		+	+			+			+			+				+			
Hippocrepis cyclocarpa		Leguminosae		+		+		+			+			+				+			
H. cyclocarpa var. leiocarpa		Leguminosae		+	+			+			+			+				+			
Lolium multiflorum	Simbil	Gramineae		+	+			+			+			+			+				
Hordeum leporinum	Shaaralae Ab Shtirt	Gramineas		+	+				+			+			+				+		

Abbreviations: Per. = Perennial; Shr. = Shrub; Her = Herbage; Me = Medium; Hi = High; Go = Good; Ab = Abundance; Po = Poor; Ann = Annual; Ra. = Rare; Tre = Tree

Table 16. (Cont'd)

Scientific name	Common name	Family	Life cycle		Description			Range importance			Feed composition			Palatability			Seed production				Remarks
			Per	Ann	Her	Shr	Tre	Hi	Me	Po	Hi	Me	Po	Hi	Me	Po	Ab	Go	Me	Ro	
B. Species common in the physiographic zone I :																					
Medicago araborium	Qurt	Leguminosae	+		+				+		+			+				+			Burg El Arab El-hammam El Mattani
Lotus collinus	Garn-el-Ghazal	leguminosae	+		+				+		+			+					+		Burg El Arab, Sidi Barani but rare
Lotus arabicus	Gotb Khot-el-taeer	Leguminosae		+	+					+			+			+			+		Widespread in El Hammam (El Mattani)
Hymenocarpus nummularis	El-Maddad	Leguminosae		+	+			+				+		+					+		Burg El Arab, el Hammam and El mattani
Lathyrus marmoratus	Gelban	Leguminosae		+	+				+		+			+					+		Burg El Arab, El Dabaa and Sidi Barani
Melilotus indica var. tommosinii	handaqooq mor	Leguminosae		+	+				+		+				+				+		Burg El Arab and El Hammam
Hippocrepis unisiliquosa	Omm dowarah	Leguminosae		+	+			+			+			+				+			El-Hammam (Burg El-Arab)
Astragalus tribuloides	Ashb	Leguminosae		+	+			+			+			+					+		El-Hammam
Vicia villosa	Dohrerg	Leguminosae		+	+				+			+		+				+			Burg El Arab, El-Hammam

Table 16. (Cont'd)

Scientific name	Common name	Family	Life cycle		Description			Range importance			Feed composition			Palatability			Seed production				Remarks
			Per	Ann	Her	Shr	Tre	Hi	Me	Po	Hi	Me	Po	Hi.	Me	Po	Ab	Go	Me	Ro	
Plantago albicans	Yanam	Plantaginacae	+		+			+			+			+						+	
Vicia cinerea	Qorn-el-ghazaal or Abou-Qarn	Leguminosae		+	+			+			+			+			+				
Vicia hirsuta	Dohrerg	Leguminosae		+	+			+			+			+				+			
Vicia monantha	Dohreig or Khareeg	Leguminosae		+	+			+			+			+			+				
Lygos raetam var. borei	Ratam or Retem	Leguminosae	+			+		+				+		+						+	
Onobrychis cristo-gali	Sileisla	Leguminosae		+	+				+			+			+				+		
Onobrychis ptolemarica	Widaan-el-hardeeb	Leguminosae		+	+				+			+			+				+		
Scorpiurus mariecatus var. laerigatus	Zanab-el-agrab	Leguminosae		+	+			+			+			+				+			
Scorpiurus maricatus var. subrillosus	Zanab-el-agrab	Leguminosae		+	+			+			+			+				+			
Trifolium tomentosum	Qort or Kreissht-er-roai	Leguminosae		+	+				+		+				+				+		

Table 16. (Cont'd)

Scientific name	Common name	Family	Life cycle		Description			Range importance			Feed composition			Palatability			Seed production				Remarks
			Per	Ann	Her	Shr	Tre	Hi	Me	Po	Hi	Me	Po	Hi	Me	Po	Ab	Go	Me	Ro	
C. Species common in the physiographic zone II																					
Astragalus spinosus	Kidand	Leguminosae	+			+		+			+			+					+		
Agropyron juneum	Gazzoof	Gramineae	+		+				+		+			+				+			
Artemisia herba-alba	Sheeh	Compositae	+			+			+			+		+							
Palantago albicans	Yanam	Plantaginaceae	+		+			+			+									+	
Lygos raetam var. bovei	Ratam or Retem	Leguminosae	+			+		+				+		+						+	
Pisum sativum var. arvense	Pessela	Leguminosae		+	+					+			+		+				+		
Astragalus hamosus	Degees	Leguminosae		+	+			+			+			+					+		
Medicato littoralis	Qort	Leguminosae		+	+			+			+			+						+	
Medicago polymorpha	Qort	Leguminosae		+	+			+			+			+							
Midicago troneatula	Qort	Leguminosae		+	+			+			+			+			+				
Lotus polyphyllos	Qarn-el-Ghazaal	Leguminosae		+	+				+			+		+				+			

Table 16. (Cont'd)

Scientific name	Common name	Family	Life cycle		Description			Range importance			Feed composition			Palatability			Seed production				Remarks
			Per	Ann	Her	Shr	Tre	Hi	Me	Po	Hi	Me	Po	Hi	Me	Po	Ab	Go	Me	Ro	
D. Species common in the physiographic zone III																					
Atriplex nummularia	Qataf	Chenogodiceae	+			+		+			+				+		+				
Periploca angustifolia	Halaab	Asclepiadaceae	+			+		+			+				+				+		
Periploca laevigata	Halaab	Asclepiadaceae	+			+									+						
Malva silvestris	Khobbeiza	Mavaceae			+				+				+			+					
Medicago arabica	Barseem shogiry	Leguminosae	+			+			+		+			+				+			
Scorpirus muricatus var. Laevigatus	Zanab El-Agrab	Leguminosae		+	+			+			+			+				+			
Argyroobium abyssinicum	Kood	Leguminosae		+	+				+			+			+				+		
Argyrolobium uniflorum		Leguminosae	+		+			+			+			+				+			
Astrogalus annularis	Mohallaq	Leguminosae		+	+			+			+			+				+			
Medicago ascharsoniana	Dreisi	Leguminosae		+	+			+			+		+					+			
Astrogalus trigonus	Qataad	Leguminosae	+			+		+				+				+			+		
Ohonis vaginalis	Hotteiba	Leguminosae	+			+		+			+			+				+			
Cassia stuctii	Senna	Leguminosae	+			+			+			+			+			+			
Chrysanthemum coronorium	Oquhowaan	Compositae		+	+			+				+			+						

Table 16. (Cont'd)

Scientific name	Common name	Family	Life cycle		Description			Range importance			Feed composition			Palatability			Seed production				Remarks
			Per.	Ann.	Her.	Shr.	Tre.	Hi.	Me	Po.	Hi	Me	Po.	Hi.	Me	Po	Ab	Go	Me	Ro	
Crotalaria aegyptiaca	Natasch or netesh	Leguminosae	+			+			+			+			+			+			
Ohonis serrata	Seita or Zeiti	Leguminosae		+	+				+			+		+				+			
Lathyrus sativus	Gelban	Leguminosa		+	+				+		+			+					+		
Onbrychis ptolemarica	Widaan El-Hardeeb	Leguminosae		+	+				+			+			+				+		
Lygos ractam var. bovei	Ratam or retem	Leguminosae	+			+		+				+		+						+	
Hymenocarpus nummularis	El-Madad	Leguminosae		+	+			+				+		+					+		
Lotus arabicus	Gatb Khef-Elteer	Lguminosae		+	+					+			+			+			+		

Table 16. (Cont'd)

Scientific name	Common name	Family	Life cycle		Description			Range importance			Feed composition			Palatability			Seed production				Remarks
			Per	Ann	Her.	Shr.	Tre	Hi	Me	Po	Hi	Me	Po.	Hi	Me	Po	Ab	Go	Me	Ro	
E. Species common in physiographic zone IV :																					
Helianthemum lippii	Qadib	Cistaceae	+			+			+			+			+			+			
Dactylis glomerata	Nigeel	Gramineae	+		+				+			+		+				+			
Digitaria commutata	Habit-el-deb	Gramineae	+		+				+			+							+		
Echiochilon fruticosum	El-Yadma	Boroginaceae	+			+			+		+				+						
Prosopis juliflora	Prosopis	Leguminosae	+				+	+			+					+	+				
Retama retam	Retama	Leguminosae	+			+		+			+			+					+		
Schismum barbatus	Nashash-el-reeh	Gramineae		+	+				+			+		+					+		
Brassica tournefortii	Kaber	Cruciferae		+	+					+			+			+					
Enarthrocarpus stronguiatus	Shiltaam	Cruciferae		+	+				+			+			+				+		
Eracaria planata	Lesles	Cruciferae		+	+				+				+		+					+	
Astragalus trimestris	Oorein	Leguminosae		+	+																

Table 16. (Cont'd)

Scientific name	Common name	Family	Life cycle		Description			Range importance			Feed composition			Palatability			Seed production				Remarks
			Per.	Ann.	Her.	Shr.	Tre.	Hi.	Me.	Po.	Hi	Me	Po.	Hi.	Me.	Po	Ab	Go	Me	Ro	
Plantago crypsoides	Degez	Plantaginaceae		+	+			+			+			+						+	
Plantago ovata	Geneima	Plantaginaceae		+	+			+			+			+					+		
Astragulus asterias	Abu-equifa	Leguminosa		+	+			+			+			+					+		
Medicago coronata	Qort	Leguminosae		+	+				+			+		+					+		
Vicia cinerea	Qireinent ghazal	Leguminosae		+	+			+			+			+			+				
Onobrychis crista-galli	Sileisla	Leguminosae		+	+				+			+			+				+		
Onobrychis ptolemarica	Widaan El hardeeb	Leguminosae		+	+				+			+			+			+			
Trifolium tomentosum	Gort or Kreissht-er-hasi	Leguminosae		+	+				+		+				+				+		
Artemisia herba-alba	Sheeb	Compositae	+			+			+			+		+							
Chrysanthemum coronorium	Oquhowaan	Compositae		+	+			+				+			+						
Lathyrus marmoratus	Gelban	Leguminaseae		+	+				+		+			+					+		

Table 16. (Cont'd)

Scientific name	Common name	Family	Life cycle		Description			Range importance			Feed composition			Palatability			Seed production				Remarks
			Per	Ann	Her	Shr	Tre	Hi	Me	Po	Hi	Me	Po	Hi	Me	Po	Ab	Go	Me	Ro	
F- Species common in the physiographic zone V :																					
Plantago albicans	Yanam	Plantaginaceae	+		+			+			+			+						+	
Dactylis glomerata	Nigeel	Graminaea	+		+				+			+		+				+			
Brassica tournefortii	Kabar	Cruciferae		+	+					+			+	+		+					
Schismum barbatus	Nashash El Reeh	Gramineae		+	+				+			+		+					+		
Helianthemum lippii	Qadib	Cistaceae	+			+			+			+			+			+			

Range condition, trend and grazing capacity

Serious deterioration of the rangeland has taken place, with no sign of ending. The main causes of deterioration are overgrazing by sheep and goats, destruction of natural vegetation in marginal rangeland for barley cultivation and other purposes, and the uprooting of shrubs for use as fuel. The effect of these factors is accentuated by periodic drought.

Following are the main features of this deterioration:

- Disappearance of desirable perennial plant species over much of the area. Where present they are extremely reduced in vigor.
- Species classified as undesirable or unpalatable a decade ago are now being heavily grazed.
- Increase in the density of undesirable species in some areas.
- Total disappearance of vegetative cover in increasingly large areas around settlements and watering points.
- Soil erosion by water and wind.
- Excellent vegetative cover and biomass in small areas that are protected from grazing or where slight grazing occurs (corners of orchards, fenced range areas).

Livestock

Animal Resources in Relation to Farming Systems

The core of agricultural activities in the Northwest Coast is livestock production, which provides a livelihood for 75% of the population and represents 59% of the gross regional product. With respect to animal husbandry, as one of the main sources of income, the natural rangeland is used to rear sheep, goats, camels, and donkeys. Sheep meat and wool are the main economic products, while milk, goat skin, and goat and camel hair are important by-products for local use. Donkeys and camels are still used for draft and transportation. There are some cattle and horses, particularly in the irrigated areas in Zone I. However, animal production in the Northwest Coast of Egypt is concerned mainly with sheep and goats.

Livestock Population and Distribution

The population of animals in the Northwest Coast is summarized as follows (MOA Census, 1990):

- Sheep: 435,128
- Goats: 203,047
- Camels: 8,161

According to El Naggar and Perrier (1989), 97% of the farmers own sheep, goats, camels, cattle, donkeys, and horses. Eighty-four percent are sheep and goats, 14% donkeys, 1% camels, and less than 1% cattle. Farmers sell milk in the tourist villages and in the town of Marsa Matrouh, or they process the milk into cheese and butter.

The poultry industry varies from intensive to extensive production, with practices ranging from traditional methods to modern techniques for market distribution. Many projects for intensive commercial production are located in the area, both state-owned and private.

In the private sector, 258 Bedouins have established small projects for poultry production. The total amount of meat produced is 102 t/yr, with an input of 367 tons of chicken feed per year.

Farmers own about 14,000 donkeys for carrying loads, and for riding by women and boys (who attend school), as well as agricultural operations such as plowing and threshing barley.

The total number of camels is 8,161. The only surviving breed in the area is the one-humped camel. Camels graze on shrubs or low quality spiny plants in the interior. The Bedouins in specific areas such as El Sholahy, El Mathany, El Neguila, and Ras Abu-Laho, are more interested in camel breeding than in other areas.

Camel hair is the only by-product derived from camels, and is sold as raw material or prepared into yarn for weaving. Twenty-five percent of the farmers sampled have camels, an average of 16 with a maximum herd size of 70. These farmers live in the rangeland strip where the rainfall is 50 mm and the native plants are low quality shrubs and spiny shrubs.

Sheep and goats

From 1965 to 1984, the Bedouins increased their sheep and goat production to meet an increasing demand for meat by other Arab countries. Between 1985 and 1987, the population started to decline. In 1990, farmers owned 638,175 head of sheep and goats.

The density of the livestock population varies from district to district as well as between the three production strips from the sea inland to the interior. Thirty percent of the sheep and goats are located in East Marsa Matrouh, 19% in West Marsa Matrouh, 34% in Sidi Barrani, and 8% in El Salloum. In the coastal strip, most of the farmers have fig orchards, therefore grazing is limited, and because livestock can damage trees, farmers who own sheep and goats use the interior lands for grazing. However, livestock population increases in the mixed production and rangeland strips.

The maximum number of livestock owned by a farmer is 750 (600 sheep and 150 goats) with a mean of 117 (88 sheep and 29 goats) and a standard deviation of 127 (98 sheep and 29 goats). The ratio of sheep to goats is 2.67. Flock sizes are 50–60 head with a single shepherd without a dog. One ram is required for every seven ewes to ensure maximal fertility, and one buck can service a greater number of does.

The males remain with the herd throughout the year, with one main breeding season in June. Lambing and kidding coincide with the beginning of the grazing season, during the months of November and December. In certain flocks the lambing season may begin as early as September, depending upon the nutritional status of the livestock.

The Barki fat-tailed sheep with coarse wool is the only surviving breed, and there is a local breed of goats of small body weight. Development trials have been implemented to introduce improved Barki rams and improved breeds of goats into the herds.

Lambs and kids suckle some milk, with the excess hand-milked and used for human consumption or processed into by-products. Where there is natural vegetation and green barley fields, some of the weaned lambs and kids are fattened by the owners.

Demographics

Total Population and Distribution

The total population of Matrouh governorate was reported by CAPMAS (1992) to be 161,163, including 83,338 males and 77,825 females. Matrouh governorate consists of seven districts: Burg El Arab, El Hammam, El Dabaa, Matrouh, Sidi Barrani, El Salloum, and Siwa. The last district is not considered a part of the Northwest Coast. The World Bank Project in the Western Province, including Zones III, IV, and V, defined most of the Bedouins in this area as rural inhabitants.

The data show that about 40% of the population resides in the Western Province of the Northwest Coast (i.e. Zones, III, IV, and V), while the remainder reside in the east, especially in the irrigated areas of Zone I. Figs 13, 14, and 15 illustrate population statistics of the Western Province.

Population growth in Matrouh governorate

A number of rural development projects have been undertaken in recent years. These projects represent a concerted and sustained effort by agriculturally oriented institutions and agencies including research, extension, marketing, finance and cooperatives. These projects have resulted in considerable development. Thus, the area of substantial increase in rural population includes the three districts of Burg El Arab, El Hammam (Zone I) and El Dabaa (Zone II), with a population increase over 10 years of 68, 57, and 46%, respectively. The population in the Northwest Coast increased from 112,547 in 1976 to 160,567 in 1986, showing an overall increase of 43% in 10 years.

Population of Bedouins and newcomers

About 167,020 people, from 5 major tribes and El Morabtein, and representing approximately 34 sub-tribes, reside throughout the year in the Western Province (Zone III, IV, and V). In 1988, it was estimated that the 5 major tribes represented roughly 60% of the population of the districts of Marsa Matrouh, Sidi Barrani and El Salloum, while El Morabtein made up the remaining 40%. It can reasonably be assumed that almost all the rural population in the Western Province are Bedouins. It is estimated that the non-Bedouin newcomers in Matrouh governorate constitute about 15% of the total population. This estimate has been used by governmental agencies for policy and planning.

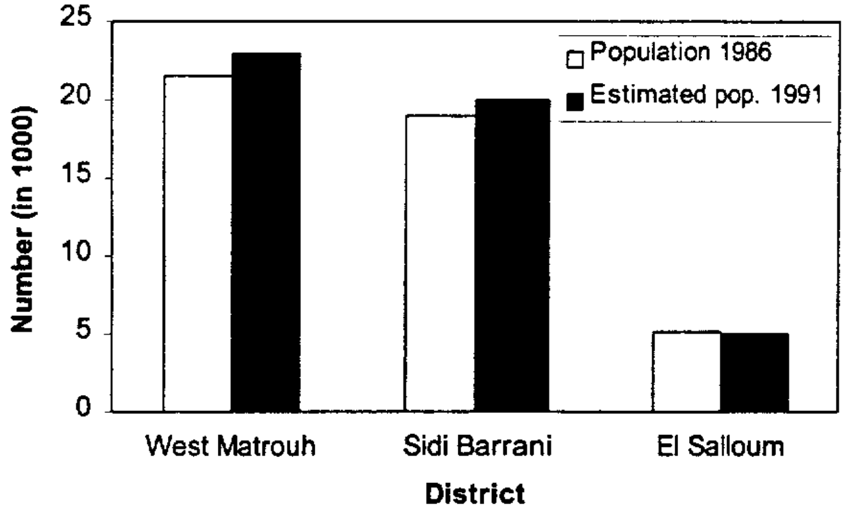


Fig. 13. Population in Matrouh governorate in the Western Province in 1986 and 1991.

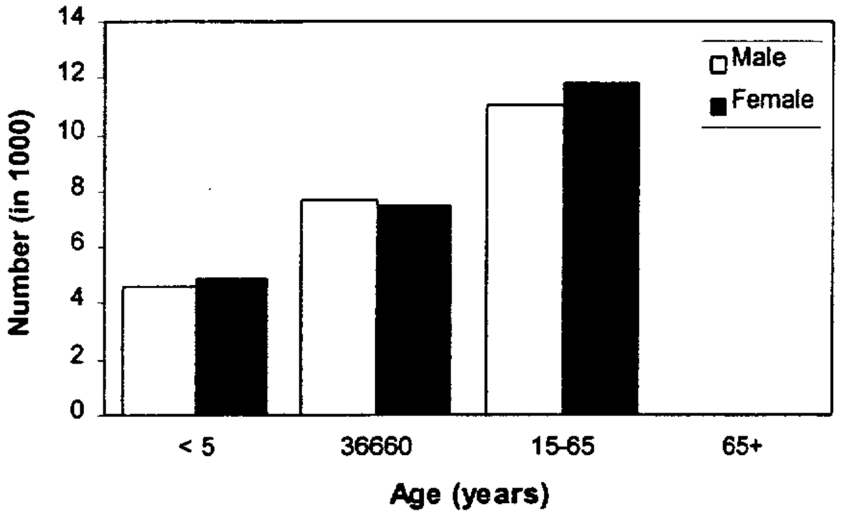


Fig. 14. Age structure of the population in the Western Province: Distribution by age group and gender (1991).

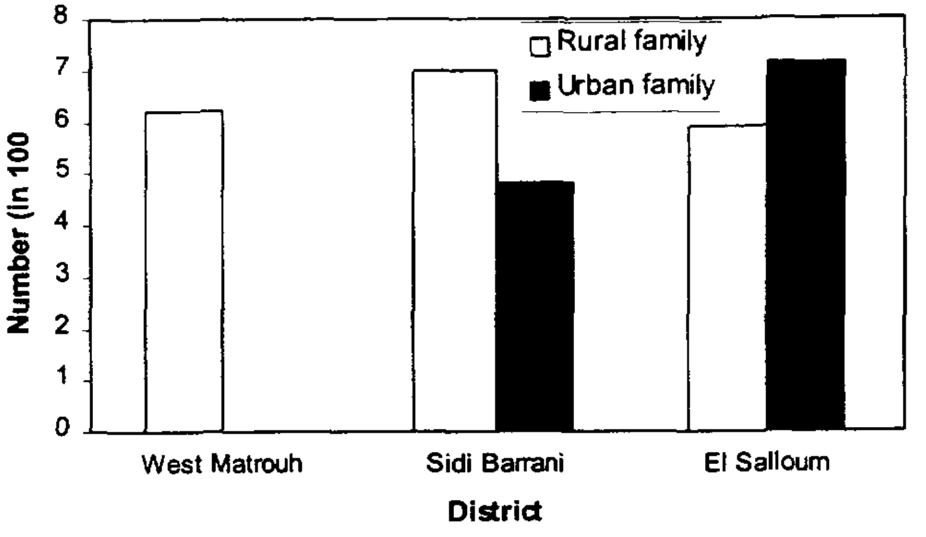


Fig. 15. Estimated average size of families in the Western Province (1991).

The overall stratification system is based upon socially inherited privilege and consists of an unchanged rank. The closer the blood relation an individual has to the tribal sheikh, the greater his power, prestige and influence. Bedouins adjust well to the demands of modern life as long as they do not threaten their pride, privacy and property. People are anchored in the tribal system by the accumulation of wealth. Fig. 16 illustrates the tribal structure and leadership.

Settlement Pattern

Settlement hierarchy

City. The definition of a city is based on the types of services and the level of each service available. Population must exceed 10,000.

Village. Population is between 5,000 and 10,000, with a low level of services.

Ezbah* or *Bayt: The most basic unit, does not constitute a settlement.

Types of rural settlement

There are three levels below the village:

1st type. This settlement consists of a number of shops and a mosque.

2nd type. This settlement occurs around wells and cisterns far away from the main settlement, and relies on rainwater.

3rd type. This settlement occurs along dry valleys (*wadis*) and washes which run in north–south.

