HARNESSING SALTY WATER
TO ENHANCE SUSTAINABLE LIVELYHOODS
OF THE RURAL POORS IN EGYPT

EGYPT
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BACKGROUND INFORMATION

1.1 PHYSICAL SETTING

- The Egyptian territory is almost rectangular, with a N-S length of approximately 1,073 km and W-E width of approximately 1,270 km (Figure 1). It covers an area of about one million square kilometers.
- Geographically, Egypt can be divided into four main regions: (i) the Nile Valley and Delta, including El Fayum depression and Lake Nasser; (ii) the Western Desert, including the Mediterranean littoral zone, the oases (Siwa, Bahariya, Farafra, Dakhla and Kharga), Tushka and Uweinat; (iii) the Eastern Desert, including the Red Sea littoral zone and the high mountains; and (iv) Sinai Peninsula, including the littoral zones of the Mediterranean, the Gulf of Suez and the Gulf of Aqaba.
- The country consists of 26 governorates (in addition to Luxor). The total area of the governorates located in the Nile valley and Delta is about 79,000 square kilometers (about 7.9% of the total); while that of the other governorates account for 92%.
- Another possible distinction of regions can be made, as follows:
    - The Metropolitan, including Cairo, Alexandria, Port said and Suez;
    - Lower (the delta) Urban Egypt;
    - Lower Rural Egypt;
    - Upper (the valley)Urban Egypt;
    - Upper Rural Egypt;
    - Border (Red Sea, Sinai, Matruh and New Valley) Urban; and
    - Border Rural.
- The country lies for the most part within the temperate zone. The climate varies from arid to extremely arid. The air temperature frequently rises to over 40^0 C in daytime during summer, and seldom falls to zero in winter. The average rainfall over Egypt as a whole is only 10 mm/year. Along the Mediterranean, where most of the winter rain occurs, the annual average rainfall is about 140 mm/year, decreasing rapidly inland. The evaporation rates are high, being in excess of 3,000 mm/year.

1.2 DEMOGRAPHIC FEATURES

- Egypt's population is about 67.3 million; with 51% male and 49% female and an average growth rate of 1.99% (CAPMAS, 2003).
- The population is unevenly distributed over the country's physical area; which reflects both historical population distribution and the uneven distribution of fresh water resources (general trend).
- The urban population accounts for about 42% (CAPMAS, 2003) and is expected to increase in the future (2017) to 48%; which will pose more pressure on the most populated regions (cities of the Nile valley and delta); thus increasing urbanization and decreasing arable lands.

1.3 SOCIO-ECONOMIC CHARACTERISTICS

- The total Gross Domestic Production (GDP) of Egypt is estimated at L.E. 299,623 million (2001-2002). Agriculture accounts for about L.E. 49,600 million (or about 17%); while it contributes for about 32% of the jobs (The total number of labor force in Egypt is estimated at about 20 million in 2003).

- The main objective for socio-economic development is to enlarge the inhabited space from about 5% (at present) to 25% (in 2017). The main constraint is the availability of resources (water on the top), and main services (roads, housing, schools, health services, etc.).
- The regions suitable for expansion are distinguished according to their comparative advantages. They include:
    1) The desert fringes of West Delta and the Valley;
    2) The Western Desert;
    3) Sinai;
    4) The North coast; and
    5) The Eastern Desert.

1.4 WATER RESOURCES

- The main source of water in Egypt is surface water available from the Nile. *This source of water is totally consumed; being mainly confined to the Nile valley and delta.*
- The second source of water is groundwater in the Nubian sandstone. The aquifer extends over 79% of the country physical area; however, groundwater in such formation is almost non-renewable.
- Other sources of fresh water include rain and flash flood which together amount about 1.5 billion cubic meters per year if properly harvested and conserved.
- Groundwater in the Nile valley and delta can not be considered a resource in itself since the aquifer is recharged as a result of activities based on the Nile water.

> The pressure on fresh water will rise since demands increase whereas the possibilities to augment the supply are fairly limited. Moreover, pollution will increase and some water resources may become unfit for certain uses.