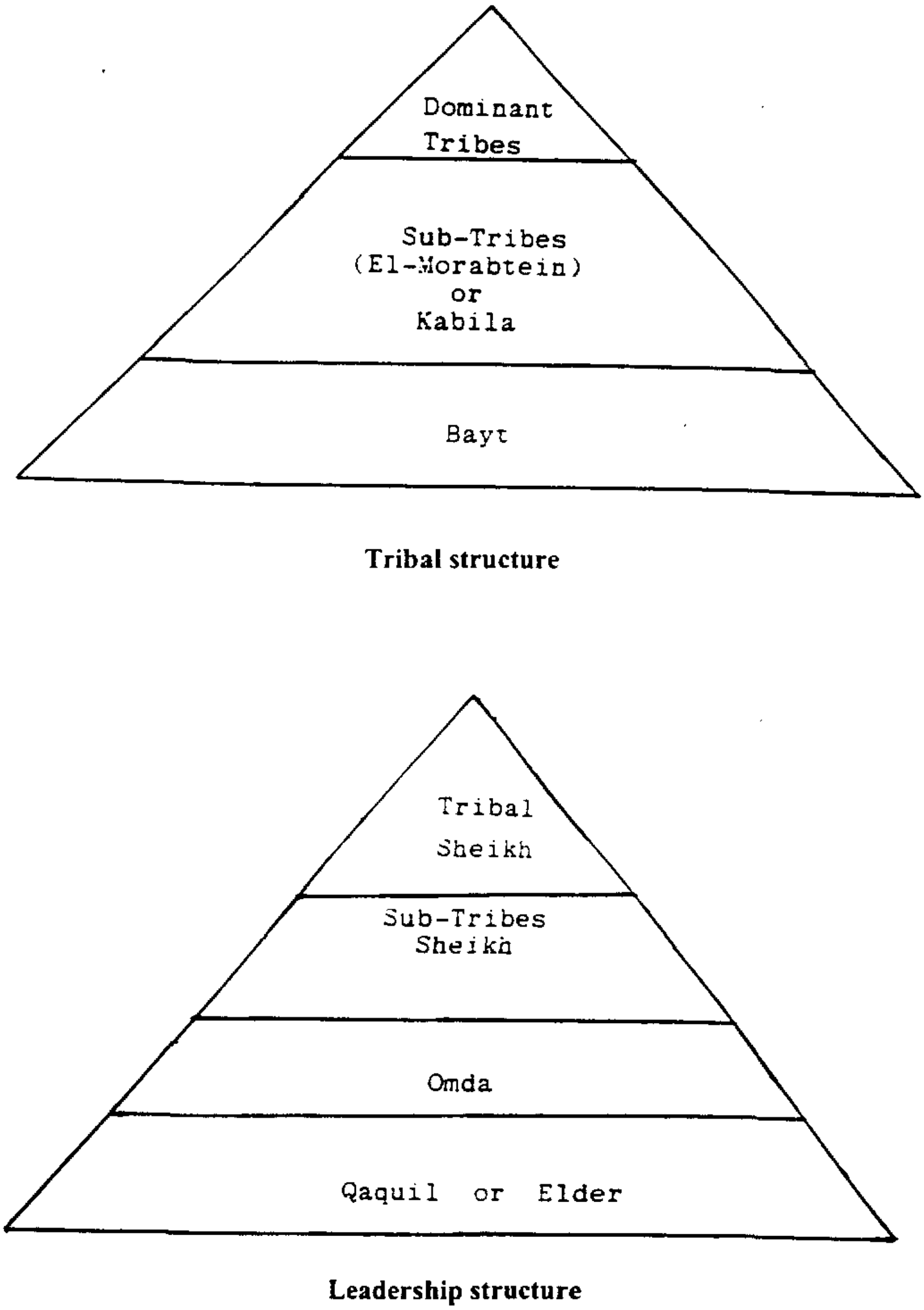


Fig. 16. Tribal structure and leadership.

Land tenure and water rights
As agriculture has become more commercialized, issues have arisen regarding the use of land as collateral. The land tenure system is based on tribal rights.

Each tribe has established itself in an expanse of the desert and maintains exclusive rights to it. The *majlis orfy* is a tribal tribunal consisting for territorial dispute. A claim to a piece of land is initiated by what is known as *wadaa el yad*. With continued use the land become owned, so the individual has rights to its use and can pass these rights to his descendants.

Role and responsibility of women
Gender dictates the type of work that men and women are expected to do. Women are restricted to work around the house. Women's status is below that of men, and their economic, social, and legal rights are inferior to those of men. Women understand and undertake some domestic processing of agricultural products. Women are not independent economically—all responsibility is assumed by the men. They have the right to own herds and small animals or a home garden. They have the right to the products of what they own.

Settlement types and residual pattern
Matrouh governorate is divided administratively into seven districts. Each main town is surrounded by a number of satellite villages. In addition, a number of villages, hamlets and settlements are scattered in the desert expanses of the hinterland. Although the Bedouins have traditionally been a nomadic people, the Government's determined policy of encouraging sedentarization has meant that a negligible proportion of the population is entirely nomadic. With assistance from the Government and the World Food Program, the majority of the households in the Western Province now have a permanent dwelling; only a minority of rural households still rely on tents as their only source of shelter. No nomads are found close to the coastline.

Labor Force
The estimated potential labor force in the Western Province, defined as the male and female population between the ages of 5 and 64 years of age, is 38,210 (Fig. 17). The general pattern is for the number of females to exceed the number of males. This pattern reflects the tendency for males to migrate out of the area in search of income-earning opportunities.

Literacy by age and sex
The literacy rate in the Matrouh governorate is estimated to be 44% for those from 6 to 30 years of age. This rate is much lower than the national average. The enrollment of boys and girls in Matrouh primary schools was 57 and 34%, respectively, in 1980 (91 and 60 for rural boys and girls, respectively, in Egypt as a whole). One important reason for the low school enrollment in the region is the fact that settlements in the Northwest Coast, particularly in the Western Province, are widely scattered in the seemingly endless expanses of the desert.

Structure of employment in Matrouh governorate
Employment opportunities reflect the size and characteristics of the population which can be supported by the existing economic structure. Based on this, imbalances between the demand and supply of labor may take place, and the limited capacity of agriculture to

absorb labor has led to considerable unemployment and under-employment. Population pressures have also lowered the per capita productivity of the land and the standard of living—the labor force participation rate in 1986 was 34%, with over 42,000 people either employed or available for employment.

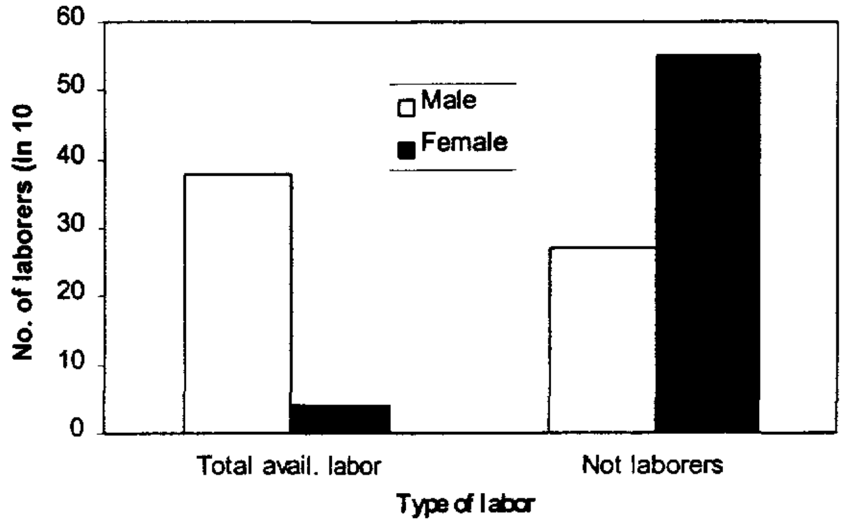


Fig. 17. Matrouh governorate labor force participation rate (1986).

On-farm labor, wages, supply, and demand

The use of family labor for agricultural production is related to family size, livestock, land holding, and off-farm employment. On a large farm it is assumed that the family will provide only 25% of total labor, with the remaining 75% hired. Members of large families are more involved in management and supervision and less involved in manual labor. This is a sign of high status and prestige. Large farms hire labor for harvest of cereal and tree crops, threshing, and livestock herding.

Permanent labor in animal husbandry usually continues throughout the year. The involvement of men, boys, women, and girls varies depending on how close to the home the animals are fed, and on the time of lambing or kidding and lactation. During the five months when animals are grazing on the range (roughly September–January), animal care is entirely in the hands of the men and boys responsible for the herd. On average, one man and one boy are required to look after a mixed flock of 100 head of small ruminants (on average, 75% sheep and 25% goats). During lambing, kidding and lactation (roughly February–April for sheep and February–August for goats), men and boys take the animals to graze during the day on nearby rangeland. Women and girls feed, water and milk the animals morning and evening, and assist with the care of the young animals.

Labor requirements for crops vary by month and by agricultural activity. Plowing with a tractor requires 1 man day per feddan for wheat and barley in November and December, and for watermelon and melon in April. Weeding requires 2 woman days and 2 boy days per feddan for watermelon and melon during June, and 4 woman days and 4 boy days for fig and olive in November and April. Pruning requires 5 man days per feddan for fig and olive during January. Harvesting requires 5 man days and 4 woman days per feddan for wheat and barley during May and June. Fig harvesting requires 13 man days, 7 woman days and 7 boy days per feddan during October and November. Threshing of wheat and barley requires 2 man days per feddan with draft animals during June. Guarding watermelon and melon requires 1 man day per feddan during June. The work day is usually 8 hours, except in animal husbandry and wheat and barley harvesting, where the work day extends to 10–12 hours. Girls tend to work primarily within the household, assisting with tasks such as water and fuel-wood collection, or with care of animals.

One man and 1 boy are required to move with a herd of 100 head. Wages are LE 2.00 per day for both men and boys. The available male agricultural labor force is only fully employed during the cereal harvest months of May and June. It is seriously under-employed during the months of February, March, April, July, and August. The demand for female labor is equal to or exceeds the available female agricultural labor force in 9 out of 12 months. The general level of unemployment of males and females in agriculture is even greater in the Western Province and in the governorate as a whole.

Labor supply and demand in Matrouh governorate

The World Bank study found an excess labor supply of 11,000 man days during February, March, and July, 9,000 man days during April and December, and 6,000–7,000 man days during January, August, September, and November (Figs 18 and 19). Also, there is an excess labor demand between 9,000 and 12,000 man days in May and June during the harvesting of wheat and barley. To compensate for this shortage, work hours are increased, with heavy reliance on women and boys, and labor is diverted from other activities. In the Western Province, the excess supply ranges between 2,000 and 6,000 man days throughout the year, except in May and June. Heavy reliance on mechanized harvesting, threshing, and winnowing may solve the shortage during these two months.

Bedouins, Immigrants, and Social Welfare

Bedouins

Ismail *et al.* (1976) states that the large majority (87%) of the population of the region are Bedouins. They have lived in this area for centuries and have developed values, a social system, and techniques in sheep breeding and agriculture which have allowed them to survive in harsh natural surroundings. As a result of improved medical care and more adequate provision of food and water, the Bedouins are rapidly increasing in numbers. The economic basis for their existence has remained the breeding of sheep and goats. Consequently, the number of sheep has increased. This has been made possible by a policy whereby heavily subsidized animal feeds are distributed via cooperatives. The number of sheep has doubled in recent years. A considerable number of people have been able to increase their income by trading with Libya. Since the beginning of 1975 this trade has, however, been strongly curtailed by both the Egyptian and Libyan Governments. As a result, incomes resulting from this trade have dropped sharply. More and more Bedouins are working in Libya, where they earn high wages, mainly in sheep herding. It is, however, becoming increasingly clear to the Government, and to the Bedouin leaders, that additional employment will have to be created in agriculture, industry and tourism—otherwise social instability can be expected in the region.

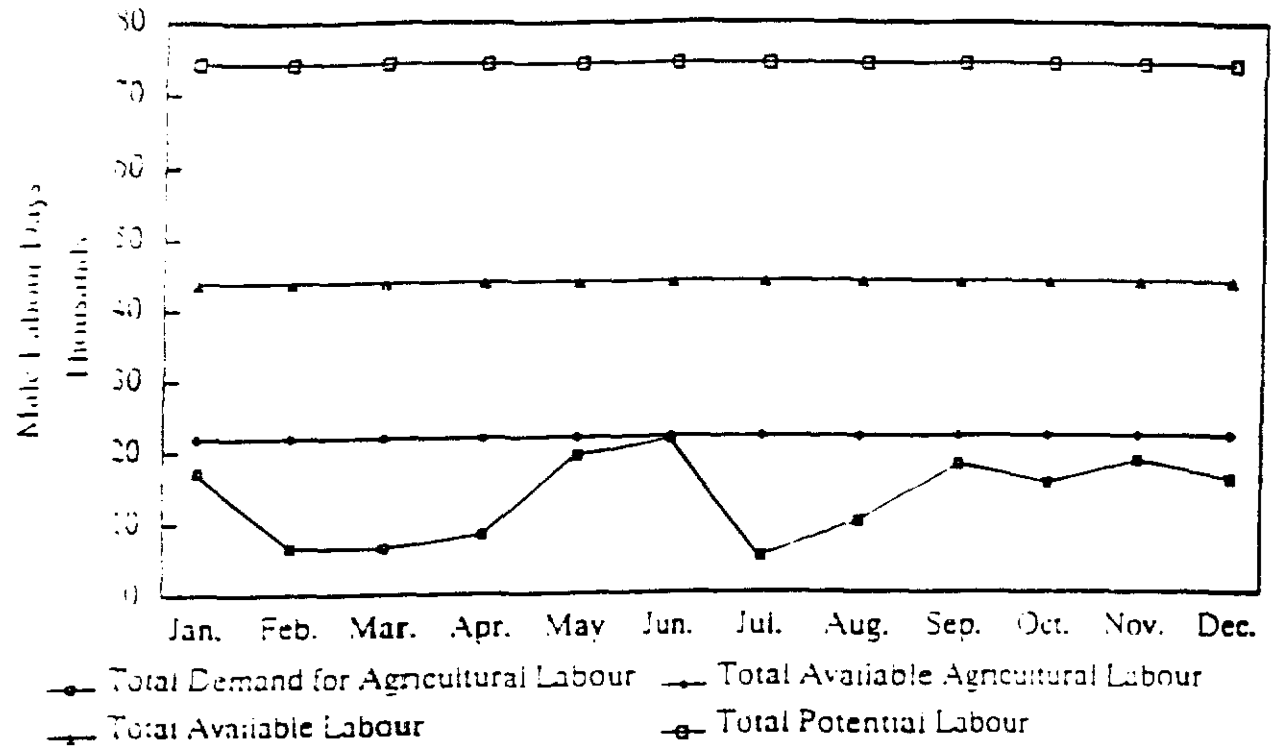


Fig. 18. Supply and demand for male agricultural labor in Matrouh governorate (1990).

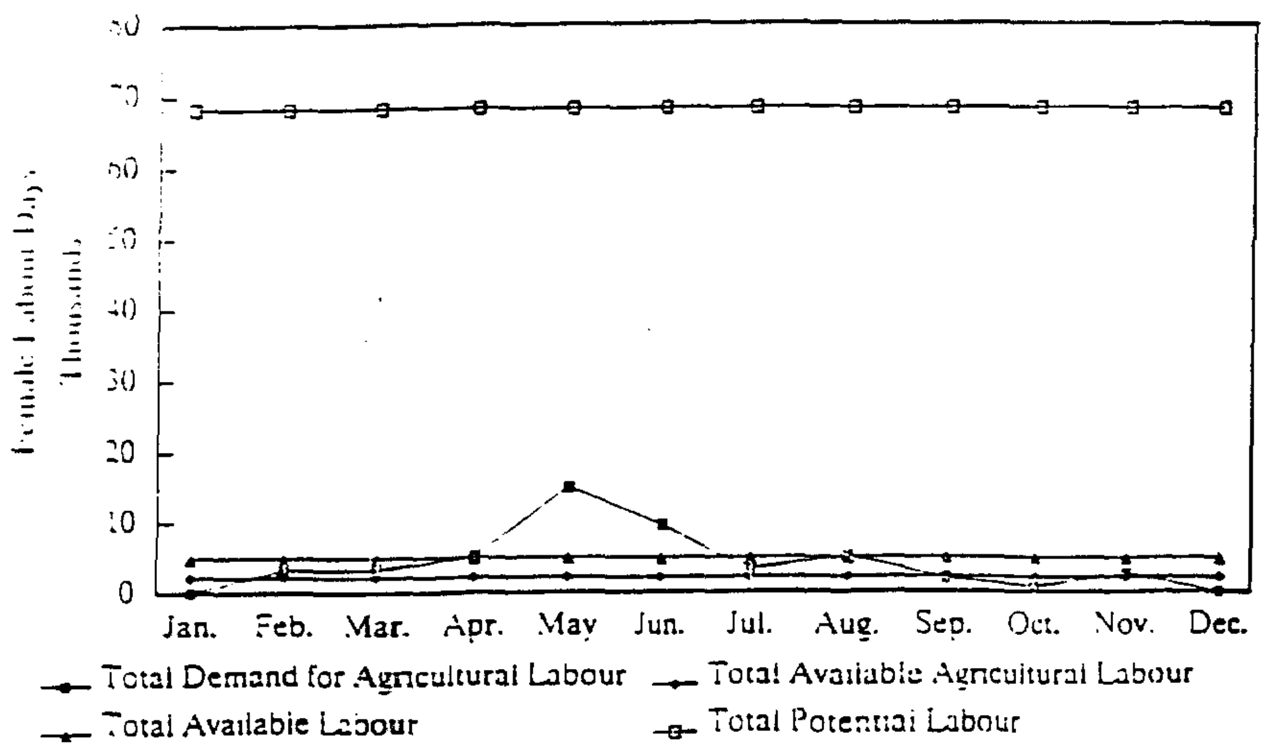


Fig. 19. Supply and demand for female agricultural labor in Matrouh governorate (1990).

Bedouins prefer the introduction of agriculture irrigated by Nile water as a first step towards modernization of their economy. Nile water would increase the value of the land which they consider to be theirs. They are keenly interested in growing irrigated crops, and they feel that this type of work will suit them.

Bringing Nile water to the entire Northwest Coast will have an important psychological effect on the Bedouins since they will be allowed to share the main resource of the country: the water of the Nile.

The Bedouins have some fear about the possible immigration of a large number of people from the Nile Valley. They know that the Government can take the land which they own according to tribal law and can sell it to immigrants. They are also aware that they are the weaker party in the competition for the newly created jobs, because immigrants are more properly trained and have more experience. But they are generally willing to accept the immigrants, even as farmers, as long as they themselves can benefit from the developments at least as much as the immigrants. The issue of land ownership is crucial in this respect.

About 30% of the Bedouins still live in tents, up to a distance of 50 km inland, as, for example, in the sector of Sidi Barrani. They would like to benefit from public utilities and public services. But on the other hand, they are very much tied to their land and their wells and cisterns, which are scattered throughout the area. The more public utilities such as water and electricity and public services become available in the coastal strip, the greater the number who will move to the coast and to centers where such facilities are provided. The increasing ownership of cars and small trucks will enable them to continue exploitation of the rangelands and barley lands in the interior.

The agricultural cooperatives should be an important instrument for the Bedouins to help them to develop more productive forms of agriculture and sheep breeding and more adequate services. Unfortunately, it is not so. Bedouins have become members mainly because it is a condition for receiving subsidized sheep feed. Initiative in the local cooperatives does not develop because the central cooperative in Marsa Matrouh is following a strong policy of centralization. Local cooperatives are mainly distribution and collection points for this cooperative. The central cooperative acts as an organization for the supply of sheep feed and for the marketing of a few products such as barley, sheep and wool. If the cooperatives are to function as instruments for self-help for the Bedouins, an entirely different policy of approaching the members should be adopted.

Immigrants

Immigrants constitute only a small part of the population of the region (about 13%). They are largely concentrated in the towns of Marsa Matrouh, El Salloum, and Burg El Arab. They work mainly for the Government and for the building and gypsum industries. Of those working in the building industry, not more than 30% have brought their families with them, and none of those working in the gypsum industry have done so. Even among government workers, many have left their families behind in the Nile Valley because they consider living in the region to be too much of a hardship. Insufficient supply of water and electricity, lack of schools, poor quality of education, and lack of recreational facilities are most frequently mentioned as deterrent factors.

Social welfare services

The governorate administration has a Department of Social Affairs. Its task is to work for the establishment of a just society, in which all categories of the population are offered the opportunity to develop their individual capacities. Special attention is given to the disadvantaged, such as the disabled, the jobless, widows, orphans, and delinquents. Its main activities are:

- Awarding of pensions and subsidies.
- Assistance to private societies for social welfare.
- Pre-vocational training for boys and girls.
- Rehabilitation of the disabled.
- Child care, mainly through nursery schools.
- Family planning.
- Adult education.
- Women's clubs.
- Assistance to families to start a cottage industry or business: the "productive family."
- Assistance to the victims of war.
- Assistance to the families of those in the armed forces.

The work is done through "social units," which are desert areas covering about 10,000 persons. There are social units in the 10 major towns and villages, but only Sidi Barrani has a well-equipped social unit.

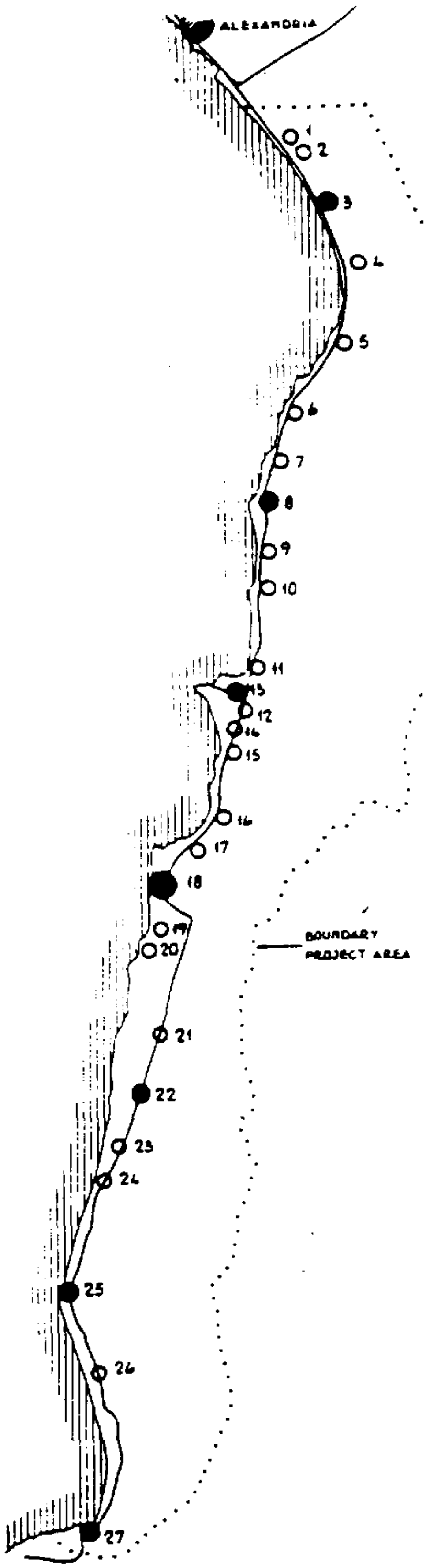
Most of the activities of the social units concern the immigrants. This is caused by a number of factors such as: the dispersed habitation of the Bedouins, the fact that they practice their own mutual help within the tribal organization, and their different values, as a result of which, for example, they are less interested in family planning. Only in Sidi Barrani is the social unit properly accommodated.

Service centers and town planning

Service centers. There are 26 settlements in the Northwest Coast. Most of these settlements provide services for the rural population living in the surrounding areas. Most of the service centers are spaced about 15 km apart in the east and of 20–25 km apart in the west. Marsa Matrouh is the largest center and the only town where a range of health, education and consumer services is available. The region leans heavily on Alexandria's facilities, while many durable goods are nowadays brought in directly from Libya. All the other centers in the region provide local services exclusively (commodity shops and markets, sheep markets, primary and preparatory schools, social and medical centers, private and cooperative stores, etc.). An inventory and classification of the service centers is presented in Fig. 20.

Approximately 70% of the regional population, excluding Marsa Matrouh, lives in scattered rural settlements. Most live in remote, inland desert areas. This group has very limited access to service centers, which are located exclusively in the coastal zone either on the railway line (in the east) or on the main highway (west of Marsa Matrouh).

Although the centers are fairly evenly distributed along an east–west axis, the services provided by each center vary considerably and are often not proportional to the size of the population to be served. In addition, centers which are equipped with facilities, such as a school or a medical center, are often so small and isolated that staffing is difficult and the performance of the staff very low.



1. Bahig
2. Burg El Arab
3. El Hammam
4. El Imayid
5. El Alamein
6. Sidi Abd El Rahman
7. Ghazal
8. El Dab'a
9. Sidi Shabib
10. Galal
11. Fuka
12. Hainera
13. Ras El Hekma
14. Atnuh
15. Sidi Heneish
16. Garawla
17. Samla
18. Marsa Matruh
19. El Qasr
20. Um El Rachem
21. El Methany
22. Neguila
23. Shamas
24. El Bisri
25. Sidi Barrani
26. Boglela
27. Salum

* = more than 30 shops
+ = 10 to 30 shops
o = less than 10 shops

Fig. 20. Distribution of service centers in the Northwest Coast.

Resource Management and Productivity

Land Use

Arable Land

More than 10% of the land in the Northwest Coast has been identified as suitable for cultivation. FAO/UNDP (1970) estimated the areas suitable for cultivation to be 390,700 fed (164,160 ha) including four classes as follows:

- Class 1: Suitable for all crops (203,875 fed or 85,626 ha)
- Class 2: Suitable for medium- to deep-rooted crops (36,850 fed or 15,477 ha)
- Class 3: Suitable for shallow-rooted crops (inland sand) (139,375 fed or 58,536 ha)
- Class 4: Suitable for shallow-rooted crops (coastal land) (10,600 fed or 4,451 ha)

An estimated 1,641,510 fed (689,420 ha) are considered rangeland, and 47,225 fed (19,842 ha) salt marshes. Several surveys have been conducted since 1970, including the Land Master Plan (1985). Semi-detailed surveys were conducted in certain regions, including El Neguila (Zone IV), El Qasr (Zone III) Baqqush (Zone III), and Fuka and El Dabaa (Zone II). by the Desert Research Center (1983). Burg El Arab and El Hammam (Zone I) received special attention regarding suitability of irrigation with Nile water. Most of these surveys (Ismail *et al.* 1990) combined Classes 1 and 2 into suitability Class II (14.67% of the area) and Classes 3 and 4 into suitability Class III (10.82% of the area).

The distribution of the estimated cultivable areas in the five physiographic zones of the Northwest Coast is presented in Table 17. The data show that the Eastern Province (Zones I and II) in the Northwest Coast includes 158,275 fed (66,502 ha), while the Western Province (Zones III, IV and V) includes about 230,000 fed (96,639 ha). Zones II and III have the largest areas of Class II, a type of land that has minor limitations that reduce the choice of crops and interfere with cultivation of a wide range of crops and fruit trees. Class III, characterized by restrictions on root depth and adverse elements of topography, is abundant in Zones IV and V. Zone III (Ras El Hekma to Ras Abu-Laho) has the largest area of cultivable lands (a combination of Classes II and III).

Table 17. Distribution of classes in the five zones of the Northwest Coast (fed).

	Class II	Class III	Total
Zone I	69,360	10,350	79,710
Zone II	60,815	17,750	78,565
Zone III	75,325	26,775	102,100
Zone IV	21,900	50,450	72,350
Zone V	11,000	46,975	57,975
Total	238,400	152,300	390,700

1 ha = 2.38 fed.

A land survey carried out by the Ministry of Public Works and Water Resources in 1989 for Matrouh governorate (Western Province) showed that there are about 246,000 fed (103,361 ha) suitable for agriculture in that region. A small fraction of the cultivable area, about 11,316 fed (4,755 ha) is irrigated from cisterns, wells and reservoirs.

From the agricultural point of view, the Northwest Coast can be classified into three environmental production systems from the coastal line inland:

Coastal strip. The first production strip extends from the seashore 5–10 km inland. Geographically, it occupies a small area which includes the beach and the coastal plain.

Along the southern boundary of the coastal plain there are ridges running parallel to the sea. There is a ridge in Ras El Hekma at a distance of 200 m from the sea, and one south of the town of Marsa Matrouh 3 km from the sea. West of Marsa Matrouh, the coastal plain is narrow, intermittent, or absent. Between Sidi Barrani and El Salloum, there is a flat coastal strip 2–4 km wide, behind a ridge of dunes about 10 km east of El Salloum. Trees and vegetables are cultivated with *wadi* runoff water as well as with water from *sanias*, galleries, and some cisterns.

Mixed production strip. The second production strip is located between 10 and 20 km inland. Rainfall is the main source of water, with frequent use of runoff water. There are a few non-artesian wells but the farmers consider them as only a secondary water source. The area comprises ridges, *wadis*, and depressions and is located just behind the ridges of the coastal system. Generally, the topography is uniform with a gradual slope from south to north. Some 218 *wadis* run from south to north in a hydrographic network of distinct organization with narrow, elongated plains and closed depressions. There are lands suitable for surface runoff utilization to improve barley cultivation and tree production. Flocks of sheep and goats are raised in this strip.

Rangeland strip. The third production strip is situated between 20 to 50 km inland. This land system extends southward to the bluffs of the Libyan Plateau and constitutes a major portion of the land area. Within this strip there are two sub-areas: the northern sub-area, which is used for the grazing of sheep and goats with some limited barley cropping, and the interior sub-area which provides communal grazing of the natural vegetative cover of shrubs, sub-shrubs, spiny bushes, and low-quality grasses. The area has a gentle to gradual slope from south to north. Rainfall varies from 50 to 100 mm, and is the main water supply. There are few wells in the area, which are used mainly for watering animals. Soil type influences the distribution and growth of natural plant communities. Access to grazing is governed by grazing rights according to tribal membership.

The agricultural potential of the different soil types in the Northwest Coast is presented in Table 18.

Table 18. Agricultural potential of soil types in the Northwest Coast.

Soil type	Location	Agricultural potential
A. Wind-blown soils		
Coastal dunes		
Shifting oolitic sand dunes	Small scattered areas along the coast consisting of loose, oolitic sand grains.	Fig.
Cemented oolitic sand dunes	forming the majority of the coastal dunes consisting of cemented grains.	Not suitable.
Cemented oolitic ridges	1 to 2 m high of cemented parallel to the coast ridges.	Not suitable, but if they are in depressions, they are suitable for vegetables and moderately deep-rooted crops.
Inland dunes		
Quartz sand dunes	Found in areas south of Sidi Barrani.	Not suitable.
This quartz sand sheets	Found south of Sidi Barrani.	Rangelands.
Thick quartz sand sheets	South of Sidi Barrani.	Dense natural vegetation for grazing.
High and moderate quartz sand dunes	Sidi Barrani.	Dense natural vegetation for grazing.
B. Former beach plain soils:		
Deep sandy loam to loam or clay loam	Large areas in Marsa Matrouh and Sidi Barrani.	Exclusively used for barley cultivation. Suitable for all crops and the most promising soils in the area.
Deep loamy sand to slightly loamy sand	A few areas in Marsa Matrouh and Sidi Barrani.	Suitable for all crops except deep-rooted crops like olive trees.
Limited and moderately deep sandy loam to loam soils over caliche or rock.	Scattered areas in Marsa Matrouh and Sidi Barrani.	Suitable for shallow and moderately rooted crops, depending on soil depth.
Poorly drained and very saline soils	Located south of the coastal dunes.	Not suitable.
C. Soils of the elongated depressions:		
Deep loam to clay loam soils overlain by sand	South east of Marsa Matrouh	Cultivated with barley, they are suitable for all crops.
Deep loam to clay loam soils overlain by sand poorly drained and very saline	South to the coastal ridge.	Not suitable.
D. Soils of the alluvial fans and outwash plains		
Moderately deep sandy loam to loam over caliche or rock.	Scattered areas southeast of Marsa Matrouh.	Suitable for vegetables, field crops and moderately deep-rooted corps.
Deep sandy loam to loam or clay loam soils.	Scattered south of Marsa Matrouh to El Mathany, El Qasr, El Sunniyate	Exclusively used for barley but suitable for all crops.
E. Soils of the wadis		
Wadi bottoms with deep sandy loam to loam soils.	Marsa Matrouh plain	Suitable for all crops.

Water Resource Use and Management

Water resources, including rainfall in the Northwest Coast, consist of surface water and groundwater. In addition, there are five stations for desalination of seawater for domestic purposes and animal use. Recently, some of the stations have been supplied with brackish water from galleries to increase desalination efficiency. A pipeline supplies Matrouh City, settlements, and tourist installations along the Alexandria–Matrouh road with Nile water (only domestic purposes and tourist development).

Use of Surface Water Resources

Water for agriculture from Burg El Arab to El Salloum comes from two sources: surface runoff and runoff from *wadis* (El Shafei 1984). Both depend on rainfall.

Natural winter watering

Natural winter watering takes place in:

- Depressions, where the topographical situation favors the accumulated water from the *wadis* or the surface runoff from higher areas.
- Water-spreading zones, where the runoff from *wadis* spreads freely downhill and accumulates at natural obstacles (sand dunes or rocky hills).

This natural watering is irregular, depending mainly on topography. The low flat areas upstream from natural obstacles invariably receive more water than can be retained by the soil which is lost to infiltration and evaporation.

Artificial winter watering

Artificial winter watering is promoted through the construction of various types of dikes (Figs 21, 22, and 23):

- Dikes built to prevent the loss of *wadi* runoff water to the sea.
- Dikes built in spreading zones or to divert *wadis*. In some cases, spreading is facilitated by opening channels through which the runoff reaches isolated fields.
- Transverse stone or earth dikes built in the beds of the small *wadis* to facilitate sedimentation and create terraces for better management of runoff water.
- Small dikes built parallel to the contour lines to retain the surface runoff.

Techniques for artificial winter watering

There are several methods of winter watering, which depend on the ratio of the spreading area to the amount of runoff water available and to local soil and topography.

Flooding

This method is suggested for gently sloping areas that are free from ridges or depressions, and when the runoff water of the *wadi* is considered important. The water is directed by canals to the beneficiary area, which is divided into small basins by dikes to submerge the basins, one after another, through pipes or spillways.

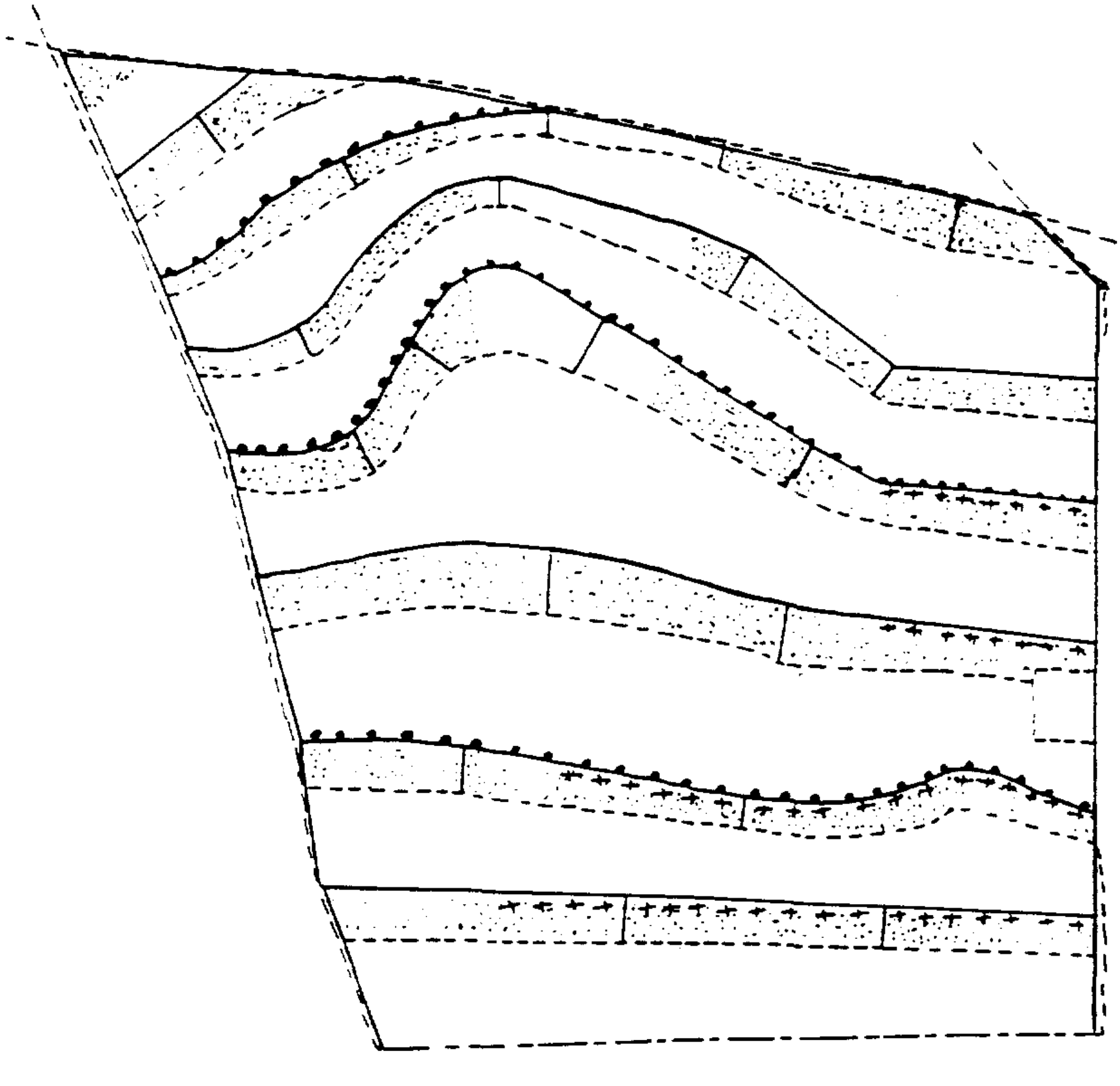


Fig. 21. An earthen dike (El Shafei 1984).

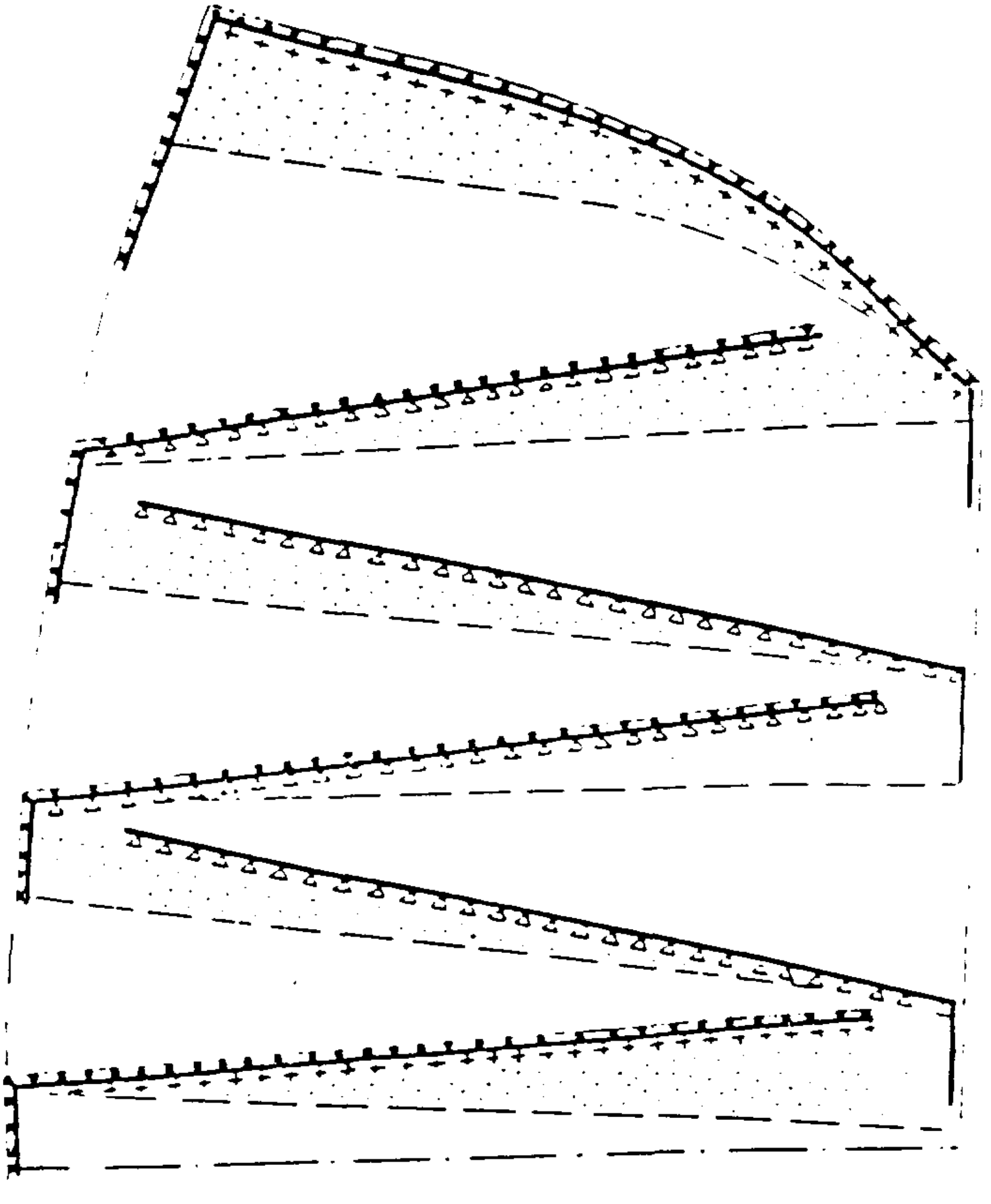


Fig. 22. Stone dike (El Shafei 1984).

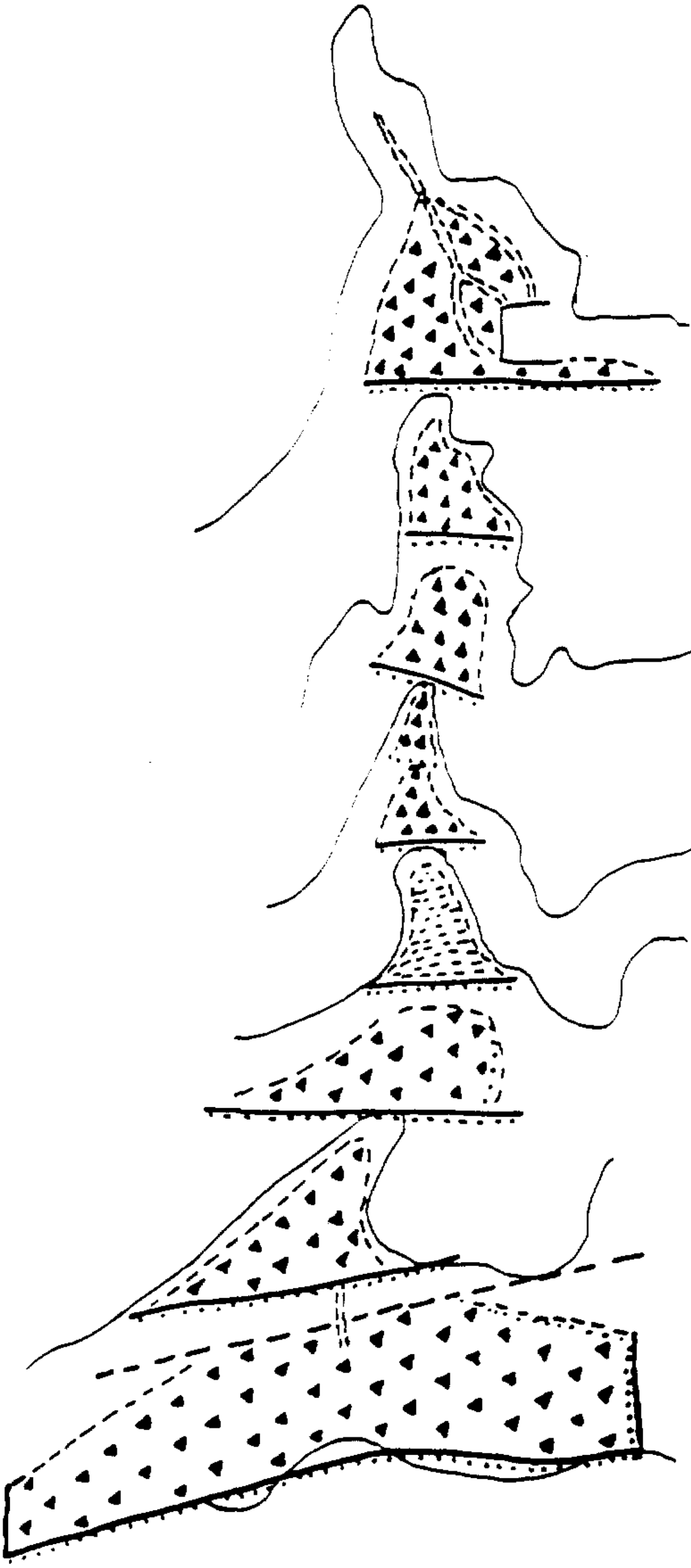


Fig. 23. Cemented dike for tree plantation in *wadis*.

Spreading

This method is suitable for steeper slopes and when runoff water is not sufficient to submerge the whole beneficiary area. Spreading is based on the construction of two series of dikes, which are set at a small angle to the contour.

After flowing down and across the slope in shallow streams along the length of a dike of one series, the water flows around the end of the dike and is picked up by the second series of dikes, which conducts it further down and across the slope in the opposite direction. In this way the runoff water accumulates in narrow strips upstream from the dikes, which can be planted with trees or vegetables. The angle at which the dike meets the contour is such that the velocity of the water, even at maximum discharge, is kept low to avoid erosion.

FAO/UNDP (1970) reported on six separate projects in El Neguila, covering an area of 1,494 fed (627 ha). The net beneficiary area is about 200 fed (84 ha) of first strips, which receive an average of 990 m^3/fed, and about 390 fed (163 ha) of second strips, which receive 350 m^3/fed.

In Fuka, there are five spreading projects covering an area of 875 fed (367 ha), with a net area of 345 fed (144 ha). Some 119 fed (50 ha) of first strips receive an average of 574 m^3/fed.

Terracing

This method is suggested for *wadis* with even bank slopes and where there is no land suitable for cultivation downstream. Terracing is done by constructing a series of level earth dikes across the channel of the *wadi*. After filling one terrace, the runoff water flows to the next through side passes. The side passes are designed such that all excess water passes through them to avoid the overflow of the dikes. At side passes, the edges of the dikes should be protected against erosion by pitching.

Terracing is also created by constructing stone dikes without mortar. Water passes through the openings in the stone, leaving the silt upstream. FAO/UNDP (1970) suggests nine possible projects for terracing in El Neguila, covering an area of about 375 fed (157 ha). Four terracing projects have also been suggested in Fuka, covering an area of about 110 fed (46 ha).

Use of sheet runoff

Surface runoff water flows over the land in amounts that depend on factors such as rainfall intensity, seasonal occurrence of precipitation, vegetative cover, land slope and soil type. A rough estimate of the annual sheet runoff coefficient (relation between annual rainfall and annual runoff) for short courses of water flow runoff (50–100 meters) varies from 0.15 to 0.35 depending mainly on the slope of the land. For longer courses of water flow, the sheet runoff coefficient is lower: 0.05–0.10. Sheet runoff is the main source of surface water in the area between Fuka and Burg El Arab (Zone II).

Sheet runoff can be utilized either through the construction of water conservation works for immediate use or through storage. A potential area of about 135,000 fed (56,722 ha) in the Northwest Coast (El Shafei 1984) could benefit.

Sheet runoff is used as follows:

Storage in cisterns. Sheet runoff is currently used to fill existing cisterns. A large number of cisterns, dating back to the Roman period, exist in the Northwest Coast. These cisterns have been excavated in the rock and their capacity varies from 100 to 3,000 m^3 with capacity increasing to the south. There are also many new cisterns, excavated in the last 20 years by the Ministry of Development, New Communities, Housing and Public Utilities (MDNCHPU) with the help of the WFP. In addition, a few concrete reservoirs have been constructed in locations not suitable for cistern excavation. The stored water is used for human and animal consumption and for establishing tree plantations. Some small dikes or ditches are sometimes necessary to lead the sheet runoff into the cisterns or reservoirs. It is estimated that one cistern or concrete reservoir with an average capacity of 300 m^3 requires a catchment area of about 4–5 fed (1.7–2.1 ha).

Cisterns have been excavated in the rock since ancient times, as well as dikes or channels constructed to direct or facilitate the accumulation of runoff water to the cisterns. The majority of the cisterns are equipped with a silt trap. Most of these cisterns were, however, silted up. In 1950 the Government began to clean and repair some of the smaller cisterns at a rate of 10–15 a year. After 1960, this number increased. In the last decade more attention was given to cleaning and repairing the cisterns, as well as to excavating new ones.