- The situation calls for efforts to augment available water resources to ensure healthy life. This dictates the search for additional water resources. However, due to the limitations imposed on fresh water (Nile water constant and deep groundwater non-renewable), the only way out is the development of non-fresh water in addition to the increase of water use efficiency.
- Increasing water use efficiency is getting high attention at present through various actions, namely through the application of Integrated Water Resources Management (IWRM) and reuse of drainage effluent.
- The Ministry of Water Resources and Irrigation has recently (November 1999) initiated a “Groundwater Sector” to ensure a proper management of fresh groundwater and flash floods along with environmentally safe development and management of non-fresh groundwater.
- Since its establishment, the Groundwater Sector is concentrating on important issues, including:
    1) The state of present groundwater development and management;
    2) Conduction of awareness campaigns for groundwater protection;
    3) Legislative aspects for licensing of wells and pollution control;
    4) Investigation of appropriate technologies for groundwater management, rain water harvesting and conservation of flash flood water; and
    5) Augmentation of the supply.

With respect to Non-Fresh groundwater, a survey has been accomplished covering almost 50% of the country's physical area (accessible area), including data of drillings for petroleum, salinity distribution in water wells, desalination plants on beach wells, etc.
An important factor is the impact of desalination activities (including disposal of brine) on the groundwater salinity.

Table 1. Some Social and Economic Indicators

	Unit	1997	2017
General			
• Population	Million	59.3	83.1
• Urbanization	Ratio	0.44	0.48
• GDP at economic growth of 6%	Billion L.E.	246	789
Economic Development Situation			
• Irrigated area	Million acre	7.985	9.806
• Gross production value	Billion L.E.	34.46	35.27
• Net value per unit of water	L.E./cum	0.64	0.65
• Food self-sufficiency	%	73	40
Social Objectives			
• Create living space in the desert	% total population	1.5	18
• Employment in agriculture	million	5.01	6.20
• Employment in industry	persons/year	2.18	4.99
• Coverage drinking water	persons/year	97.3	100
• Coverage sanitation	%	28	38
Water Availability			
• Nile water	BCM	55.5	55.5
• Deep non-renewable groundwater	BCM	0.7	3.0
• Brackish groundwater	BCM	0	2.0
• Supply/demand ratio agriculture	%	1	0.86
• Supply/demand ratio domestic	%	1	0.64

1.5 WATER WRIGHTS

- Water wrights depend on the regions (location) and source of water. In the Nile valley and delta, where the major portion of available fresh water allocated to agriculture is surface water, water wrights depend on land ownership, the area cultivated, type of crop and availability of water (which might change according to location of parcel and water diversions, etc.). This situation creates conflicts, especially between owners located at the head of the system and tail Enders.
- Tail Enders may be obliged either to drill a well (drilled on their own expenses) or reuse drainage water.
- In areas depending on groundwater, the licensing system ensures water wrights.
- In the deserts, the present system of water wrights is highly dependent on indigenous culture (cases of oases and wadis); where ownership of water is very recognized.
- In the desert regions, where investors are the main users of water, water wrights are based on the license of wells (potential and sustainability of groundwater).

AVAILABILITY OF NON-FRESH GROUNDWATER AND OTHER SOURCES OF SALINE WATER

2.1 CHARACTERISTICS OF MAIN AQUIFER SYSTEMS

- The Hydrogeological framework of Egypt comprises six main aquifer systems (RIGW, 1993, updated in 1999), as shown in Figure 2. These are:
  1) The Nile alluvium;
  2) The Nubian sandstone;
  3) The Moghra;
  4) The coastal and wadi aquifers;
  5) The karstified carbonate; and
  6) The fissured and weathered basement rocks.
- Characteristics of aquifer systems differ greatly in terms of extension, transmissivity, renewability, groundwater quality, etc. (see Table 2).

Table 2. Characteristics of Main Aquifer Systems in Egypt

Aquifer	**Location**	**Top of aquifer (m+msl)**	**Saturated thickness (m)**	**Depth to groundwater (m)**	**Transmissivity (seqm/day)**	**Salinity (mg/l)**
Nile valley & delta	Valley South delta North delta	0-20 0-20 0-100	10-200 100-500 500-1,000	0-5 0-5 0-5	5,000-10,000 5,000-10,000 5,000-25,000	<1,500 <1,500 >5,000
Coastal aquifers	Med coast Qaa plain Arish	0 50-100 15-30	<5 60-80 40-50	15 50-70 0-30	 300-800 200-1,000	>5,000 1,000-6,000 600-2,500
Nubian sandstone aquifer	Siwa Kharga Dakhla Farafra Baharyia E. Oweinat East. desert Nekhil Oyun musa	600-800 200 150-300 100-300 200-500 200 0-30 100-500 1,000	500-1,000 500-800 1,000-1,500 800-1,200 1,500-2,000 100-300 <200 2,000 1,500	Flowing 0-100 0-20 flowing 0-30 30-50 flowing flowing flowing	1,000-3,000 2,500-4,000 9,000-15,000 1,000-2,5000 5,000-10,000 2,500-4,000	<1,000 <1,000 <1,000 <1,000 <1,000 <1,000 3,000-4,000 1,500-2,000 1,000-4,000
Moghra aquifer	Wadilnatrun Qattara	0-200	500-900	100	Very complex system	1,000-12,000
Fissured carbonate	Helwan, wadi araba	0-100		flowing		1,000-12,000
Hard rocks	South Sinai East. Desert	0-50		50		1,000-2,000