New cisterns are excavated in the rock just as the ancient ones were. The WFP has participated in constructing cisterns to be used in the irrigation of fruit trees. It is assumed that each cistern will irrigate 5 fed (2.1 ha) after 5 years. That means cultivating 1 fed (0.42 ha) in the first year, with 1 fed added in each subsequent year. Usually these small farms are equipped with small stone collecting dikes to slow down the sheet runoff and allow more water for irrigation. Before 1979, only 13 of these cisterns had been constructed in El Salloum and Sidi Barrani. Since then, more attention has been given to cistern construction (Table 19) (GTZ 1992).

Table 19. Cistern construction between 1979 and 1984.

Year	Number	Volume (m^3)
1979	99	29,450
1980/81	481	82,503
1981/82	600	87,695
1982/83	706	100,160
1983/84	336	57,000
Total	2,221	35,608

Direct utilization of sheet runoff. Water conservation structures for the direct utilization of sheet runoff have been constructed in the Western Province (Zones III, IV, and V) by farmers with the assistance of the WFP on an estimated area of 33,000 fed (13,865 ha). The main aim of such works is to divert sheet runoff from other areas into the band between two dikes, and to reduce the velocity of water running on the surface. This can be achieved through the construction of small dikes, earthen or stone, parallel to the contour lines, spaced at 50–100 m, depending on the slope. By reducing the velocity of surface flow, the water is forced to percolate into deeper soil layers. Therefore more water is made available for crops and soil erosion is prevented. In areas with marginal rainfall, or in dry years, the cultivation of winter crops can be restricted on narrow strips of land, upstream from each dike, where sheet runoff accumulates. The ratio between cultivated and non-cultivated areas can be 1:3 or lower.

Use of Groundwater Resources

Hydrologic data from the Northwest Coast shows that out of 910.63 mcm/yr rainfall, about 248.36 mcm/yr infiltrates into the ground, and 124.18 mcm/year percolates into the main water table. Only 50% may be exploited safely for irrigation and domestic purposes, i.e. about 64 mcm/year (El Shafei 1984).

Drilled wells

At present, there are six drilled wells tapping the limestone aquifer at Fuka. These wells could be equipped with turbine pumps. In September 1984, only one of the wells was in operation. Each well could safely produce 25 m^3/hr. It is estimated that the total annual withdrawal from these wells is about 48,000 m^3.

There were six drilled wells in Hatawa near Marsa Matrouh, drilled during World War II. These wells were once used to supply Matrouh with municipal water, but have not been used since 1964.

Dug wells and windmills

If the water table is greater than 54 m from the surface, windmills are the most suitable means of lifting water from wells in the Northwest Coast.

The wind blows at a fairly constant speed of 15–20 km/hr. According to existing meteorological data, the average daily operation of a windmill could be 12–14 hours.

Between 1959 and 1965, the General Desert Development Authority (GDDA) installed 1,010 windmills on dug wells in the area from El Salloum to Burg El Arab. However, many of these have been removed or are out of order due to lack of maintenance. The discharge of the windmills depends on the diameter of the dug well, the depth of the water, and wind speed. According to an FAO survey in 1970, a windmill may discharge up to 0.8 m^3/hr.

Recently, local farmers started to use small fuel-driven pumps to obtain water from the dug wells where the water table is less than 5 m from the soil surface. At present it is estimated that only 300 windmills are in operation, the majority of them in El Dabaa. In the last decade, more attention has been paid to dug wells with an inner diameter of 1 m, lined with limestone to a depth of 7 m. Water depth is 0.5–1.0 m. Water is lifted by buckets, *shadoufs*, small pumps, or windmills. Following is a summary of wells dug in the last few years.

Year	Number
1978	90
1979	137
1980/81	133
1981/82	36
1982/83	142
1983/84	120
Total	868

A rough estimate of groundwater developed from dug wells annually is about 275,000 m^3.

Collection galleries

The most extensive galleries are at El Qasr, where 16.5 km have been developed among the coastal sand dunes. The total annual withdrawal of water from collecting galleries in El Qasr is estimated at 360,000–400,000 m^3.

The gallery system was developed during World War II in the Baqqush-Burbeita area, and is reported to have produced 290 m^3/day. Unfortunately, this system was abandoned and has silted up. A less successful gallery was constructed at Buqbug during World War II and eventually destroyed.

Existing Water-Harvesting Activities

Since 1959, various efforts have been made to make use of the *wadis* and surface runoff water. Dikes have been constructed to prevent the *wadi* runoff water from reaching the sea and to facilitate the natural winter watering in the spreading zones and rangelands. GDDA constructed about 44,000 m of multi-purpose dikes, with a volume of about 300,000 m^3. Some small winter watering constructions have also been built by farmers.

Since 1975, considerable work has been executed in the field of water harvesting, a summary of which is presented in Table 20.

The total annual withdrawal of water from collecting galleries in El Qasr in 1970 was estimated to be 250,000–360,000 m^3 (0.56–0.1 m^3 per meter run per day). Based on the results of pumping tests on wells in El Qasr, preliminary estimates have been made on the probable perennial yield of galleries tapping coastal dunes. A properly constructed gallery located perpendicular to the slope of the water table could yield 5–10 m^3/day per m^2 of saturated material penetrated on the landward side of the gallery. Thus, if after the pumping level has reached equilibrium, and the depth of water in the gallery is 0.5 meter, the gallery would yield a steady 2.5–5 m^3/day/m of gallery length.

Summary of Water-Use Activities (1975–1985)

Much good work has been done in the Northwest Coast during this period. These activities are summarized bellow (dikes and small dams built are summarized in Table 20):

Cisterns cleaned:	Number	4,056
	Volume	1,058,988 m^3
	Cost	LE 4,786,080
Cisterns constructed:	Number	2,221
	Volume	356,808 m^3
	Cost	LE 3,482,528
Wells dug:	Number	868
Collecting galleries:	Length	16,535 m
	Cost	LE 595,260

Table 20. Main small dams and dikes constructed in the Northwest Coast (since 1975).

W.No.	Region	Name	Catch. km²	Dich Q 1000m³	Estimated Volume m³				Area served F	Remarks
					Earth	Pitching R	Pitching	Filter		
3	Sallum	Agrab	-	-	-	-	-	-	-	Understudy
94	S. Barrani	Zawaya	6.72	13.44	1500	-	-	-	50	R
97, 98 100	S. Barrani	Maktla	39.12	78 24	30000	-	-	-	150	3 R Dykes
101, 102 .... 103/ 104	S. Barrani	Zewaida	38.10	76 20	40000	-	-	-	200	4 R Dykes Prevent flow to sea
122	S. Barrani	Tarfaya	6.25	12 50	20000	750	500	350	150	R
127	S. Barrani	Diba	28.54	57 08	10000	-	-	-	150	R
132	Negella	Delaab	15 8	31 60	20000	1200	-	450	150	R
135	Negella	Ghuzeel	10 9	21 80	20000	750	500	350	150	R
144, 145 146	Negella	Range D.	73 49	146 93	20000	700	380	300	100	R D Collecting W of 3 wadis
153	Negella	Hetiya	15.04	30 08	40000	1500	950	600	100	R D Collecting w from several wadis
			1268 31	511 875	215000	4900	2330	2050	1200	

Table 20. (Cont'd)

W No	Region	Name	Catch Area km²	Dich Q 1000 m³	Estimated Volume m³				Area served F	Remarks
					Earth	Pitching R	Pitching	Filter		
176A	Qasr	Ashtan	88 93	204 54	Repaired 1982		-	-	-	-
181	Qasr	Ramla	124 35	268 00	Repaired 1979		-	-	-	-
187	Matruh	Nagamish	116 66	208 8	25000	-	-	-	50	Div. dyke
188	Matruh	Kalalib, Br of Yadam	77 80	140 04	40000	1000	600	400	200	D The water to suitable land
193	Matruh	Alam	33 29	59 29	15000	-	-	-	50	3 R. dykes
105	Baqqush	Sakher	16 07	20 89	30000	2000	1000	-	150	3 R. dykes + canal + 3 terrace dykes
-	Baqqush	Nadora	-	-	4000	-	-	-	-	R.
207	Baqqush	Smeit	42 4	55 12	7000	-	-	-	-	R. dyke di. the water to the sand dunes
217	Fuka	Fuka	148 67	133 80	40000 40000	-	-	-	50 100	4 dykes, pr. flow to the sea
-	Dabaa	Samra	Divert water to suitable land through canal, irrigation by spreading dykes							-
			1139 39	2066 805	541500	15800	6330	3560	2800	

Management and Productivity of Farming System Components

Barley Production

The coastal plain is in the center of the agricultural activities of the coastal region. It has been cultivated, mostly with barley, since Roman times and for this reason it is locally known as the "barley plain." Barley is well adapted for this region, because of its drought tolerance, short growing season, and low water requirement when compared with wheat. Barley is an ideal crop for integrated farming systems based on crop/livestock production. It is used either for grazing as a green fodder or harvested at maturity as grain and straw. The stubble in the field is also grazed.

Agronomic practices

In the late autumn and winter, the fields are prepared for cultivation, which is normally done in a single pass following the broadcasting of seed and the first substantial rain. Only a few farmers (mainly those who own a tractor) also plow before the rain, although early plowing would permit improved rainfall penetration and would improve crop establishment. Tractors are mainly owned by larger and more affluent farmers or hired out by the cooperatives. Larger farmers obviously plow their own land before they hire out to other farmers. As a result, small farmers may not be able to plow their land at the optimum time (after rainfall).

Most of the cereal area is now cultivated by tractor, with only some of the poorest farmers continuing to use draft animals (donkeys and camels). Table 21 presents the distribution, power and numbers of tractors in 1981 and 1991 in the Northwest Coast. Two distinct trends are clear: first the sharp increase (several fold) in the number of tractors in all the zones, with Zone I showing the largest increase because of the introduction of irrigated lands, and second, the shift towards tractors of higher horsepower. The benefits of the latter must be measured against the possible adverse effects on desert soils. due to tillage operations. Cereal area sown varies markedly between good and bad rain years, but averages 90,000 fed (37,815 ha) and reaches as high as 130,000 fed (54,621 ha) in very good years (FAO/UNDP 1970). These areas represent 50 and 70% of the total Northwest Coast area in bad and good rain years, respectively.

Table 21. Distribution of tractors (units) in the five zones of the Northwest Coast in 1981 and 1991.

Zone	Tractors < 25 hp		Tractors > 25 hp	
	1981	1991	1981	1991
I: Bug El Arab	40	12	347	1049
El Hammam	9	5	237	5115
II: El Dabaa	381	4	294	1652
III: Marsa Matrouh	28	41	1216	3140
IV: Sidi Barrani	-	1	7	783
V : El Salloum	-	-	-	347
Total	458	63	2211	12,086
(% increase)		(–13.8%)		(+547%)

Varieties of barley grown include local types as well as the improved variety, Giza 123, and the newly developed varieties Giza 125 and Giza 126 on a small scale.

A portion of the harvested grain is generally retained for planting the following season. Following a total crop failure, seed may be purchased from larger farmers or from outside the area. The seed rate is estimated at about 30 kg per fed and is kept deliberately low to achieve a relatively low plant population and permit the growth of weed species valued as animal feed. In good rainy years, barley tillering compensates for the lower seed rate. In poor rain years, when a barley grain crop cannot be harvested, the annual weed growth within the crop provides an important forage for small ruminants to supplement their feeding on whatever standing barley has survived. The annuals are mainly drought-tolerant, early-maturing legumes (e.g. species of *Trifolium*, *Medicago*, *Hippocrepis*, and *Astragalus*), which not only provide an additional source of protein for animals but also have a beneficial effect on fertility maintenance in shallow soils. Thus, although the area cultivated to barley has expanded at the expense of the rangeland, reductions in forage availability may at least be partially compensated for by the deliberate encouragement of weed growth, even in poor rain years.

Barley yields are low and highly variable. Grain may be harvested only in a good rainy year—on average three or four years in 10—or from the less marginal lands which have better soils and greater water accumulation. However, the increased use of earth and stone dikes in cereal land has to some extent reduced the risk of total crop loss on less marginal land. An estimated 33,000 fed (13,865 ha) of cereal land (of which about 65% is planted to barley) is now served by some form of water harvesting structure, although the structures may consist of simple low earth mounds, built by small farmers to restrict runoff loss.

Farmers prefer 6-row varieties over 2-row types, not only for their high productivity but also because of the traditional and religious belief that 2-row barley goes to the malting and brewery industry. The tillering capacity of the 6-row types is lower than that of the 2-row, but the number of the grains per ear is much greater, especially the main tillers. Grain yield is equal for both types at high temperatures. The 6-row types, due to their rapid growth, are more adapted to a shorter season and are more widely adapted to different environments.

Drilling the seed to a depth of 10 cm when soil moisture is high increases barley yields as much as 37.5% because the seed is protected from surface evaporation. This also has a stabilizing effect on the soil because of the wind boundary layer and reduced windblast on seedlings.

Sowing of barley may be at three different times: before rain, a few days after rain, or into a wet sticky soil. In the first case, sowing is done by hand and seeds are sown more densely, possibly because many are lost to harvester ants. A study of harvester ants (*Messor* spp.) has shown that they may occur at a density as high as 40/m^2 in barley fields. Plowing is used in the other two cases. Although it is not preferred, it is becoming unavoidable due to the availability of tractors and the pattern of rainfall.

Although the soils of the Northwest Coast are generally low in nutrients, the uncertainties of water availability preclude the use of fertilizers on field crops. However, at the low yield levels currently being achieved, the manuring that results from the traditional practice of grazing animals on barley aftermath, together with the beneficial effects of legume weed growth, would appear to be sufficient to permit long-term cultivation of barley on the same land. The importance of nitrogen has been studied by various researchers, and an application of 35 kg N + 35 kg P_2O_5/ha is recommended when there is enough rainfall to ensure a reliable increase in grain and straw yields with less risk of failure due to drought. Barley straw yield was increased by 56% by using superphosphate at a rate of 100 kg/ha. Reduced availability of magnesium or zinc is associated with soils high in calcium.

The distribution of soils and micro-topographic variations limits cereal cultivation to specific parcels of land and precludes the establishment of formal fallow and cropping cycles on alternating areas as a means of fertility maintenance. However, fallows are effectively created by default in poor rain years, when a barley grain crop cannot be harvested, thus minimizing the adverse effects of continuous cultivation.

Harvesting is carried out by hand by both men and women. The crop is uprooted, then spread (either in the field or close to the home) for threshing by animal-drawn sleds or direct trampling by animals (donkeys or camels). Winnowing is done by hand. Larger farmers may hire labor during the harvest period, while smaller farmers must rely on their own family for post-harvest handling of the cereal crop, and may often have to supplement a limited income by hiring out themselves or family members to others.

After threshing, barley straw is neatly stacked for later use as livestock fodder. In view of the aridity of the region, insect pest attack in stored products is minimal and grain may be successfully stored for extended periods provided rodent and bird damage can be prevented.

Research findings

Due to high-potential barley cultivars and the use of research recommendation packages which include seeding rates, land preparation, fertilizer application, etc., increases in grain and biological yield of three new barley cultivars—Giza 123, Giza 125 and Giza 126—have been reported (NVRP 1993). In a comparative study on barley and wheat productivity under rainfed conditions in the Northwest Coast it was found that barley varieties outyielded wheat varieties under severe drought stress. In general, the biomass of the barley crop was much higher than wheat, which may explain why Bedouins prefer barley straw in these areas for sheep feeding or as green forage for grazing.

Improving the water-use efficiency (WUE) has been the focus during the past three years in the Northwest Coast. A study on the effect of cultural practices on grain yield and water use efficiency of barley under rainfed conditions concluded that grain yield, harvest index, and water use efficiency of barley crop were significantly affected by sowing date in the Northwest Coast region. The earlier the sowing of barley the higher these values were. Sowing depth did not show a clear trend. To improve WUE of barley under rainfed conditions, it was recommended to use 20 cm row spacing, 50 kg seeds/ha, and sowing on an early date (not too early) as there is enough moisture for seed germination to avoid soil moisture stress during seedling.

The response of barley to N and P under rainfed conditions in the Northwest Coast was studied by Noaman *et al.* (1990). Increasing fertilization resulted in a reliable increase in straw and grain yields. Fertilization with N and P proved to be important, especially in good rainy seasons when nutrients can be utilized by the plants. On the other hand, fertilization is not a limiting factor in rainfed areas unless there is enough moisture for soil nutrient availability for plant uptake.

Insect, pests, diseases, and weeds

Pest hazards in the area were studied by the Nile Valley Regional Program (NVRP) Phase I (1993). Findings are summarized below.

Entomology

Survey studies in the Northwest Coast found that the corn leaf aphid *Rhopalosiphum maidis* was the dominant species which infests barley. Out of 288 barley genotypes tested under constant conditions of temperature, relative humidity, and light in the laboratory, 20 genotypes exhibited resistance.

Pathology

Barley disease surveys in the Northwest Coast and North Sinai found that pathogenicity and severity depend upon precipitation, humidity, and temperature. Powdery mildew, net blotch, stripe disease and covered smut were the major diseases in most of the years studied, whereas scald disease was recorded only during 1991/92, with high severity. A high incidence of root rot was found.

Recently, Barley Yellow Dwarf Virus (BYDV) has been observed in wheat and barley fields. BYDV can be vectored by several species of aphids. It is generally present throughout the dry areas, but varies from year to year depending on conditions for aphid multiplication. The disease is diagnosed by yellowing, stunted plants. Also, new diseases such as scald, septoria blotch, and common root rot were recorded in the Northwest Coast.

Boron toxicity was observed in barley fields in the Northwest Coast in the 1991/92 and 1992/93 seasons. Samples were analyzed and found to have a high concentration of boron. The symptoms first appear as chlorosis or greenish-blue spots. Later, grayish mottles, brown blotches, spots, or necrosis may develop at the leaf edges, and spread down to the leaf base.

Weeds

Weeds constitute about 62.6% of the total production in irrigated fields and about 54.3% in rainfed fields. In irrigated fields, 20% of the phosphorus and 29% of the nitrogen are returned to the field. In rainfed fields, 9% of the phosphorus and 96% of the nitrogen are returned to soil. The remainder is either harvested with the straw or retained in the storage organs of perennial weeds. Weeds should therefore be used as forage along with the immature barley in rainfed fields in years with below-average rainfall.

Nutrient translocation and cycling under rainfed and irrigated arid ecosystems was studied by Ayyad *et al.* (1978), and the conclusions reached are outlined below.

- The application of nitrogen to irrigated barley fields adds about 8.96 g/m^2 of N to the soil, of which about 3.24 g/m^2 is utilized in the biomass of weeds. Consequently, the N-use efficiency of barley, excluding consumption by weeds, may reach 66% (48% in grains). This is a relatively high rate of recovery compared to wheat (35%) and of many other crops. This N-neutralization efficiency of barley has been reported by many others. Thus, barley may be considered as having a reliable response to nitrogen application in terms of economic yield.

- The addition of phosphorus fertilizer to barley under irrigation is essential to improve P availability as well as N, and to regulate the balance between these two elements in plant tissues. This in turn leads to the increase in yield.
- A small fraction of the total uptake of macronutrients is retained in the roots, while most is transported through the transpiration stream to the above-ground parts. Nevertheless, some nutrients are in short supply and further translocation from roots occurs. This is more obvious in rainfed barley, probably due to the higher root-to-shoot ratio.
- The percentage of the total uptake of most nutrients directly allotted to reproductive organs is much higher in irrigated than in rainfed barley. Further addition of nutrients to reproductive organs is supplied by translocation from living shoots and dying organs. A larger proportion of this supply in irrigated barley is translocated from the dying organs than from activating organs. Conversely, a larger supply is translocated to the reproductive organs of rainfed barley from active vegetative organs than from dying organs. This may explain the earlier death of active vegetative parts of rainfed barley.
- More than one third of the uptake of all nutrients (except Na) by irrigated barley is allotted to grain at maturity. This ratio is much higher than in rainfed barley (except for P). Consequently, a larger part of the nutrient taken up by barley grown under rainfed conditions is accumulated in the straw than in the grain. Therefore, in years of below-average rainfall, it would be beneficial to use the crop as forage before anthesis, since even if it succeeds in yielding grain, these grains will be of low nutritive value. On the other hand, in years of above-average rainfall, a larger proportion of nutrients is directed to grain, and it would be advisable to fertilize prior to anthesis to improve yield.

Wheat Production

One of the most important goals in the wheat program is to increase wheat production to narrow the gap between production and local consumption. Chances to increase wheat production in the Old Lands in the Nile Valley are slim due to the limited areas assigned to wheat production. In newly reclaimed and rainfed areas chances are adequate. During the past four seasons, efforts have been done to establish rainfed wheat production in the Northwest Coast. Field management practices and drought-tolerant varieties are very important factors under rainfed conditions. To encourage the adoption of wheat cultivation, seed (cv. Giza 155) has been supplied at a 75% price subsidy, which is being gradually lifted. Wheat has now been incorporated into the production system, mainly at the expense of barley, to the extent that wheat currently (1990/91) represents about a third of the annual cereal acreage sown. The practices adopted by farmers to grow wheat in the Western Province of the Northwest Coast, and the timing of operations associated with wheat cultivation are the same as those outlined above for barley.

Wheat requirements in the Northwest Coast

The success of wheat production in the Northwest Coast is based on four principal factors discussed below.

Land

Soil. A soil depth greater than 25 cm is suitable for good wheat yield. Under dry farming conditions, wheat must be grown in a non-saline area. The following areas are ranked according to their appropriateness for wheat cultivation: Sidi Barrani, El Salloum, West Matrouh, and East Matrouh. Soil fertility must be taken into consideration and areas of poor nutrition must be avoided.

Topography. Because of the low rainfall compared to evapotranspiration in the Northwest Coast, the micro-relief of the area is very important, and rainfall must be most directly and indirectly used. Good wheat yield could be obtained by planting in depressions where rainfall collects and making use of an additional water supply from runoff water.

Water

By applying the yield deficit law relevant to moisture deficit in the Northwest Coast, current wheat yield is found to be not be more than 14–20% of optimum. There are seven critical stages in wheat, starting with emergence and continuing to maturity. Some 450 mm of rainfall is required to obtain a high yield. The average precipitation in most areas of the Northwest Coast is about 140 mm/year. The remaining water requirement can be met by supplemental irrigation or by improving the water-use efficiency.

Climate

Climatic requirements, i.e. temperature, sunshine, relative humidity, etc., for wheat are optimum within a belt 50 km wide along the Mediterranean coast.

Wheat variety

The annual average rainfall, rainfall distribution, and mean annual temperature are important in determining the type of wheat to be grown in a particular region. Several wheat varieties, characterized by drought-tolerance, have been developed by the Wheat Research Department of the Field Crops Research Institute (FCRI), Agricultural Research Center (ARC). Sakha 8, Sakha 69 and Sahel 1 gave a good response using appropriate management practices (Sabry *et al.* 1992).

Agronomic practices

Selecting a suitable site

Selection of soil with an appropriate depth (not less than 25 cm), a depression, and avoidance of salt-affected soils are the principal elements for wheat production. This type of soil is distributed at several locations in the Northwest Coast.

Mulching and soil conditioners

Improving water-use efficiency is the most important factor for the success of wheat cultivation. Traditional methods (plant stubble from the previous crop) and new methods (hydrogell, bituminous emulsion, polymers and other chemical methods) improve conservation.

Soaking grain

Soaking wheat grain in rainwater collected in a depression is recommended. Inoculation by associative bacteria for nitrogen fixation leads to higher yields on dryland.

Fertilization by foliar application

There was very little interest in the use of commercial fertilizer in dryland farming prior to the 1950s, but since this time, fertilizers have been tested under dryland conditions in the United States and many other countries of the world. Foliar application of NPK and trace elements increases wheat yield. In the 1992/93 growing season in the Northwest Coast, fertilizer at the rate of 107 kg P_2O_5 + 50–70 kg N/ha obtained the highest grain yield. The highest grain yield under rainfed conditions was obtained by using a seeding rate of 95 kg/ha and a row spacing of 20 cm.

Crop rotation and biofertilizer experiments show that wheat grown after lentil gives the highest grain yield, while wheat infected by associated bacteria gives the highest number of spikes/m^2.

Average yields for cereals under the uncertain rainfall pattern of the Western Province are low, and generally in the range of 2–4 ardab/fed (equivalent to 240–480 kg/fed or 571–1,142 kg/ha for barley, and 300–600 kg/fed or 714–1,428 kg/ha for wheat).

Comparative barley and wheat grain yields at different levels of moisture availability are given in Table 22.

Table 22. Barley and wheat grain yields at different moisture levels.

Moisture: rainfall or irrigation (mm)	kg grain/mm moisture	
	Barley	Wheat
200	7.5	1.1
300	8.0	6.1
400	8.7	5.6
500	3.4	8.7
600	5.6	7.8
700	4.7	11.6

Source: Ford Foundation, Middle East and Africa Seminar (1977).

On the assumption that water harvesting structures associated with cereal cultivation may double the effective rainfall, i.e. bring moisture levels up to the order of 200–300 mm, the data suggest that barley is still likely to be a more efficient user of available moisture than wheat. Only where land configuration and allocation permit a ratio of water harvesting area to cropped area of at least 5:1 is wheat yield likely to become competitive with that of barley.

Legume Research Activities in the Northwest Coast

The activities of the Legume Research Department of the FCRI, ARC, in the Northwest Coast began several years ago with pilot experiments to study the possibility of establishing a research program in the area. One of the experiments is entitled "Evaluation of Faba Bean Germplasm for Performance under Moisture Stress in the Northwest Coast." Another experiment was conducted in two locations in the Northwest Coast to study the effect of seed rate on grain yield of small and large seed lentil varieties. The performance of local and exotic lentil genotypes was also studied. Unfortunately, precipitation during 1993/94 was very low, resulting in severe drought and severe damage to all crops, including wheat, legumes, and, to a lesser extent, barley.

Orchards

Agronomic practices

Orchards are established following plowing to remove weeds. As currently practiced, plowing achieves only shallow cultivation, although deeper sub-soiling is preferable in hardpan areas.

Olives

Olive seedlings are planted without a pattern, resulting in an estimated population of 40–60 trees per feddan, compared with the recommended 80 trees per feddan achievable with more regular spacing. Orchard maintenance practices vary with the resources available to the farmer. Where sufficient cistern capacity exists, supplementary water is applied at a rate of approximately 0.5 m^3 per tree per application during the summer months over the first 2–3 years. At least two applications are normally made per summer, although there is considerable variation from farm to farm in both frequency and volume of water. For smaller farmers, watering is done by hand using buckets. Larger farmers sometimes use water more efficiently by hiring water tanks with pump and hose attachments.

Inorganic fertilizers are not used, and although manure is sometimes applied to individual trees, it is not a general practice. The application rate of manure was recently reported as 4 kg per tree (El Naggar *et al.* 1988). A few of the relatively wealthy farmers use foliar fertilizers (principally nitrogen and trace elements), and may also use pest and disease control measures to the extent they feel necessary. Pruning is not widely practiced. Where pruning is carried out, it appears to be only partially understood, with the result that the tree frame may not be correctly established, with inadequate attention paid to selection of branches for pruning on mature trees, bearing in mind that fruiting takes place on two year-old wood.

The main olive cultivars are Mission, Hamid Wateim, Picual, Manzanillo, Tuffahi, Kalamatas, and Shemlali, Shemlali being the most widely grown. Neither comparative yield data nor assessment of oil percentage for different varieties grown is available.

Picking is done entirely by hand, and fruit is often harvested before being fully ripe, thereby reducing both the quality and quantity of oil. The oil percentage is generally low, 14–18%. Twenty *baladi* (local) oil presses are operated by large farmers in the Western Province, permitting a portion of the crop to be processed locally. The remaining crop is sold to traders mainly for pressing in commercially operated factories in Marsa Matrouh or elsewhere, or is pickled for on-farm domestic consumption or sale.

Inefficient post-harvest handling, particularly the frequent delays in moving the crop off-farm for processing, cause "sweating" of the fruit and further deterioration in the final quality of oil produced.

Figs

Figs are grown mainly along the coast among the sandy dunes and on sandy loam soils. Planting is in March and, because of their ease of propagation, hardwood cuttings are taken from trees already established on the farm or from neighboring farms and directly planted in the orchard site. The desire to plant fruit trees now appears to be well established, with farmers expanding their orchards whenever suitable water and financial resources can be made available. The density of fig planting in the Western Province averages 80–100 trees per fed, compared with the recommended rate of 160 per fed.

As with olive tree populations, the lower number reflects the farmers' preference for limiting water demand in view of the uncertainty of rainfall. Where farmers have gained access to additional water through the construction of new cisterns, they have tended to increase the area planted to fruit trees rather than raise the tree population in existing orchards.

Fig tree maintenance practices follow those described for olives, with no special attention being given to trees other than irregular watering in summer during the initial 2–3 years, and weeding as necessary. The productivity per tree and the quality of the final product are therefore limited in a similar manner.

Supplementary summer water is applied in variable amounts from cisterns or—with wealthier farmers—mobile tanks during the first three years of establishment. Firm data on current application rates are scanty and inconsistent, although it is assumed that about 1.0 m^3 of water is provided to each tree during each of the first three years. Farmers irrigate their young trees several times during the summer months in the first three years. After planting, the amount of water is gradually reduced from year to year (ICARDA 1988).

The main variety is Sultani, a table variety which is either marketed fresh or used for domestic production of jam. The variety is not considered to be ideal for drying, a process which if available at farm or local level would add to the potential value of fig production and open additional marketing opportunities. The introduction of alternative varieties, which may be more suitable for drying, is complicated by the ease with which farmers can acquire the existing local variety.

Other varieties are Barkawi, which may actually be a strain of Sultani (FAO 1970). Both are table varieties and the fruits are marketed fresh. A few other local varieties are grown to a very small extent, including Bayoudi, Adsi, and Aboudi. Again, comparative yield data are not available.

Orchard production

The ICARDA (1988) survey gives the most reliable recent assessment of tree crop yields. Olive yield ranges from 0.10 to 55 kg/tree during years with below average rainfall (average 8.7 kg/tree); 2 to 90 kg/tree in years of average rainfall (average 22.5 kg/tree); and 1 to 130 kg/tree in good rainfall years (average 28.2 kg/tree). Olive yields under dry farming and irrigation conditions are presented in Tables 23 and 24.

Table 23. Olive yield under dry farming conditions.

Location	Age (years)	No. of trees	Average yield (kg/tree)
Wadi Maguid	8–10	12	8.8
El Neguila	8–10	15	11.7
Orawla	12	2	7.5
El Neguila	14	11	17.6
Orawla	14	9	14.7
El Qasr	14	15	14.7
Fuka	14	9	12.4
Orawla	16	1	26.0
Wadi Maguid	20	2	62.5
Orawla	20	2	23.2
Fuka	20	4	34.0
Fuka	20	12	31.0
Average			17.9

Table 24. Olive yields under irrigation.

Location	Age (years)	No. of trees	Average yield (kg/tree)
El Qasr	10	1	24.0
El Qasr	12	14	79.2
Fuka	12	11	46.7
El Qasr	12	9	25.4
El Qasr	14	5	36.6
El Qasr	32	2	137.5

Fig yields are estimated at 4.0, 7.0, and 10.5 kg/tree in the first, second and third years, respectively. Yields then fluctuate with variations in rainfall and tillage operations. The ICARDA survey showed the following yield ranges: 1 to 50 kg/tree during poor rainfall years (average 10.7 kg/tree); 3 to 120 kg/tree in average rainfall years (average 25.5 kg/tree); and 12 to 200 kg/tree in good rainfall years (average 32.7 kg/tree).

Protected Agriculture

Protected agriculture has recently been introduced to the area in response to the growing market for fresh vegetables associated with the spread of tourism in the Northwest Coast. About 90 units are now operational in the Western Province, 74 of which are in West Matrouh and 16 in Sidi Barrani. Average production is about 20 kg/m^2 for tomato and 15 kg/m^2 for cucumber with two production cycles possible each year. Units cover an area of 540 m^2, suggesting that total annual production may be in the order of 1,000 tons of tomatoes and 700 tons of cucumber.

Small quantities of vegetables are grown in the open, often associated with orchards. Estimated production areas for the main crops in the winter and summer seasons are given in Tables 25 and 26, respectively.

Table 25. Area (fed) cultivated with vegetables in the winter season, 1989/90.

Crop	El Hammam	El Dabaa	Matrouh	Sidi Barrani	Total	Production (t/fed)
Tomato	18	29	35	45	127	1.5
Cucumber	-	12	5	-	17	2
Leaf vegetables	15	18	22	3	58	-
Mint	8	7	32	12	59	0.5
Pepper	40	-	-	-	40	1.0
Pea	92	2	18	3	115	0.5
Lettuce	12	-	-	-	12	
Potato	18	-	-	-	18	1.0
Broad bean	102	5	22	12	141	1.0
Bean	6	-	9	1	16	0.5
Faba bean	18	-	8	2	28	0.5

1 ha = 2.38 fed.
Source: MALR (1991).

Table 26. Area (fed) cultivated with vegetables in the summer, 1990.

Region	Regional total	Tomato	Water-melon	Sweet melon	Pepper	Squash	Other vegetables
Burg El Arab	1,862	648	641	139	46	128	260
El Hammam	3,574	1,158	1,989	424	-	-	3
El Dabaa	292	25	148	5	-	114	-
East Matrouh	655	302	350	-	-	-	3
West Matrouh	567	45	376	141	-	-	5
Sidi Barrani	2,412	-	2,000	400	-	-	12
Total area	9,362	2,178	5,504	1,109	46	242	283
Production (t/fed)		1.5	2	4	1	4	

1 ha = 2.38 fed.
Source: MALR (1991).

Range Resource Management

Factors Affecting Range Management

A wealth of range-related information, collected by numerous scientists and institutions over the past 30 years, is available for the Northwest Coast of Egypt. The available information provides an adequate characterization of the region's rangeland and is considered sufficient for the planning and improvement of range management.

The rangeland ecosystem of the Northwest Coast is characterized by low precipitation, high moisture deficit and poor soil conditions. These factors combine to limit the productive capacity of the range and make it highly vulnerable to deterioration, unless proper land use practices and controls are adopted.

Rangeland resources in the region are undergoing rapid and serious deterioration. In many areas, the degradation of rangeland has already progressed to the stage of complete denuding of the vegetation cover and the loss of valuable topsoil, making recovery impossible or extremely expensive.

The present carrying capacity (or the appropriate stocking rate) for the region is less than 320,000 sheep (or equivalent). The average animal population of the Northwest Coast over the last five years exceeded one million head. This situation has created a serious imbalance between the present animal population and the available range resources. This, in turn, has caused several significant ecological changes including:

- Disappearance of desirable range forage plant species over much of the area, or, where they are present, vigor is extremely reduced.
- Increase in the density of undesirable plant species.
- Disappearance or reduced vigor of species previously classified as moderately desirable or undesirable.
- Total disappearance of vegetative cover in increasing areas around settlements and watering points.
- Soil loss as a result of erosion by wind and water.

These changes have resulted in serious reduction (more than 50% in some cases) in grazing capacity. Furthermore, the disappearance of the valuable perennial species has increased the dependence on short-lived, less reliable annual species.

Overgrazing is the most important single factor causing rangeland deterioration. The following factors have accelerated or contributed to the process:

- The natural rangeland vegetative cover has been removed from extensive areas, mainly for crop production. Moreover, there is evidence that additional areas are being disturbed every year. The availability of modern tractors through government-supported cooperatives is a major cause of this trend. The local, animal-drawn plow has nearly disappeared from the area. This type of plow does not cause as much destruction as the tractor and thus affords greater soil protection.
- Removal and uprooting of shrubs for fuel.
- Destruction of natural vegetation through urban encroachment, and recreational and military activities.

Range Improvement Studies

Extensive range improvement experimentation has taken place since the establishment of the Ras El Hekma Experimental Station (Zone II) in the early 1950s. Field experiments have been established and monitored at that station and at a number of substations located throughout the region. The experiments focus on the selection of mostly introduced plant species for use in reseeding of depleted rangeland in the region. Some of the studies have involved the evaluation of water conservation measures to aid in the establishment of vegetative cover and to increase productivity. Results of these experiments are available at the Desert Research Center, and summaries of these investigations have been collected (DRC 1983).

Ayyad (1979) stated that native species would be more appropriate for reseeding programs in the area since they have evolved in this harsh environment over many millennia. Ayyad initiated a program, as part of SAMDENE (1979) and REMDENE (1983, 1982), to evaluate the revegetation potential of a number of native species.

Van der Veen *et al.* (1969) reported the establishment of a number of demonstration plots at locations along the coast from Fuka to Sidi Barrani (Zones II, III, and IV) in 1967/68. Seed and transplants of native and introduced species were used and proved highly successful. A series of experimental/demonstration plots were initiated by McGowan International (1982) at several locations in the area. The study dealt with annual medics (*Medicago* spp.) seeded in areas, largely barley fields, generally receiving substantial amounts of runoff water. Plots were successful in some of these locations. Only one site showed a reasonable plant density despite good moisture condition at that time.

Two range plant nurseries were established at Borg El Arab and Fuka (Zones I and II) in 1969. Propagation of blue panic grass was also carried out at the horticulture nursery at El Qasr for transplant to sandy areas in the Sidi Barrani region. The Agricultural Research Center maintains a nursery in the Mariut area which includes some forage plant species.

Several activities to improve the natural rangeland in the area of West Matrouh (Zone III) and Sidi Barrani (Zone IV) were begun in the 1980s. Some seedling nurseries were established to produce fodder trees and shrubs (especially *Acacia saligna*, *Prosopis juliflora* and *Atriplex nummularia*) and seedlings which are distributed to Bedouins free of charge. An estimated area of about 14,000 fed (5,882 ha) was transplanted with the above-mentioned trees and shrubs.

Approaches to Rangeland Improvement

On the basis of previous improvement studies carried out in the region, three general approaches to range improvement are possible:

- Natural recovery.
- Artificial revegetation.
- Growing fodder shrubs in barley fields.

A prerequisite for any range improvement is the proper control of grazing pressures, distribution, and timing. A review of 52 rangeland studies, many of which were carried out for ten years or more, shows that there is no method that is entirely satisfactory on an overgrazed range. The first step is to adjust the stocking rate, then apply management. None of the demonstration plots, experimental plots or protected areas were maintained properly despite the presence of fences and guards. With too many animals competing for the sparse forage in the highly deteriorated rangeland outside such plots, it is difficult to keep the animals out of the improved range plots.

Natural recovery

This approach involves manipulation of animal numbers and distribution in such a way that the natural vegetation, particularly the desirable species, is given the opportunity to regain its vigor and abundance and to restore its productive capacity. The rate of natural revegetation depends on such factors as:

- Present range condition (e.g. amount of desirable species remaining).
- Climatic conditions, particularly annual precipitation.
- Present soil condition (e.g. soil surface stability, soil type).
- The potential productive capacity of the site.
- The grazing regime to be adopted (particularly as it relates to intensity and time of grazing).

This procedure does not necessarily require complete protection from grazing during the recovery period. In fact, complete protection from grazing may slow down the recovery process. Downward adjustment of animal numbers is the initial and most important step. The degree of reduction necessary depends on the factors listed above. Animal numbers can then be gradually increased, as range condition improves, to the appropriate carrying capacity.

The processes may be slow and may not be possible in areas where serious deterioration in vegetation and soil conditions has taken place. In most areas, however, this is the only avenue available for improvement because site and climatic conditions do not allow successful and cost-effective artificial revegetation. According to available data, grazing capacity could be more than doubled in some sites (e.g. the coastal plain range site) if this procedure were properly employed. Water conservation (e.g. contour furrowing, water spreading) at the appropriate sites would speed the rate of recovery and increase productive capacity.

Artificial revegetation

Many high-ranking government officials perceive artificial reseeding as the only realistic large-scale measure to solve the problems of rangeland overgrazing and deterioration in the Northwest Coast. In other words, they view artificial reseeding as an alternative to proper management. This attitude is extremely dangerous and could lead to wasted funds and efforts because of the following:

- Artificial reseeding cannot substitute for proper range management. In fact, proper grazing management is an essential prerequisite for the establishment and maintenance of a successful stand of an artificially seeded range. Without proper management, the introduced vegetation will disappear, at a faster rate than the original vegetation which evolved over thousands of years under the harsh climatic and misuse conditions. It should be noted that most of the experimental and demonstrative plots established in the region during the past three decades disappeared almost completely within a short period as a result of overgrazing by sheep and goats.

- Range improvement through artificial reseeding in this region has been shown to be possible only in selected sites with favorable soil characteristics and additional soil moisture supply (e.g. runoff water). The total area suitable for reseeding represents only 9% of the total area of rangeland, and most of that area is currently used for barley and horticulture crop production.
- The average annual precipitation is too low to allow for successful reseeding using the currently available technology. A minimum of 250 mm of annual precipitation is needed for effective and cost-effective artificial reseeding. In Matrouh and Sidi Barrani, annual rainfall exceeding that level is exceptional. Even rainfall of more than 200 mm/year occurs only twice in ten years.
- Most of the species recommended for artificial revegetation require extensive seedbed preparation for successful establishment. This would result in the destruction of what is remaining of the highly adapted original vegetation and will render the soil more susceptible to erosion.

The above discussion does not mean that artificial revegetation should be totally excluded as one of the means of range improvement. It was intended, however, to emphasize the limitations and requirements for this type of range improvement and put it into perspective for regional planning purposes.

Artificial revegetation has been shown to be possible in the region under the following conditions:

- Non-saline depression sites, with medium-textured soil, receiving additional moisture from runoff water. These are found mainly in the coastal plains. The following species are the most promising species for such areas: *Oryzopsis milliacaea, Phalaris tuberosa, Dactylis glomerata* var. Hispanica, *Agropyron elongatum, Pterium sanguisorba*, and *Atriplex nummularia*. All are perennial grasses, with the exception of the last two, which are a perennial forb and a shrub, respectively. Water conservation measures would improve the probability of successful establishment and increase productivity. Such measures may include water spreading, contour furrowing, or small basins (e.g. 2 × 4 m in area, 5–10 cm in depth).
- Deep sandy sites. These are found mainly in Sidi Barrani (Zone IV). The main adapted species here are the perennial grass *Panicum antidotale* and the shrubs *Acacia saligna* and *A. cyanophylla*. Where surface stability is a problem, e.g. natural vegetation cover has disappeared as a result of overgrazing or cutting, soil conservation measures become necessary. While there are many methods available for this purpose, including use of petroleum mulch and polymers, establishment of windbreaks using any plant material or residue that is locally available (e.g. common reed, *Phragmytis communis*) is quite effective.
- Barley fields. In addition to the production of barely grain and straw, barley fields could provide valuable forage for use by range animals and at the same time increase soil surface protection and soil fertility. Self-reseeding annuals, such as subterranean clover, vetches and medics could be used.

Emphasis in species selection for artificial revegetation should be on the use of perennial herbs (grasses and forbs) and shrubs, rather than annuals, with the possible exception of barley fields as noted above. The density and growth of annuals depends more on rainfall than the deep-rooted perennial herbs and woody species. Furthermore, most annuals are low in productivity, short-lived, and of nutritional value only during the rainy season. The perennials and shrubs, on the other hand, provide a more reliable production and maintain adequate forage quality through the dry summer season when forage reserves are scarce.

Growing fodder shrubs in barley fields

The potential for growing fodder shrubs is probably in the range of 180,000 to 240,000 fed (75,630–100,840 ha), perhaps more.

Assuming a mean annual fodder shrub production of 400 kg dry matter and 60 kg crude protein per fed per year, there is a production potential of 75,000–100,000 metric tons of dry matter and 11,000–15,000 metric tons of crude protein per annum. That is an energy diet of 136,000–182,000 sheep/annum and protein for 600,000–940,000 sheep/annum.

Fodder shrubs thus meet the protein requirement of the small ruminant when range and crop residue resources are added, since the present population of small ruminants in the area is estimated around 1 million sheep and goats.

Fodder shrubs should not be planted on the stony plateaus where production would be too low for economic viability, but restricted to deep soils in depressions between the seashore and the Alexandria–Salloum road, above the 120 mm isohyte. These soils are usually cropped to barley, therefore shrubs should be established in widely spaced rows (10–15 m apart) so as not to disturb mechanical tillage and harvesting of the cereal. Shrub density would thus be of the order of 210 plants per feddan.

In such conditions production may be expected to reach an average of 1 kg dry matter per shrub (3 kg fresh leaves), or 200 kg dry matter/fed/yr. To this should be added 200 kg of barley straw (and stubble) and 125 kg of barley grain. The total production per feddan would thus be 540 kg dry matter and 44 kg crude protein.

The carrying capacity is thus 1.1 sheep/fed/yr in terms of energy and 2.7 sheep/fed/yr in terms of protein (45 g crude protein/sheep/day). If 12 fed (5 ha) of rangeland is added to each feddan of barley + shrubs, the carrying capacity of each feddan of barley + shrubs would be about 2.1 sheep/feddan, i.e. a potential flock of about 500,000 sheep.

Fodder shrub selection

The most productive species, given the conditions of the area, are:

- For deep silty soils: *Atriplex nummularia*
- For deep sandy soils: *Acacia saligna* (*A. cyanophylla*), *Opuntia ficus-indica*, and *Salsola vermiculata*.
- For shallow soils: *Atriplex halimus*, *Colutea istria* (*C. haleppica*), *Periploca laevigata*, and *Salsola vermiculata*.
- For saline soils: *A. halimus*, *A. glauca*.
- For sand dunes: *Haloxylon pesicum*, *Hedysarum argentatum*, *Atriplex canescens*, and *Prosopis juliflora* (local).

Range Management Policy

The primary objective of any effective range management policy is to achieve maximum sustained productivity. Such a policy requires, as a first step, control of grazing pressures and distribution in order to maintain a balance between the number of grazing animals and the grazing capacity. Once this is achieved, range improvement measures can be implemented to initiate development towards the maximum potential for the various range sites.

At present, there is no clear range management policy for the region. In the late 1960s, a plan for controlled grazing was developed and approved by the Government (the Egyptian General Desert Development Authority, GDDA). The implementation of the plan was to start with the establishment of the first grazing district in El Salloum area. The plan failed, due, apparently, to the following reasons:

- Lack of in-depth consultation with the people directly affected (not necessarily restricted to elected representatives) by the plan. No attempts were made to solicit input from the population concerned or to explain to them the details of the plan and the reasons for the change. The people felt the plan was developed and imposed upon them from the outside.
- Lack of genuine government support for the plan due to political pressures or to the lack of appreciation and/or understanding of the problems facing the rangeland of the region. For example, no range management section existed at that time and no staff was specifically allocated to oversee implementation.

Although the ownership of most areas of rangeland rests with the Government, traditional tribal territories are well known. The traditional tribal system of sanctions and rewards is effective in organizing and resolving problems of resource allocations among families belonging to the same tribe or to different tribes. Abou Guendia (1985) describes a system of deferred grazing supported by tribal tradition. It involves demarcating the site using strips of barley and spreading the word among the other breeders that the area is preserved for use in late spring and summer.

Livestock Production and Management

Livestock Production

According to El Naggar and Perrier (1989), 97% of the farmers own sheep, goats, camels, cattle, donkeys, and horses. Of all animals owned, 84% are sheep and goats, 14% donkeys, 1% camels, and less than 1% cattle. Table 27 presents the total production and estimated value of animal by-products (milk and wool) in the Northwest Coast.

Table 27. Production and value of animal by-products.

By-product	Production (t)	Value (1000 LE)
Crude wool	1,291	3,542
Milk	2,082	1,663

Source: Ministry of Agriculture Census (1990).

At present, livestock production is low. The lambing rate is about 0.8 lambs per year per ewe. For the goats, the kidding rate is about 1 kid per adult female per year (Dragutin 1990). The subsidized supplementary feed (50 kg of concentrate per adult sheep/goat) plays an important role in maintaining the animal production. Concentrate supplements reduce the mortality rate, which is usually very high in traditional animal husbandry, particularly in a succession of dry years.