2.2 GLOBAL ESTIMATES OF NON-FRESH GROUNDWATER

- Non-fresh groundwater exists in almost all aquifer systems (as shown globally in Figure 3 and Tables 2 and 3). However, the exploitation of this resource is still limited for a number of reasons, including:
    1) Unfamiliarity with the dynamics of brackish groundwater during exploitation (quality changes);
    2) Occurrence of brackish groundwater is in low demand areas;
    3) Desalination had always the label of being expensive;
    4) Unfamiliarity with the operation of RO plants for brackish water;
    5) Questions with respect to disposal of the brine (the hyper saline effluent).

Table 3. Global Estimates of Non-Fresh Groundwater in Egypt

Aquifer	Location	Extension (km^2)	Salinity (mg/l TDS)	Exploitable volume (billion m^3)
Coastal aquifers	Coastal dunes Fluviatile of wadis Calcarenites Shallow marine sand	20,000	>2,000	<2 total
Nile Alluvium	Fringes North coast	1,500 7,500	>1,500	4 total
Moghra aquifer	West of Nile delta	10,000	>3,000	>1
Nubian sandstone	Eastern desert Sinai	100,000	1,500-3,500	>100 100
Fissured carbonate aquifer	Western desert Eastern desert	500,000	1,000-12,000	5 total

2.3 CHARACTERISTICS OF AQUIFER SYSTEMS CONTAINING NON-FRESH GROUNDWATER

Coastal Aquifers

- In the coastal aquifer systems, both along the Mediterranean as well as along the Red Sea (20,000 km^2), the water bearing formations (Quaternary And Late Tertiary) comprise (see Figures 4, 5, and 6):
    1) the coastal dunes;
    2) the coastal bars;
    3) the fluviatiles of the wadis;
    4) the calcarenites; and
    5) the shallow marine sands.
- Groundwater is recharged from local rainfall and runoff (flash flood).
- In Mariut area to the west of Alexandria, excess irrigation water in land reclamation projects contributes to the recharge of the brackish water.
- Groundwater salinity is affected by sea water intrusion and is generally in excess of 2,000 mg/l.
- In some locations along the Red Sea, local reservoirs, mainly of geologic structural origin, are found in Tertiary and pre-Tertiary. These are found at Ayoun Musa and El

Qaa in Sinai and also at Shagar, Safaga, Quseir, Ras Peras, and Halaib in the Eastern Desert.

- The exploitable volume of non-fresh groundwater is of the order of 2 billion m^3.

El Moghra Aquifer

- This aquifer (Figure 7), dominated by fluvio-marine sands, occupies a wide area located to the west of the Nile Delta.
- The water-bearing beds belong to an ancient delta of a river dating back to early Miocene times.
- The thickness of the aquifer varies from a few tens of meters at the eastern side to almost 1,000 meters at the western side (in the vicinity of the Qattara and Sidi Barrani).
- Non-fresh groundwater in that aquifer occupies a wide belt to the west of Wadi El Farigh and Wadi El Natrun and the water changes to saline and hyper-saline further to the west.
- Groundwater in the Moghra aquifer is fossil water, although there are indications of minor hydraulic continuity with the Delta aquifer.
- Volume of exploitable non-fresh groundwater in the Moghra aquifer (>3,000 mg/l) is about 1.8 billion m^3.
- Associated with El Moghra aquifer, there is a localized aquifer in the Pliocene beds, known as Wadi El Natrun.
- The Pliocene aquifer contains generally non-fresh groundwater (salinity > 1000 mg/l) and is fed mainly by lateral seepage from the Delta aquifer and from upward leakage from the Moghra (unexplored).