Livestock breeders sell all male lambs at various ages (3–8 months) and almost all of the kids (males and females). According to Matrouh Cooperative statistics, in 1989 the total number of lambs sold in the Western Province was 255,000, of which 80,000 (50,000 lambs and 30,000 kids) was exported to the Gulf countries.

Grazing Practices and Studies

The mixed sheep and goat flocks graze the plains; camels usually graze the poorer rangelands. These animals depend on pasture for one third of the year (during winter and spring), grazing on dried-up plants and cereal stubble, along with supplemental grains, during the rest of the year. The estimated average carrying capacity varies between 20 and 30 sheep per feddan depending on area and rainfall. Because of overgrazing and pasture degradation there is increased dependence on supplements, using grains and concentrates transported from the Delta. Animals are watered daily in summer, and in winter intermittently or not at all, depending on how much water is obtained from natural vegetation.

Grazing studies at Ras El Hekma station in the early 1950s (DRC 1983) provide a great deal of useful information on the grazing capacity of rangeland in that area. Van der Veen *et al.* (1969) conducted a regional evaluation of the rangeland. This evaluation was based on extensive field surveys and includes estimates of the carrying capacity and range condition of the various range types, descriptions of flock movements and grazing patterns, and a survey of watering points.

Some of the sites evaluated in that survey were re-examined in Abou Guendia (1985). It is obvious from the comparison that the grazing capacity of most range types has been reduced substantially (up to 50% in some cases) over the past 13–16 years (Table 28).

Table 28. A comparison of grazing capacity estimates (acres/sheep or equivalent) for various range sites.

Site	1969 estimates	1984 estimates	Potential†
Salt marsh	25	25	20
Rockland	20	25	15
Sub-desert	17.5	No data	15
Coastal plain	17.5	22	10
Eroded coastal plain	20–25	30–35	15–20
Inland dune (vegetated)	12.5	15	8
Saline upland	20	No data	15
Desert range	25	No data	25

† Based on natural recovery for sites in which a reasonable proportion of the original cover is still present and provided that no serious soil erosion has taken place.

In some areas this reduction in the productive capacity of the rangeland is irreversible, at least without prohibitive costs, because it is associated with serious soil losses. The least change was observed in some of the salt-marsh sites. The greatest deterioration was observed in the northern areas, particularly around settlements and watering points. Although a "sacrifice area" around such features is usually inevitable with any system of grazing, the increase in size of such areas in this zone is alarming.

Grazing capacity estimates in the Northwest Coast suggest a total of 311,000 sheep or equivalent could be maintained, assuming moderate supplementation and drought feed (57 kg barley and 114 kg chaffed straw/sheep or equivalent per year). Although there are no detailed estimates of the present carrying capacity, current grazing capacity is much lower. Therefore, the present stocking rate is at least three times the proper grazing capacity. This lack of balance between the number of grazing animals and the available grazing resources confirms the evidence of widespread overgrazing discussed earlier in this section.

The disappearance of the perennial species as a result of overgrazing has resulted in substantial reduction in the productivity of the rangeland. Furthermore, it has increased the dependence of range animals on the production of short-lived, less-reliable annual species. The density of annuals also appears to have decreased everywhere except around barley fields and orchards where there is a source of seed and partial or complete protection.

The livestock management system uses two approaches, nomadic and sedentary, and varies from a system of pastoral production to a mixed-crop, production–livestock system.

Grazing and supplemental feeding are the major sources of nutrition for sheep and goats. The proportion of feed from these sources varies by season with a heavy dependence on feed supplements. Only 30% of nutrition in winter comes from grazing; this increases slightly to 43% in spring but drops again to 30% in summer. In autumn, grazing provides a scant 17% of total nutrition.

Generally, sheep and goats graze well and can adapt to many types of feed. They prefer to graze in the early morning and late afternoon and can be seen grazing a distance of one day's walking from a water source. Active grazing occurs for about eight hours per day. If alternative pastures are available, sheep will spend 60% of the time eating grasses and weeds, 30% selecting various forbs (herbs which are not grass-like or grass), and 10% browsing shrubs. Goats will spend 20% of the time grazing grasses and weeds, 20% selecting forbs, and 60% browsing shrubs. This indicates that sheep and goats do not compete for the same source of plant food. Farmers depend on two grazing sources for livestock production: natural vegetation and green barley crop and stubble. Some sheep and goat producers in the Western Province move their flocks to Siwa Oasis where there are fields of berseem. In the Eastern Province some flocks are moved to the irrigated areas in Zone I.

Natural grazing occurs in uncultivated arable lands belonging to farmers but within tribal lands beyond the production strips and the interspersed rangeland. These lands are suitable for cultivation, but because of low rainfall, the farmers leave the land for grazing. Vegetation includes annual grasses and weeds as well as shrubs and sub-shrubs.

Ninety-two percent of the farmers sampled ranked the right to graze sheep and goats on a farmer's field as the first choice of pasture, and the right to graze on tribal lands as the second. The right to graze communal or common lands was a third choice when off-farm grazing is extensive (El Naggar *et al.* 1988).

The interspersed rangeland, or non-arable land, located south of the railway line (which connects Alexandria to El Salloum) and stretching inland, provides most of the grazing material for livestock. Grazing rights are assigned first as a communal right of access, second as a tribal right of access, and third as a farmer's right to graze his own stock. In these interspersed lands, sheep and goats are allowed to graze on the open range only for limited periods where the land is fallow due to the long dry season. As a result of these restrictions, the Bedouins must move their flocks to better grazing as far away as Siwa Oasis (200 km). Trucks with water tanks have extended the distance of movement to the grazing lands of the interior.

The season for grazing is from the first of November through the end of May. This period of time is called *el rabie* which means "spring." During summer and autumn, less than 10% of the farmers let their sheep and goats graze weeds in fallow. In winter and spring, over half the farmers let their animals graze weeds in fallow. Alternatively, if natural pasture is available, more than 85% of the farmers let their sheep and goats graze these lands during all seasons.

Availability of barley and field stubble depends on the amount of rainfall, the macro- and micro-relief of the land, and soil moisture (for crop production). In rainfed farming, there is a close relationship between barley cropping and livestock production. Performance of the crops on the fringes of the fields lets the farmer know if barley yield will be too low to warrant harvest. When this occurs, 43% of these farmers let their sheep and goats graze a part of these fields, and harvest the remainder for grain and straw. In poor cropping years, all farmers let their sheep and goats graze a portion of the field (either as green pasture or instead of harvesting the mature crop).

The portion of the barley field grazed ranges from 20 to 100% of the crop sown, with a mean of 50–55% and a standard deviation of 29–47%. In average rainfall years, only those farmers (13%) with the greatest investment in livestock allow grazing of the barley crop. In good cropping years, only 9% of the farmers let their sheep and goats graze the barely. In poor cropping years, when the crop has a low stand density, some farmers sell the right to graze their barley fields to sheep and goat breeders.

Stubble grazing usually starts immediately after harvest and lasts through the summer months.

During the last few years the decrease in rainfall has caused severe reductions in the regeneration of grass and shrubs, causing traditional sources of grazing to decline. This has led to increased dependence on commercial concentrates (World Bank and MALR 1992).

Farmers now transport large amounts of concentrates to the flocks instead of moving flocks to new grazing lands. The major sources of supplemental feed are barley and wheat grain, cotton seed cake, and barley and legume straw.

The farmers receive rationed quantities of cotton seed cake from the cooperative societies, amounting to 3 kg/head monthly for nine months per year (a total of 27 kg/head of cotton seed cake) as feed supplements. Seventy-two percent of the farmers buy additional cotton seed cake on the market.

Barley and wheat grain are the second major sources of supplemental feed for sheep and goats. The contribution to total nutrition from barley grain is 5–30 kg/head, seasonally. The minimum contribution from wheat grain ranges from 2 to 5 kg/head, with the maximum contribution ranging from 90 to 99 kg/head.

Barley and legume straw are the third major feed supplement for sheep and goats. All farmers use their own stored barley straw as supplemental feed.

Other sources of feed supplement for livestock are faba bean bran and garlic straw. The faba bean bran is purchased in small amounts and fed for a short period of time.

Animal Nutrition

Fattening animals on the rangeland is one of the major agricultural activities in the Northwest Coast of Egypt. However, it is practiced by traditional methods that disregard the necessity and importance of proper range and grazing management. Feed supplements are used to supplement grazing. Concentrate feed-mixtures, grains and berseem hay are traditional feed supplements imported from the Nile Valley at high cost. Table 29 summarizes the amount and cost of animal feed consumed by livestock in the Northwest Coast (CAPMAS 1991).

Table 29. Total amount of consumed feed supplements and their cost.

Feedstuffs	*Forage crops*	*Straw*	*Grain*	*Concentrates*
Amount	3,000 fed	22,000 t	1,000 t	33,000 t
Value (1,000 LE)	2,438	2,075	4,865	11,187

1 ha = 2.38 fed.
Source: CAPMAS (1991).

Significant areas of range are witnessing serious deterioration of their vegetative covers. Natural causes have contributed to the deterioration of such range areas. These factors gradually reduce the long-term productive potential of the rangeland, as can be observed most clearly in El Neguila and Sidi Barrani (Zone IV).

Halophyte, along with several halophytic plant communities, is widespread in the Northwest Coast. It constitutes a significant part of the local flora in many areas. Its species have been grazed or browsed by animals for a long time. Many halophytic species are long-lived perennials and maintain green biomass even in dry periods. Consequently, they provide stability to the communities, prevent erosion, provide dry season forage and resist invasion by other low-value or spiny plants.

Factors affecting the nutritive value of the rangelands

The amount of nutritives present in the rangeland in the Northwest Coast is influenced by several factors: plant species and variety, stage of growth and maturity, forage location, environment, seasonal use, salinity, solidification, and physical and chemical defenses. In the following discussion some of the most important factors will be considered.

Plant species and varieties

Plant species of the rangelands in the Northwest Coast vary considerably in their chemical composition, nutritive value and palatability (Table 30). *Limoniastrum monopetalum*, *Suaeda fruticosa*, *Nitraria retusa*, *Atriplex nummularia*, *Atriplex halimus*, and *Salsola tetrandra* are considered the most important for animal forage due to their high crude protein content and higher palatability. The protection of such range species from overgrazing is necessary to insure year-round green nutritious fodder.

Stage of growth

The process of aging and maturation is greatly associated with a decline in protein content, digestibility and, consequently, palatability (El Shaer 1981; El Bassosy 1984). Ash and fiber constituents increase with advancing maturity. Therefore, most rangelands are rich and nutritious in the wet season (winter and spring) and poor during the dry season (summer and autumn). This has been reported by many investigators, including Abd El Aziz (1982) and El Shaer *et al.* (1984). Table 31 shows the effect of season of growth on the chemical composition of *Atriplex halimus*.

The performance of grazing animals, in terms of dry matter intake and nutrient utilization (Tables 32 and 33), increases during the wet season (El Shaer 1981; El Shaer and Kandil 1990).

Table 30. Proximate analysis of digestibility of dry matter and palatability of halophytic rangelands (%).

Plant species	PR†	DM	CP	EE	CF	Ash	NFE	DMD
Alhage maurorum	S, G‡	44.0	9.45	4.42	29.5	25.9	30.73	46.4
Arthrocnemum glaucum	C	229.9	3.39	1.26	12.1	51.9	31.36	50.4
Atriplex halimus	A	34.2	12.6	2.28	2.4	22.7	37.02	66.7
Atriplex leucoclada	S, G	25.6	15.1	2.69	27.4	31.7	23.11	52.2
Atriplex nummularia	A	21.7	13.3	5.09	24.2	26.7	30.71	58.8
Halocnemum strobilaceum	C	29.7	6.69	2.22	7.04	40.3	43.75	63.0
Haloxylom salicornicum	Nil	42.2	14.8	6.11	24.1	15.9	30.09	46.5
Jancus acutus	A	35.0	7.11	2.35	28.5	12.3	49.94	34.4
Limoniastrum monopetalum	A	48.6	11.5	3.49	14.6	23.6	46.81	68.2
Nitraria retusa	A	37.6	10.2	2.46	32.6	33.0	21.74	61.8
Salicornia fruticosa	C	37.6	13.5	1.89	18.9	14.3	51.41	70.5
Salsola tetrandra	A	37.1	6.32	2.37	36.1	35.9	19.31	68.0
Suaeda fruticosa	A	25.0	10.0	5.00	33.2	16.1	35.7	70.4
Tamarix aphylla	G, C	34.9	12.9	3.99	13.6	20.1	49.41	48.7
Tamarix mannifera	A	40.0	8.19	3.57	11.6	24.9	51.74	59.6
Zygophyllum album	Nil	24.7	7.76	2.46	11.2	34.2	44.38	65.3
Zygophyllum simplex	C	40.5	11.1	2.12	16.7	29.8	40.28	56.9
Zygophyllum decumbens	C, G	37.7	9.37	1.80	24.1	26.9	37.83	49.6
Overall average		34.3	10.1	3.08	21.7	27.0	38.12	58.2

† PR = Palatability rate; DM = Dry matter; CP = Crude protein; EE = Ether extract; CF = Crude fiber; NFE = Nitrogen-free extract; DMD = *In vitro* dry matter digestibility.

‡ S = Sheep; G = Goats; C = Camels; A = All these animal species; Nil = No animal can eat it.
Source: El Shaer (1981), Abd El Aziz (1982), El Bassosy (1984).

Table 31. Chemical composition (%) of cultivated and wild *Atriplex halimus*.

Nutrients	Wet season		Dry season	
	Cultivated	Natural	Cultivated	Natural
Dry matter	26.1	29.2	34.6	38.3
Ash	19.0	21.5	22.7	26.7
Crude protein	13.9	11.2	8.95	32.1
Crude fiber	22.6	28.4	29.8	32.1
Ether extract	4.86	3.76	2.98	2.49
Nitrogen-free extract	39.64	35.15	35.57	31.4
Organic matter	81.00	78.50	77.30	73.30

Source: El Shaer and Kandil (1990).

Table 32. Proximate composition (%) of *Atriplex nummularia* (dry matter basis).

Season	DM	Ash	CP	EE	CF	NFE	ADF	ADL	NDF
Winter	29.4	24.3	11.4	4.8	30.3	29.2	31.3	8.6	55.0
Spring	27.7	31.4	13.8	5.0	27.9	31.9	30.6	8.1	54.0
Summer	33.3	25.7	10.8	4.1	30.6	28.8	33.8	10.0	63.0
Autumn	36.2	27.7	8.6	3.3	31.4	29.0	36.8	21.1	67.1

DM = Dry matter; CP = Crude protein; EE = Ether extract; CF = Crude fiber; NFE = Nitrogen-free extract; ADF = Acid detergent fiber; ADL = Acid detergent lignin; NDF = Neutral detergent fiber.
Source: Kandil and El Shaer (1988).

Table 33. Utilization of *Atriplex nummularia* by sheep and goats.

Item	Sheep				Goats				F-test
	W	Sp	Su	A	W	Sp	Su	A	
Body weight changes (g/day)	55.6^{b}	77.8^{a}	23.2^{c}	-11.1^{d}	49.4^{b}	66.6^{a}	17.1^{c}	-9.1^{d}	**
DM intake (g/day/kg$^{0.75}$)	52.0^{b}	59.8^{a}	47.7^{cd}	45.8^{dc}	53.7^{b}	58.0^{a}	49.2^{c}	44.6^{c}	**
Water intake (mL/day/kg$^{0.82}$)	262^{c}	3.11^{b}	381^{a}	356^{a}	219^{d}	257^{c}	$288b^{c}$	269^{c}	**
N balance (mg/day/kg$^{0.75}$)	99^{b}	143^{a}	49^{c}	-25^{b}	86^{b}	126^{a}	39^{c}	-24^{d}	**
Apparent digest. (% DM)	60.1^{a}	61.4^{a}	58.1^{b}	58.4^{b}	61^{a}	62.1^{a}	59.2^{b}	58.0^{b}	**
TDN (g/day/kg$^{0.75}$)	24.0^{ab}	28.4^{a}	21.2^{bc}	19.0^{c}	25^{ab}	28.7^{a}	22.0^{bc}	18.7^{c}	**
% of maint. requirements	94	113	83	76	91	104	79	66	
DCP (g/day/kg$^{0.75}$)	3.4^{b}	5.0^{a}	$2.8b^{c}$	1.9^{c}	3.5^{b}	4.8^{a}	$3.0b^{c}$	1.9^{c}	**
% of maint. requirements	150	229	125	87	138	196	117	77	

W, Sp, Su, A = Winter, spring, summer and autumn, respectively.
N balance = Nitrogen balance; DM = Dry matter; TDN = Total digestible nutrients; DCP = Digestible crude protein.
** Values in the same row with different superscripts are significantly different ($P < 0.01$).
Source: Kandil and El Shaer (1988).

Forage location

Site conditions are extremely important, as they influence the growth characteristics of range plants, and thus, indirectly, their nutritive value and palatability. Conditions include: soil fertility, plant development, runoff water, intensity of shade, and other environmental factors. Plants growing on favorable sites have a higher tolerance for grazing than plants growing on unfavorable sites. The effect of range location on chemical composition and nutritive value of range forages has been studied by the Department of Animal and Poultry Nutrition, DRC, in nine forage locations (Abd El Aziz 1982; El Bassosy 1984). All forage locations were found to have a significant effect on nutrients and digestibility (Table 34). The nutritive status of rangelands at El Zawaida, Sidi Barrani (Zone III) and El Salloum (Zone V) is much higher than in other areas. Sheep fattening should be practiced in such locations.

Table 34. Mean nutritive value (%) for common forage species† in different locations of the Northwest Coast.

Location	DM	CP	CF	EE	Ash	NFE	IV-DMD	*In vivo* DMD	Carrying cap†† min	max
El-Hamma	32.4	13.41	17.17	3.04	21.93	44.99	57.96	56.37	20	12
K 7	33.5	13.12	20.00	2.99	17.77	45.92	53.29	51.75	25	12
Galalah	37.2	10.90	23.79	4.49	14.49	45.38	47.94	46.45	25	10
Saad Mahdi	24.5	10.45	20.79	4.06	15.44	42.41	57.51	55.93	-	-
Fuka	35.6	12.05	25.46	2.22	22.40	37.83	40.42	39.00	25	8
Sidi Hinish	34.2	12.84	27.79	2.32	22.58	34.47	42.04	40.61	25	15
El Zawaida	40.4	12.12	20.17	3.85	20.52	43.34	64.72	63.41	20	8
Sidi Barrani	40.3	11.97	20.61	3.86	21.02	42.72	63.94	61.19	25	7
El Salloum	39.2	12.07	19.21	3.85	21.09	43.78	66.63	65.02	20	7

† Plant species: *Salsola tetrandra, Atriplex halimus, Nitraria retusa, Limonia stummonopeta, Echium sericum, Poluqonum equisetiforme, Plantago albicans, Tamarix aphylla, Convolvulus althacoides, Eruca sativa and Euphobia* sp.

†† Carrying capacity = Number of feddans of rangeland needed for maintenance and production of one small animal (sheep equivalent) in the flock.

DM = Dry matter; CP = Crude protein; CF = Crude fiber; EE = Ether extract; NFE = Nitrogen-free extract; DMD = Dry matter digestibility.

Source: Abd El Aziz (1982), El Bassosy (1984).

Physical and chemical defenses

Some plant species provide protection from overgrazing in the form of hooks, bristles, spines, and thorns. Nutritive value and animal selectivity are also influenced by the presence of silica, fibers, and spines. Silification of exposed tissue is a major physical defense adapted by several plant species. It accelerates tooth wear, reduces the digestibility of plant tissues and contributes to the development of esophageal cancer (McNaughton *et al.* 1985). Several range species grown in the Northwest Coast contain high levels of silica, averaging 6% during the dry season (El Shaer *et al.* 1984). Recently, Kandil *et al.* (1991) found that dry matter intake of *Tamarix mannifera* and its nutrient utilization was poor because of high silica content in comparison with other forage species. Chemical defenses may be the most important plant characteristics influencing palatability and nutritive value. This includes: nitrates, nitrites, tannins, oxalates, and various salts. Some compounds, such as terpenes, numerous classes of phenolics, steroids, cyanogenic compounds, and alkaloids, serve a specific protective function (Russell and Michael 1992).

Antimicrobial substances, such as essential oils, sometimes affect ruminate fermentation capability or plant tissues palatability (Mueggler 1970).

Palatability and nutritive value

Factors that relate to a plant's palatability include the secondary metabolites, i.e. tannins, alkaloids, sponins, terpenes, and oxalates. Anatomical features, such as thorns, prickles, dense pubescence, and textural features are also related to palatability, but the nature of these relationships is still unclear (Malecheck and Provenza 1983). Range species in the Northwest Coast differ greatly in their palatability, as shown in Table 30. However, moderate palatability is more desirable than high palatability, because this ensures that the plants are not grazed vigorously before the dry season.

Feeding practices

Palatable and nutritious plant species may be the sole feed for native livestock. In this situation, supplementary feed becomes necessary (El Shaer 1981). This practice requires a good knowledge of livestock needs as well as of the availability of nutrients from the rangeland. Supplementary feeding sometimes constitutes an economic burden upon the production enterprise, particularly using the conventional supplements, which are very expensive and mostly imported from the Nile Valley. The moderate level of crude protein in several plant species (Table 30) may meet livestock needs, in spite of their deficient energy content. Type, quantity, and quality of supplements for sheep and goats have been intensively studied by the Desert Research Center, El Shaer (1981), and El Shaer *et al.* (1986). Conventional energy concentrate supplements improve dry matter intake, growth rate and milk production of sheep and goats grazing the native ranges. Bedouins in the Northwest Coast grow rainfed barley as well as olive and date-palm plantations, which produce sizable quantities of by-products. Such agro-industrial by-products have been used successfully as non-traditional feed supplements for grazing sheep and goats. Feeding costs were reduced considerably, and net profits increased (El Shaer *et al.* 1986; Khamis *et al.* 1989) as shown in Table 35.

Table 35. Economic evaluation of feeding olive pulp and date seed as a supplement to grazing lactating ewes.

Item	Control group†	Date seed group	Olive pulp group
Total DMI (kg/head/160 days)	114.7	86.9	132.9
Total DMI (kg/100 kg dam wt/160 days)	388.9	271.5	450.4
Total cost of feeding (LE/100 kg dam wt)‡		8.9	10.2
Kg weaned lambs/100 kg dam wt	55.6	47.3	45.3
Total gain of lambs (LE/100 kg dam wt)§	166.9	141.9	136.0
Net gain (LE/100 kg dam wt) (1988 prices)	92.4	133.0	125.6

† Control diet = Berseem hay + commercial conc. mixture.
‡ Based on 1988 prices: 1 ton of commercial conc. mixture = LE 200; 1 ton of berseem hay = LE 140; 1 ton of olive pulp = LE 20; 1 ton of date seeds = LE 30.
§ Based on 1988 price: 1 kg of mutton = LE 6.
DMI = Dry matter intake.
Source: Khamis *et al.* (1989).

Studies on processing of unpalatable or less-palatable shrubs and semi-shrubs to produce improved feeds and upgrade their palatability and feeding value were carried out within the last few years (El Shaer *et al.* 1990, 1991). A number of results were obtained from these studies. For example, ensiling salt marsh plants as *Halocnemum strobilaceum* with broiler litter and molasses (Table 36) increased their acceptability and intake of goats by 13% than the controlled animals fed traditional diets (El Shaer *et al.* 1990). Judging from the nutritive value and consumption of such silage and other salt marsh plants with broiler litter silage, they would be of great value as they would participate in alleviating feed shortage in such areas. These results would suggest that such types of silage are potential sources for supplementary feeding for sheep and goats.

Table 36. Performance of sheep and goats fed *H. strobilaceum* and broiler litter silage (HS + BL silage) and the control diet (berseem hay).

Item	Sheep		Goats	
	Berseem hay	HS + BL silage	Berseem hay	HS + BL silage
Average daily gain (g)	71.6	73.3	65.0	71.7
Average daily DMI (g/kg $W^{0.75}$)	70.8	74.3	66.2	77.0
Feed conversion ratio:				
kg DM feed/kg gain	14.0	14.2	11.1	11.9
kg TDN /kg gain	6.88	7.78	5.67	5.89
Feed cost (LE/kg gain)	3.79	1.21	3.02	1.01

DM = Dry matter; TDN = Total digestible nutrients.
Source: El Shaer *et al.* (1991).

Financial Considerations: Costs and Returns

Structure of Agricultural Activity

The main types of agricultural activity in the Northwest Coast are:

- Grazing by sheep, goats, and camels.
- Dryland farming, mainly barley and wheat.
- Horticultural enterprises, mainly fruit trees in selected valleys with deep soil and supplemental water.

Animal husbandry, based on sheep and goats, in combination with barley cultivation, is the main integrated production system. Table 37 shows the sizes of various farm types in the Western Province.

Table 37. Characteristics of small, medium and large farms in the Western Province.

Farm type		Size			No. of sheep	No. of goats	Barley (fed)	Fruit (fed)
		Area (fed)	No. of farms	Frequency of farm type (%)				
Small	Without trees	< 10	< 20	50	7	3	75	
	With trees							1/3 fig
Med.	Without trees	10–50	20–100	40	45	15	30	
	With trees							2 fig
Large	Without trees	> 50	> 100	10	150	50	85	
	With trees							4 fig, 12 olive

1 ha = 2.38 fed.

The data show that the small and medium-sized farms represent about 90% of the total farms in the region. Farm components are similar, with some variation according to farm size. Olive trees are prominent on large farms.

Crop Costs and Returns

Costs and returns of agricultural production have been calculated on the basis of field interviews with nine farmers from three different locations in Matrouh governorate. In each location three farm categories were represented: small, medium, and large. Additional statistical data were used to estimate value added and average farm income per feddan.

Exchange rates from 1990 were used for six crops: wheat, barley, watermelon, melon, fig, and olive (Table 38). For each crop, seven indexes were calculated, including acreage, yield production, farm-gate price, output value, input value, and value added.

For wheat, the total acreage was 67,069 fed (28,180 ha). The seed yield was 0.45 t/fed, straw 0.375 t/fed, and aftermath 0.125 t/fed. Multiplying these indices by acreage, the total production for wheat was 30,181 tons seed, and 33,534 tons straw and aftermath. Farm prices were LE 467 per ton for seed, and LE 100 per ton for straw. Output values were computed by multiplying farm-gate price by total production. The output value for straw and seed was LE 17,448,000.

Table 38. Output values and value added for the main crops of the Northwest Coast (1990).

Item	Wheat	Barley	Watermelon	Melon	Fig	Olive
Acreage (fed)	67079	64028	5508	1109	15320	11017
Yield (t/fed)						
Seed	0.450	0.420	2	1.5	4	1.6
Straw	0.375	0.500	-	-	-	-
Aftermath	0.125	0.125	-	-	-	-
Production (t)	-	-	11016	1664	61280	17627
Seed	30181	26892	-	-	-	-
Straw	33534	40018	-	-	-	-
Output value (1000 LE)	17448	17448	3305	499	30640	6610
Input value						
(LE/fed)	31.4	31.4	51	51	40	46
% of total cost	25	25	52	52	14	22
Total input value (1000 LE)	2106	2010	281	57	613	507
Value added (1000 LE)	15342	15438	3024	442	30037	6105
Avg. farm income (LE/fed)	229	241	549	398	1960	554

1 ha = 2.38 fed.

Input values per feddan were calculated by totaling the cost of seed, fertilizer and depreciation, which for wheat was LE 31.4 per fed. Total input value was also computed by multiplying input value per feddan by acreage. Total input value for the wheat area was LE 2,106000, which represents 25% of the total cost. Subtracting total input value from output value yields the value-added index, which for wheat was LE 15,342,000. The average farm income was calculated by dividing the value added by the acreage. An average farm income per feddan was derived, which for wheat was LE 229.

Similar calculations were made for the rest of the crops. The highest average farm income per feddan was for fig, a total of LE 1,960. For another field crop, barley, it was LE 241.

Livestock Costs and Returns

Calculations have also been made to determine output and value-added indices for livestock production. First, the number of ewes and does was calculated, as well as their off-take, to provide a base for further calculation.

The number of ewes in the Northwest Coast in 1990 was 311,516 and the number of does was 145,033 (CAPMAS 1990). An off-take index representing the percentage of offspring was 78 and 108 for ewes and does, respectively (El Serafy *et al.* 1992).

The total off-take number, which was derived by multiplying the index by the total number of ewes and does, was 242,982 for ewes, and 156,636 for does. From the field interviews, it was determined that 65% of ewes were exported and 35% were consumed locally. Fifty percent of does were exported and 50% were used for local consumption.

The average yield of salable sheep by-products was 2.5 kg/head/yr for wool, 10 kg/head/yr for milk, and 48 kg/head/yr for manure. Values for goats were 0.25 kg/head/yr for hair, 30 kg/head/yr for milk, and 39 kg/head/yr for manure.

Secondly, farm-gate prices were determined, on the basis of a 1990 exchange rate of LE 2.8 per US dollar. Marketing cost, which was based on field interviews, was set at 10% of export price (applicable only to export). Consequently, farm prices were calculated by subtracting marketing cost from export price.

The average farm-gate export price was found to be LE 200 per head for goats and LE 260 per head for sheep. The average farm-gate price for local consumption was found to be LE 80 for goats and LE 110 per head for sheep. Farm-gate prices of salable sheep by-products were LE 1.00 per kg for wool and LE 0.10 per kg for manure. The input value of livestock production was estimated as follows:

- The cost of feed for 100 ewes and 100 goats is LE 9,500 and LE 7,600 per annum, respectively.
- The cost of water for 100 sheep and goats is LE 200 and LE 160 per annum, respectively.
- The cost for veterinary services for 100 sheep or goats is LE 120 per annum.
- The input value for 100 sheep is LE 9,820 per annum and for 100 does, LE 7,880 per annum.

Output Value and Value Added for all Farm Products

Total output and value added in the Northwest Coast for all farm products (including sheep, goats, watermelon, melon, fig, olive, wheat, and barley) is presented in Table 39. The table shows that livestock production from sheep and goats represents 52% of output, fruit trees 24%, field crops 22%, and vegetables 2% of total value in Matrouh governorate. Income from farm production is derived from sheep, goats, barley, wheat, fruit trees, and vegetables; livestock production from sheep and goats contributing 36% of the earned income. Therefore, livestock production represents the main source of family income. Fruits trees contribute 33%, field crops 28%, and vegetables only 3% of farm income. Fig is the biggest income producer, at 27%.

Table 39. Value of production and value added from main crops in Matrouh governorate (1990).

Item	Output value (1000 LE)	%	Value added (crop income) (1000 LE)	%
Sheep	64561	35	23970	22
Goats	26711	17	15282	14
Total livestock	81272	52	39252	36
Watermelon	3305	2	3024	3
Melon	499	-	442	-
Total main vegetables	3904	2	3466	-
Fig	30640	20	20027	27
Olive	6610	4	6103	6
Total fruits	37250	24	36130	33
Wheat	17448	11	15342	14
Barley	17448	11	15438	14
Total main crops	157222	100	109628	100

Incidence of Poverty and Distribution of Income

The lower limit of income is defined as the minimum with which a household can survive at the most rudimentary level. The upper level is defined as that which is necessary to attract and to keep a small holder in the area. In order to determine the minimum level of household income necessary for survival, the *poverty line* concept has been adopted. This concept is based on the minimum per capita requirements. The minimum annual per capita income is about LE 495. It is estimated that more than half of farm households may derive one fifth of their income from sources other than their farms.

A good year's income from a typical small farm without fruit trees falls below both the upper and the lower poverty lines. Fruit trees bring the small farm income above the lower poverty line but still below the upper poverty line. More than half of the time, the poorest households struggle on farm incomes well below the poverty line. In a low rainfall year, a majority of medium farm households are brought close to the poverty line. Only 10% of large farm households are secure in their farm income.

The per capita farm income on 50% of households on small farms is likely to be between one quarter and one third of the 1989 national average. Forty percent of medium farms have a per capita farm income equal to or 1.5 times the national average. The 10% of farms, which are large probably, have a per capita farm income 3.5 to 5 times the national per capita income.

Market Study

Literature pertinent to markets and marketing of barley, olive, fig, sheep and goats in the Northwest Coast are scanty or non-existent. Therefore, the following represents an overview of previous efforts directly or indirectly related to the Matrouh Resource Management Project (Mansour 1992).

Assessment of Production

Marketing of the current barley, olive, fig, sheep and goat production can be handled by existing marketing arrangements. Other products, including additional quantities of currently produced products and any new product for export, will require additional facilities.

The potential barley area in the Northwest Coast is 200,000 fed (84,033 ha). At present, the barley area ranges from 80,000 to 120,000 fed (33,613–50,420 ha), depending on rainfall. The present yield varies between 300 and 800 kg/fed grain and 250-500 kg/fed straw. However, with improved water-harvesting techniques, the potential grain yield could reach as high as 1,000 kg/fed (Noaman *et al.* 1991). This demonstrates a very large scope for improvement. Higher yield could be achieved through improved integrated management, including improved water harvest (NVRP 1993).

The main vegetables cultivated under rainfed conditions are watermelon, onion and tomato. The area under these crops is 1,000–3,500/fed (420–1,470 ha), depending on rainfall.

The Role of Agricultural Cooperatives

There are 58 local cooperatives in Matrouh governorate. Most farmers are members of local cooperatives, though Bedouins who do not own flocks may also be members.

The central cooperative is located in Marsa Matrouh and supervises the branches spread throughout the governorate. The cooperative is engaged in providing farmers/grazers with effective methods of crop and livestock production. In addition, it distributes seed and helps with mechanization of farming operations. The central units also market crops and animal products on behalf of producers.

Markets and Marketing Channels

Markets

The data from the Chamber of Commerce of Matrouh states that there are about 5,600 traders in the governorate. Out of this total, 3,500 traders are registered as formal traders, while the remaining 2,100 are informal. The formal traders are distributed in the various districts as follows:

District	No. of traders
Matrouh	1,200
El Salloum	100
Sidi Barrani	98
El Dabaa	136
El Hammam	252
Burg El Arab	135
Siwa	85
Unspecified	1,464
Total	3,500

No statistics are available on the distribution of the informal trading sector among the various districts. The total number of traders dealing with livestock is not known.

Animal market

The animal market is open daily except Friday from 7:00 to 10:00 a.m. About 300 head per day are bought on average.

Vegetable market

The vegetable market is located in the center of the town. The vegetable market's prices are supposed to be controlled, but these controls are not very tight.

Farmer's market

A farmer's market takes place regularly and is organized in the center of the town. This market can be closed down at the whim of the owner of the space where it is held.

Other markets

The Ministry of Supply runs three consumer cooperative shops in Matrouh. These shops supply goods such as meat, cheese and cottonseed oil, but no fruits or vegetable. For most of the commodities the price difference compared to the private shop is not remarkable.

During harvesting, additional traders enter the region. They may be on the farm, in the field or in the town where farmers bring their produce.

Matrouh Market Characteristics

Need for integrated program

Marketing exists from the planning of production to meet market demand, through the various transport, wholesaling and processing phases, to retail distribution. A basic difficulty impeding improvement in outputs and quality of farm products, and in the prices obtained, is the large number of small independent enterprises involved in the production and marketing process. It is difficult to obtain uniformity from a large number of small farmers, and uniformity is essential for presentation to consumers in an attractive form.

Market information

Inadequate information on current market *conditions* is another characteristic weakness in the Northwest Coast. It arises mainly from the large number of small Bedouins involved, their scattered nature, weak communication systems, and illiteracy.

Marketing infrastructure

There is little organized marketing of agricultural commodities produced in Matrouh. There is an urgent need for small-scale agro-industries to be established to process the expanding production of olive, fruit, and vegetables.

Communications along the coast are excellent, with a single railway line and a new highway that has connections to beach areas, which are being extensively developed for tourism. There is also an excellent asphalt road to Siwa Oasis from Matrouh. There are some dirt roads in poor condition.

Electricity is supplied from local generating plants in Marsa Matrouh and Sidi Barrani. Otherwise, no public services are available.

Transport

Transport is a major problem, because the region lacks capacity. The real beneficiaries, from a marketing point of view, are traders from outside the area who have easy access and meet the farmers without competition. Lack of transportation is often responsible for high marketing costs and for the continuance of subsistence farming.

Handling, grading and packing

Serious losses result from careless treatment in packing, transport, and market handing of fruit and vegetables. Losses of 20–50% for most fruit and vegetables occurs because of spoilage from poor handling, inadequate transport, and lack of cooling facilities. Quality improvement is hampered by the pricing system employed at the farm level. No well-established grading system exists.

Storage

Storage facilities for holding crops and farm inputs are insufficient. Generally speaking, storage facilities are inadequate, especially at the district level. There are some cold storage facilities attached to cooperatives to hold some vegetable and fruit crops. Refrigerated storage facilities to accommodate relatively small quantities of different perishable products is one of the technical and economical marketing needs.

Processing

Two levels of processing are carried out in the governorate, household and small industry.

The preparation of salted table olives (pickling) can be done at the household level. Processing of wool can only be done at the small industry level. In El Qasr, the governorate has tried to run a wool processing chain, but it has been closed down after some months.

Most of the figs produced are sold fresh, either in the local markets in Marsa Matrouh or shipped to Alexandria and Cairo for sale in wholesale markets.

The feasibility of drying figs and grapes given the climate of the Northwest Coast has not yet been determined.

Domestic demand

Olives. There is a steady demand for olives and olive products from the middle and upper income brackets. The Kroom Company runs an oil mill in Marsa Matrouh, which is supplied by the central cooperative and has capacity for raw material processing of 1,000 t/year for oil olives and 1,000 t/year for table olives.

Figs. Most fresh figs are sold as grade "1" to traders, while the remainder goes to the industry for processing.

Grapes. Egypt is a net importer of dried grapes, but imports were cut in half between 1984 (3,300 t) and 1986. Domestic production is estimated at 90 t/yr.

Almonds, apricots, and barley. The cooperative will only handle large quantities when the supply is big and prices are low.

Sheep. Sheep are the most important export commodity of the region. The domestic market is supplied via the animal market. Bedouin sheep have a particular taste which is very much appreciated by the Saudi Arabians.

Wool. Two thirds of production is handled by the central cooperative, the rest by the trade sector. All wool processing, including washing, is done outside the region.

Imports

Egyptian olives and olive products face competition from importation, while other products face domestic competition.

Exports

For those commodities which have a production potential within the Mediterranean EU countries, market entry will be difficult, except for early varieties of top quality. The potential for exportation is very limited with the exception of sheep.

Government policies and regulations

There are three areas of market regulation, all of which are being gradually lifted:

- Foreign trade restrictions.
- Production controls.
- Price controls and consumer supply.

Credit and Financial Institutions

The Government of Egypt (GOE) has a national credit policy as follows:

- Subsidized credit is restricted to a uniform maximum limit per feddan.
- Interest rates on all other loans must be moved to market rates.
- Total interest subsidies on all types of farm credit do not exceed LE 105 million per year.

Credit Demand

Characteristics of demand for credit

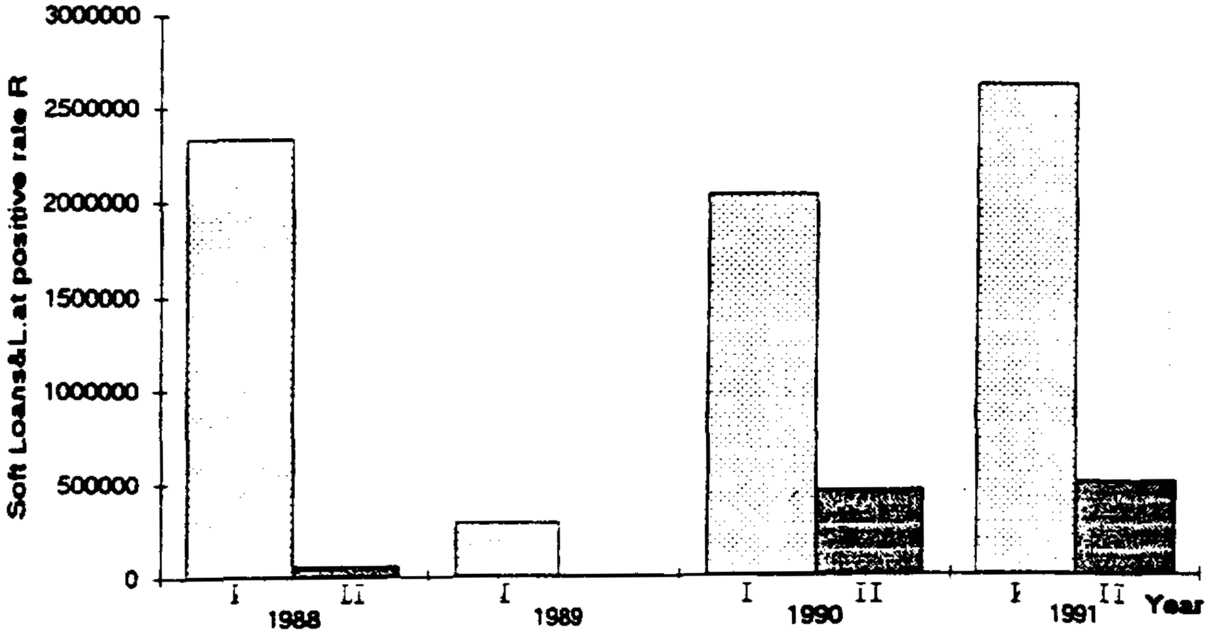
In the Northwest Coast, households need money to continue developing both farm and non-farm activities. The area depends entirely on rainfall, and households must have resources for conservation of water for human, animal, and agricultural use. Water conservation requires money for clearing the Roman cisterns, and construction of new cisterns and dikes. Money is also required to purchase machinery for agricultural production activities, and trucks to transport inputs, concentrates, horticultural products and animals to market. These activities require money on reasonable terms.

There are some international institutions, such as the World Food Program (WFP), Food and Agriculture Organization (FAO), and the Egyptian and German (GTZ) Program working in the Northwest Coast. WFP offers grants to Bedouin producers for the clearing of Roman cisterns, construction of houses, stone dikes, cisterns, and sheds, and development of rangeland. Because of fund limits there is a waiting list, and the Bedouins have to wait before receiving a grant. WFP also offers soft loans to Bedouins for plasticulture production. FAO offers free technical services and also some free inputs, such as fertilizers and herbicides. GTZ offers soft loans in El Qasr (west of Matrouh) to purchase tractors and other machines.

Thus, the inhabitants of the Northwest Coast are accustomed to receiving grants or very soft loans (Figs 24 and 25). But there is an actual need for credit on medium terms to finance activities, especially when grant funds are not available.

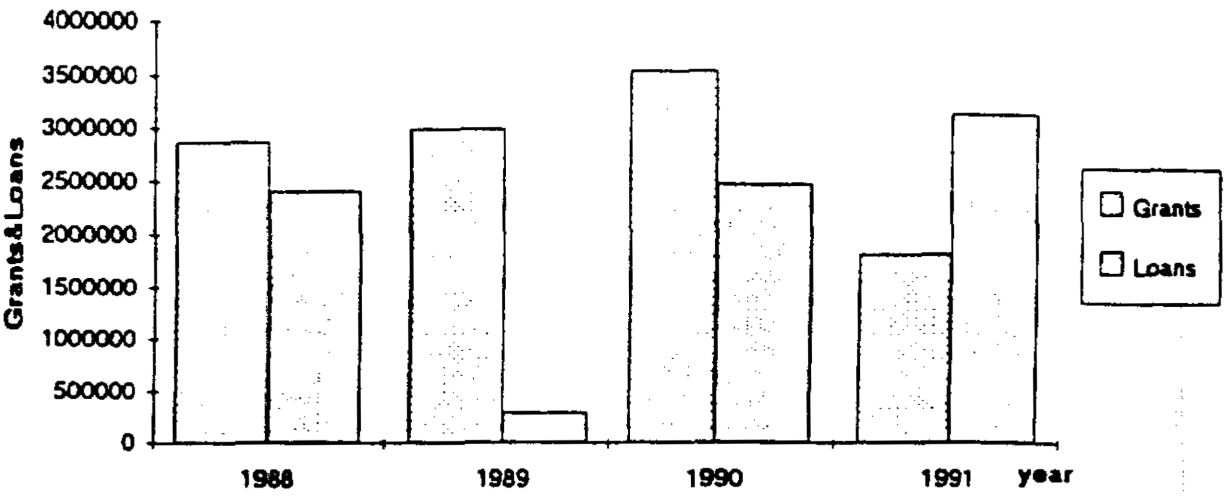
Borrowing behavior

There are no loans approved for plant production activities. Bedouin producers do not request such loans because they do not use fertilizers. No other short-term loans have been approved. In 1989/90, a loan of LE 22,000 was approved from the Bank of Development and Commerce (BDAC) to 35 Bedouins (LE 17,000 for vegetable marketing to 10 persons, and LE 5,000 for raising rabbits to 25 persons). In 1990/91, GTZ approved a soft loan of LE 4,000 to a veterinary drug store, and BDAC approved a loan of LE 7,805 to 29 Bedouins. Most loans approved are medium-term loans, through the Matrouh central cooperative. Some loans have been approved for women, one for rabbit raising and another for a veterinarian.



I: Loans approved for Bedouin producers from GOE, WFP and GTZ; II. Loans approved for Bedouin producers from BDAC.

Fig. 24. Soft loans vs loans (LE) at a positive interest rate in Matrouh governorate.



I: Grants from WFP and GOE funds; II. Grants from BDAC, WFP and GTZ funds.

Fig. 25. Loans vs grants in Matrouh governorate.

The commercial banks in Matrouh are the Misr Bank and the Cairo Bank. These two banks do not approve loans for agricultural activities. A third bank is the National Bank. In 1991 the banks approved loans totaling LE 126,000 for sheep fattening to 16 Bedouins. Most of the commercial banks provide loans for commercial activities. There is a need for loans to small-scale enterprises and businessmen for input distribution, olive and fig marketing, sheep and goat marketing and exporting, workshops for machinery repair, fuel stations, veterinary drugstores, and agro-processing projects. The Government policy is to encourage the private sector to participate in agricultural activity, with loans at market interest rate.

Saving Pattern

The Bedouins' income changes from one year to another and from place to place according to rainfall. This affects Bedouin savings to a great extent. Most Bedouins keep their savings at home rather than in banks; they do not accept interest because of Islamic belief. The householders use their savings as working capital for farming and non-farming activities; they also lend to their relatives or use it in lean years. The householder considers his savings a secret. Some use their savings in commercial activities by themselves or in partnership. Cooperatives are not allowed to maintain savings deposits or current accounts.

Formal Lending Institutions

- Matrouh BDAC.
- Matrouh commercial banks (Misr Bank, Cairo Bank, National Bank).
- GOE, WFP, FAO and GTZ grants and soft loans to Bedouins through: Matrouh Central Cooperative or local cooperatives.

Matrouh BDAC

Matrouh BDAC is a sub-branch of the Alexandria branch, established in 1962. It owns a 279 m^2 building in Matrouh City, consisting of three floors, with 10 offices on the ground and first floors and a guest house on the second floor. The staff includes 14 persons.

BDAC credit policy

The bank follows the national credit policy:

- The bank approves short-, medium- and long-term loans according to the nature of the activity.
- The bank charges market interest rates.
- Subsidized credit is restricted to main crops with uniform maximum limits per feddan.
- Credit manuals are being developed to simplify procedures.
- New credit lines are being established for finance business borrowers for farm-related business activities.

Loan terms

- Short-term loans: less than a year.
- Medium-term loans: one to five years.
- Long-term loans: more than five years

Figs 26 and 27 show the BDAC loan categorization.

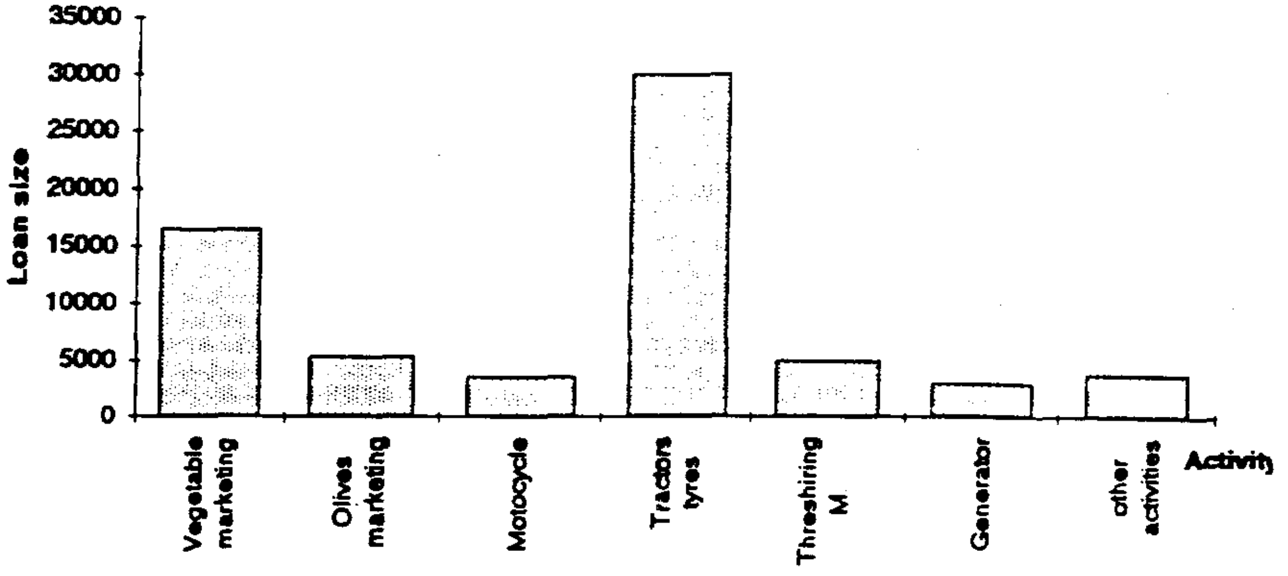


Fig. 26. Short-term loans for Bedouins from BDAC.

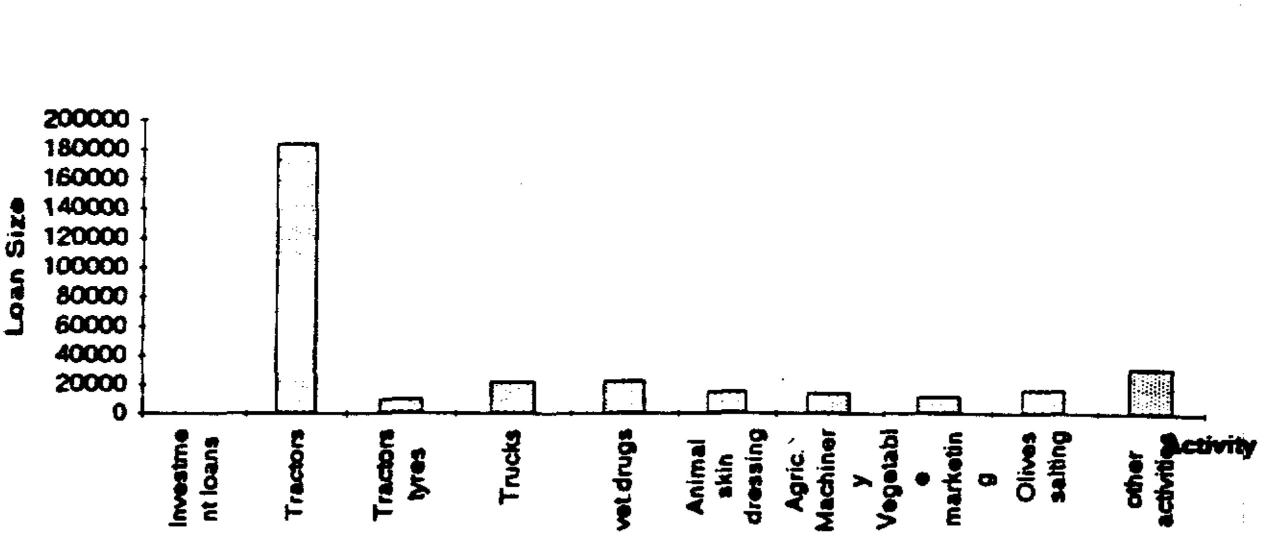


Fig. 27. Medium-term loans approved for Bedouins from BDAC.

Credit guarantee policies

The bank approves plant production loans to farmers with a crop production guarantee according to the bank board of directors directive of 22 October 1953. Loans are given to the landlord, or a tenant if he or she has an agricultural tenure card. For medium- and long-term loans, the bank provides loans against collateral.

In 1980 the BDAC began to offer credit to businessmen and food security projects.

Matrouh commercial banks

In Matrouh governorate there are three commercial banks, Misr Bank, Cairo Bank, and the National Bank, where the three banks are branches. The main activity of the banks is lending for trade activities; very little money goes to the agricultural sector.

GOE and WFP project

The project is carried out by the Egyptian Government and the WFP to help Bedouin settlement in the Northwest Coast. The project ran from 1977 to 1981, with the WFP contributing a grant of US$ 4.51 million, and the Government LE 2.66 million. The project was extended to 1987 (with the WFP contributing an additional $ 13.38 million and the Government of Egypt an additional LE 11.00 million), and again to 1991.

The project offered grants to Bedouins for:

- Housing construction.
- Clearing of Roman cisterns.
- Cisterns construction.
- Stone dikes construction.
- Sheds construction.
- Rangeland development.

FAO

The FAO project in the Northwest Coast offers free technical assistance to Bedouin producers for plasticulture.

GTZ

The GTZ project offers soft loans to Bedouin groups to purchase tractors. The Bedouins pay 17% of the price as a down payment.

The project also offers free technical assistance for new trees planting irrigation systems.

Matrouh Central Cooperative

The Matrouh Cooperative was established in 1963, with 61 local cooperatives spread throughout the governorate. The Board of Directors consists of seven members representing all governorates, districts, and tribes. The local cooperatives have six major branches spread throughout the districts.

Informal Lending Institutions

- Family lending.
- Local vegetable merchants.
- Cairo and Alexandria fruit wholesalers.
- Agro-processing factories.

Family lending is needed to cover operating costs for various activities, especially in the absence of formal lending institutions or when loans are not sufficient. Family lending is always free with interest charged.

Bedouins' Attitudes toward Loan Interest

Bedouins consider interest on loans to be *reba*, i.e., where the lender earns money on the loan, which the *shariaa* unequivocally prohibits.

There are two form of loan guarantees in Matrouh governorate as follows:

- The well-to-do can secure loans against assets.
- The poor ask that their brothers, parents or other kin co-sign with them. Many of the poor feel that they would ask the *Omda* to co-sign with them.

If a payment schedule is disrupted by drought or epidemic, loans must be rescheduled.

Loan Risks among the Poor

In the Northwest Coast there are special circumstances that affect high risks credit demand:

- Tribal structure.
- Settlement of the Bedouin population.
- Absence of formal ownership of land and collateral.
- Climatic and disease problems.
- Weak technology-base for rainfed agriculture.
- Rainfed agricultural production levels.
- Marketing risks.
- Management and staff limitation.

The poor Bedouins do not want to ask for a loan. They cannot reasonably be expected to repay the loan with the output for which the loan was sought. There is a keen sense of realism, and a desire to use the loans wisely. Their willingness to have co-signatories and to involve their families in guaranteeing the loan is a good indicator of their commitment to repay.

Conclusions

- The Northwest Coast has special circumstances that affect credit demand.
- The existing financial institutional capacity for supplying credit to households and businesses for agricultural and non-agricultural activities is still well below demand.
- There is a need to strengthen the interrelationship between adoptive research, extension, training, veterinary, credit, and marketing entities in the project area. This is a need to improve Bedouin productivity and net income and decrease credit risks.
- Establishing a local community association would be helpful to decrease credit risk. A community is defined as a blood-related group living in a specific geographical location. Free technical assistance in the project area would be helpful.
- Interest rates must be restricted to production activity revenue to increase Bedouin participation.

Institutions and Support Services

Social Services

Education

Published data for educational services in Sidi Barrani and El Salloum indicate that the number of elementary and secondary schools is 36 and 2, respectively. These schools serve about 26,000 children.

Interviewing the Bedouins revealed that education facilities are insufficient to meet their growing need for education. Lack of teachers is the main problem facing the expansion of schools. On other hand, education is book-centered, which does not help the students to know how to participate in activities in community life. There is no provision for adult education to help bridge the gap between aspirations and realities.

Health

There is only one hospital with 24 beds in Sidi Barrani serving about 26,000 inhabitants. The number of outpatients in Sidi Barrani hospital was 21,000 in 1986, while the number of in-patients was 480.

Although the Bedouins interviewed in Sidi Barrani said that medical care at Sidi Barrani hospital was adequate, they prefer traveling to Marsa Matrouh.

Welfare services

The Ministry of Social Affairs and Insurance has a department located at Marsa Matrouh. Its activities are directed to social welfare services and income-generating projects, particularly for low-income households. These two objectives are pursued through the following activities:

- Awarding of pensions and subsidies.
- Assistance to private voluntary societies for social welfare.
- Pre-vocational training for boys and girls.
- Rehabilitation of the disabled.
- Child care, mainly through nursery schools.
- Family planning.
- Adult education.
- Women's associations.
- Assistance of families to start small industries or businesses through the Productive Families project.

Cooperatives

Two types of cooperative societies exist in Matrouh governorate. The first is the agricultural cooperative society, which provides Bedouin producers with agricultural goods and services. The second is the productive cooperative, which serves non-agricultural activities.

Agricultural Support Services

Research

The Ministry of Agriculture and Land Reclamation (MALR), through the ARC and the Desert Research Center (DRC), is the main institution with a permanent rudimentary presence in the area. The ARC Matrouh Agricultural Research Station (MARS) at El Qasr has five technical staff concerned with field and horticultural crop research. The site occupies 10 fed (4.2 ha), but the only developed facility is a small fruit tree nursery. The majority of fruit tree seedlings planted in the project area continue to be supplied from the long-established Burg El Arab station east of the project area. The research activities of the station are not linked into a comprehensive agricultural development program in which farmers might gain access to inputs and information and at the same time bring their technical problems to researchers for investigation. DRC has a 40 fed (16.8 ha) research station at El Gharbaniat in the eastern Zone I. The main activities are related to irrigated fodder crops and shrub species. Other activities are related to salt-tolerant and drought-resistant species of fodder and field crops. DRC also sponsors research medium- and long-term projects related to assessment and management of plant, animal, soil, and water resources.

Extension

Extension services are provided in the Northwest Coast through the Directorate of Extension Services under MALR, which supervises the work of technical staff at governorate and district levels. Responsibility for the crop extension service has changed hands several times in recent years, and as a result, the Matrouh Development and Reconstruction Sector (MDRS) continues to provide extension support, especially to farmers involved in the development programs supported by FAO, WFP and German funding.

Only 13 of the 60 established posts for extension agents are currently filled (Table 40), and staff are not linked to a systematic program of support for farmers. Nor is there any formal mechanism to link the technical information being promoted with sources of funds for inputs. As a result, the impact of the extension services on production has been small and generally restricted to demonstration of cultivation practices for horticultural crops planted in association with the installation of water harvesting and storage structures under grant aid projects.

Table 40. Extension service personnel in the Northwest Coast

Post	No.	No. actually present			Duty station	Required qualification
		Men	Women	Total		
Director of Extension	1	1	-	1	MM	Ag. grad. + 14 yr exper.
Heads of Divisions						
Horticulture	1	1	-	1	MM	Ag. grad. + 8 yr exper.
Animal production	1	-	-	-	MM	Ag. grad. + 8 yr exper.
Programming	1	-	-	-	MM	Ag. grad. + 8 yr exper.
Rural development	1	-	-	-	MM	Ag. grad. + 8 yr exper.
Ag. Councils	1	1	-	1	MM	Ag. grad. + 8 yr exper.
Extension aid equip.	1	1	-	1	MM	Technical High School
Asst. Dir. of Extension	7	7	-	7	Districts	Ag. grad. + 8 yr exper.
Extension Deputy	7	7	-	7	Districts	Ag. grad. or Ag. High School + experience
Village Extension Agent	60	10	3	13	-	Ag. grad. or Ag. High School + experience
Agric. Council Secretary	6	1	-	1	-	Ag. grad. or Ag. High School + experience

MM = Marsa Matrouh.

Training

There are no agricultural training establishments in the Northwest Coast. Training is either done outside the area in centers, such as the DRC and ARC, specializing in different disciplines or commodities, *in situ* in the Northwest Coast (mainly for the farmers), or abroad (mainly for the trainers themselves). Farmer training has been largely affected by independent budgets associated with international aid agencies. Due to the lack of systematic extension, training has often had only marginal relevance to the farming system in the area and has had little evident impact on production.

Threats to Sustainability

The Northwest Coast is a coastal desert ecosystem with fragile natural resources. The management of these resources and their productivity face several constraints. Many of these constraints have a strong bearing on the sustainable development of the Northwest Coast. Proper identification and assessment of these constraints is essential for the success of research and development activities in this region. The constraints in the Northwest Coast could be categorized as physical, technical, social, and institutional.

Physical Constraints

The major physical problems are the amount, distribution and reliability of rainfall in relation to the distribution of cultivable soils, and the technical and economic feasibility of increasing the efficiency of water use. The mixed production system is based on a fragile environment in which the use of natural resources has increased due to the sedentarization and concentration of the population. Various techniques have now been introduced to increase the use of rainfall. However, it is clear that considerable volumes of rainwater presently remain unused each year and are lost through a combination of evaporation, seepage and runoff into uncultivable *wadis*.

The increased installation of water harvesting and storage structures has undoubtedly raised total production of cereal and horticultural crops and led to a continuing expansion of the cultivated area. However, in view of the fragile nature of the environment, it is questionable whether a continued expansion of cultivation, to a level attainable only on the basis of the technical feasibility of water harvesting, would be sustainable over the long term. Further, the expansion of cultivation would be at the expense of the remaining rangeland and would have implications for the viability of an animal production element in the mixed farming system in its present form—an issue likely to be of major social concern to Bedouin pastoralists.

The soil resources are invariably characterized with low fertility. Very low organic matter content, low supplying power for most macronutrients (N and P) and micronutrients (Mn and Zn) are common features for calcareous and course-textured non-calcareous soils. Fertilizer use is very limited under rainfed conditions. Appropriate means and techniques are needed to remedy the low soil fertility.

The soil in the region faces the dynamic problems of water and wind erosion. The main factors conducive to soil degradation are natural as well as human-induced due to soil cover eradication. Conservation practices need to be elaborated based on an integrated management approach including soil, water, plant, and animal resources. The trade-off relations between agricultural expansion and resource conservation should receive maximum consideration.

In conjunction with the expansion of cultivation, the level of mechanized land preparation has also increased to a point where only a few farmers continue to use animal draft power. The higher number of tractors has enabled larger areas of cereal land to be prepared. Access to additional tractors for use by groups of small farmers could improve the timeliness of cultivation, but the methods of plowing, and the levels to which tractors become available, need to be carefully monitored in view of the potentially adverse effects of mechanized cultivation on soil structure. The unpredictable rain gives a perceived urgency to land preparation for planting. Soils are therefore often plowed when too wet and sticky, thereby damaging soil physical characteristics and increasing the risk of soil loss through subsequent wind erosion.

Land degradation and resource depletion (e.g. loss of biodiversity) through overgrazing are major environmental problems confronting the region. Pastoral regions, in particular, have been affected by land degradation. This is reflected in the loss of carrying capacity, widespread soil erosion by wind and water, and a greater vulnerability to recurrent drought. This decline in productivity has affected the livestock owners, who face several complex problems simultaneously:

- Maintaining enough stock of the right age and sex to allow for recuperation in dry times and to provide a steady production of food.
- Producing enough food to support enough labor through all seasons to maintain the herd/flock.
- Keeping the younger generation motivated and educated for pastoralism.
- Maintaining access to pastures and stock water.
- Maintaining the necessary social relations that can offer "insurance of capital" and supplementary food in times of need.

Technical Constraints

Technical factors limiting crop production include the low inherent yield potential of crop varieties currently cultivated, the husbandry practices adopted for specific crops in the context of a mixed farming enterprise, and methods for harvesting and post-harvest handling of produce with respect to optimization of both crop quantity and quality.

Only limited attention has so far been given to the development of varieties and technologies appropriate for rainfed farming in marginal areas. Considerable scope exists for the continued improvement of planting materials and husbandry practices, particularly in relation to the crop-water balance, the identification of crop maintenance techniques for sustainable use of land under continuous cultivation, and post-harvest handling.

Where improved varieties have been identified and introduced for both barley and wheat, no formal follow-up has been made by the extension service of their spread and impact on productivity or overall production. In addition, the extension service is not in a position to provide the necessary educational support needed to train farmers to protect improved seed from adulteration with local seed in order to maintain identity and yield potential.

It is necessary to develop research priorities to address the production constraints of the region. Multi-disciplinary research teams from different research institutions and universities outside of the governorate and staff of the Ministry of Agriculture in the governorate should be established. Given the complexity of dryland farming systems, greater financial support is required.

Socioeconomic Constraints

The Bedouin society is governed by long-established traditions which continue to have a major impact on the adoption of unfamiliar crop and animal production practices. The strictness of social and cultural codes may be interpreted as limiting the rate at which innovation can be introduced and frustrating the efforts being made to ensure stable and sustainable agricultural development.

There is little organized marketing of agricultural commodities produced in Matrouh governorate. Private traders are able to exploit the situation to their advantage. The principal agricultural output is lambs, cull stock, fig, and olive oil. There is little structure to the market system and producers tend to sell on an individual basis to a trader. There are various markets operating in the governorate, the biggest being at El Hammam, close to the border with Alexandria governorate. Wool producers receive a poor price because wool is presented for sale in a dirty and ungraded condition and frequently contains sand and foreign matter. There is also an urgent need for small-scale industries to process the rapidly expanding production of fruit, vegetables, and olives for oil.

Agricultural development in the governorate has been constrained due to insufficient financial support. Until 1989, the DBAC did not operate in the region. The extent of credit for agricultural activities remains minimal. So far, there is no major international co-financing to support agricultural development of the region. Farmers, especially the poor, will not pay interest.

- Other social constraints include the following:
- Mobile nomadic community, some rural households still rely on tents as their only source of shelter.
- Only 50% of farmers on medium and large farms are likely to be prosperous enough to have adequate surplus for investment.
- Each tribe has established itself on a specific area in the desert and maintains exclusive right to it.
- The enrollment of boys and girls in Matrouh primary schools was 67 and 34%, *respectively, in 1980, while it was 91 and 60%, respectively, for rural Egypt* as a whole.

Institutional Constraints and Potentials

The majority of government support to the agricultural sector has so far been directed to the development of the Nile Valley and Delta, thus focusing on the needs of irrigated agriculture. Support services for rainfed agriculture have received relatively little attention. The under-developed nature of support services in the project area is a reflection of the lesser importance which has been attached to the area's development needs and potentials.

Adaptive research, extension and training facilities exist in the area, but with only a limited infrastructure and very low staffing levels. Interaction between the institutions and the communities is unsystematic and lacks an organized framework in which to operate. As a result, meaningful contact between the technical institutions and Bedouin farmers and the impact of the institutions on agricultural development has been considerably restricted.

There is no systematic program of extension and demonstration in the project area. In the absence of extension, individual farms (usually those who have already exhibited a degree of innovativeness), have been persuaded to accept technology made available on a grant basis, and their farms are then considered demonstration plots. The assumption has been that a minimum level of farm resources is needed in order for technical innovations to be introduced. The outcome has been a concentration of development resources and technical innovation in the hands of a small number of the relatively wealthy farmers. Bedouin tradition is for poorer relatives to be assisted by those better placed. The provision of assets to those farmers with already greater resources may therefore ultimately have a beneficial effect on those with fewer resources.

Recommendations for Future Research

From the agro-ecological point of view, the Northwest Coast is divided into three sections, with different potential:

- Burg El Arab to Fuka. There are no *wadis*, and thus no *wadi* water flow. The main sources of water are rainfall and irrigation water from El Nasr and Bahig canals. This area could be used for experiments on supplemental irrigation and fertilization to maximize crop production. Also, experiments on crop rotations could be established.
- Fuka to El Neguila: This area is characterized by the coastal plain and *wadis* running from south to north. The area receives a reasonable amounts of *wadi* flow. The limiting factor in this area is not the amount of water but water management. Developing *wadi* systems by improving watershed management and conservation tillage operations are the core research activities, in addition to improving field crops and rangelands on the plateau.
- El Neguila to Sidi Barrani: Most of the *wadis* in this area are situated 20–50 km inland. About 80% of the water could be used for improving the integrated barley/livestock-based system and implementing a new crop forage rotation to maintain or increase soil fertility, as well as implementing new small-scale water harvesting techniques on the farm.

Mapping of landforms, topography, soil, and hydrology in these areas would help in the evaluation of water resources, their conservation, and rational utilization. However, information on runoff, a major water resource, is scanty. It is not possible to estimate water availability from climatic data, because it is related to a multitude of factors: rate of precipitation, infiltration capacity, local topography, and moisture content of surface material. These relationships need to be thoroughly studied and detailed topographic maps for the selected sites need to be made to maximize the use efficiency of the available water resources.

Research is also needed on the effect of weather conditions on farming operations (e.g. plowing, sowing, and fertilization), and is also needed to prepare the production probability charts of the major crops in these areas in view of the highly variable climate. Such studies would use the meteorological data on the soil characteristics for constructing simulation models for plant growth, development, and production. This modeling will help raise crop production in the rainfed areas of Egypt.

A suitable land-use system and appropriate cropping patterns should be developed for the different soil types in the selected sites of the Northwest Coast as well as the North Coast of Sinai. Such a land-use system should take into consideration the main environmental variables of each area.

Integrated modeling for the design and implementation of soil conservation measures should be adopted. Innovative models have been published and tested in several areas in the last few years.

The adoption of known technology appropriate to the area, geared to increasing the productivity of existing crops rather than raising production through an expansion of the area cultivated, is recommended. Potentially useful approaches include:

- More widespread use of potentially higher-yielding crop varieties and cultivars which meet the quality requirements for domestic and market consumption.
- Increasing, on a unit area basis, the availability of runoff water and/or the rates and frequency of water from storage facilities.
- Adoption of pruning in fruit trees.
- Manure/fertilizer application to horticultural crops in association with improved water management.
- Mechanized threshing of cereal crops to minimize grain loss.
- Improved timeliness of land preparation for cereals amongst smaller, poorer farmers with restricted access to tractor services.
- Improved timeliness in harvesting horticultural crops and greater selectivity in picking (especially olives) to maximize production and optimize marketable quality.

Rangeland development programs have shown that it is possible to increase forage production in low rainfall areas by grazing control, water harvesting, and the introduction—or re-introduction—of selected annual and perennial forage plants such as *Atriplex*, medics, and local palatable species. The development of rangeland with controlled grazing by sheep kept under semi-intensive systems of management can lead to significant increases in flock productivity in terms of number of lambs weaned, red meat, and milk production. A number of successful schemes have been implemented under similar environmental conditions in North Africa and the Arabian Peninsula.

The establishment of national identity in the Bedouin population is a delicate matter and needs to be handled with great care. It is essential to encourage more participation from the different social classes, leaders and followers, males and females, different generations, and traditional as well as modern leaders. This participation should be phased in as part of the project, with emphasis on the planning phase.

The political relationship between the Egyptian and Libyan Governments plays an important role in the future of this region. This relationship has witnessed many ups and downs. Its impact on the attitude of the Bedouins towards work and choice of occupation cannot be overstressed.

The rate of social change in the area is quite high due to the impact of urbanization; improvement of roads, infrastructure, and communications; tourism; and political and social goals of the Government. Social changes should be the subject of assessment and monitoring.

Coordination and interaction between research carried out in the Northwest Coast and extension services need to be developed and strengthened.

Tailored and well-coordinated training programs should be offered at the various levels of officials and farmers. Such programs should be geared towards dealing with the major problems and constraints prevailing in the rainfed area.

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