Alluvial Aquifers

- These are located both in the Nile proper as well as in the Delta.
- They consist essentially of Quaternary alluvium and are reported in the peripheries of the main fresh water in the same aquifer.
- The thickness of the brackish water horizons vary from few meters to more than 500m (Figures 8, 9 and 10 for the northern delta).
- Groundwater salinity, both bicarbonate and chloride, is in excess of 1,500 mg/l. This salinity results from the lateral seepage of saline water from the adjacent aquifer systems (manly the carbonates), from the upward leakage of paleo-groundwater from deep seated aquifers and also from runoff water sweeping marine rocks (sea water intrusion).
- The volume of exploitable non-fresh groundwater is estimated at approximately 4 billion m^3.

Nubian Sandstone Aquifer

- The eastern portion of this regional aquifer occupies an area of about 100,000 km^2 and holds non-fresh groundwater with salinity up to 3,500 mg/l. This type of water is reported at Wadi Qena, Wadi Umm Hibal, Dahmit and Adendan. etc. in the Eastern Desert as well as in Idfu, Esna, Kom Ombo, Aswan, Kalabsha, etc. in the Nile Valley.
- Similar non-fresh groundwater and passing into saline water at depths is reported in the same aquifer in Qattara Depression.
- In the Sinai Peninsula non-fresh groundwater dominates the Nubian formations.

- Similar non-fresh groundwater and low saline water are found in the Eastern Desert along the Red Sea. Areas of interest are Safaga, Quseir, Mersa Alam, Halaib etc.
- On the regional level (see Figure 11), the estimate of the brackish water in the Nubian Sandstone aquifer is in excess of 200 billion m^3.

Fissured Carbonate Aquifers

- These occupy an area of about 500,000 km^2 (Figure 12) and are the least explored in Egypt. The thickness of the carbonate section is in excess of 1,000 m.
- In most locations where groundwater is extracted, non-fresh groundwater is found. Of such locations reference is made to Siwa, South Qattara, Farafra, North Kharga, Kurkur (in West Aswan) and South El Fayoum. All these locations are in the Western Desert.
- In the Eastern Desert, the few locations include Wadi Araba, St. Paul and St. Antonio.
- In Sinai the locations include the famous springs of the eastern side, Hamam Musa and a good number of wells drilled in the central portion.
- The reserve estimates of the exploitable non-fresh goundwater in the fissured carbonates is in the order of 5 billion m^3 (further exploration is needed).

Hardrocks

- Hardrocks are outcropping in Southern Sinai and the Eastern Desert. They consist of Precambrian igneous and metamorphic rocks and Mesozoic and Tertiary volcanic rocks.
- Very little is known about the groundwater occurrences in these hardrock aquifers.
- It is expected that the occurrence of groundwater is restricted to fractures and fissures since the rocks have no primary porosity. The permeability of the smaller fissures diminishes usually rapidly with depth, hence deeper groundwater (deeper than 100 m below the surface) only occurs in very large regional fractures and is most probably non-fresh groundwater.
- Shallow groundwater is either recharged by seepage from wadis or by direct percolation of rainfall.
- The volumes are very small and the quality shows a very large variation.

2.4 ESTIMATES OF NON-FRESH GROUNDWATER PER AQUIFER SYSTEM

- The aquifer systems of interest are the Nile alluvium (the Pleistocene of the North delta), Nubian sandstone, coastal aquifers, Moghra and Carbonates. Information related to such aquifer systems are summarized in Appendix I.
- It is clear, from the previous section, that some aquifer systems are renewable while others do not receive any recharge.
- The only aquifer systems experiencing recharge, although very little, are the coastal aquifer systems (rain and sea water intrusion) and the Pleistocene (sea water intrusion).
- Non-fresh groundwater is found at depths ranging from 0 (north coast in the Nile alluvium, carbonates and coastal aquifers) to more than 800 m (the Carbonate).
- The term *"safe yield"*, as appearing in Appendix 1, can not easily be applied to non-fresh groundwater in Egypt. Reasons include:
    1) Safe yield is generally based on the rate of groundwater recharge (which could be annual or average annual);

2) In that respect, the Nile alluvium (Pleistocene) and the coastal aquifer systems can be considered in the estimation of safe yield, as they are recharged (possibly) from sea water (intruding) and rain; while the carbonate is not considered due to the complex fissuring system; and
3) Only two third of the saturated thickness can be technically withdrawn.

- For the Pleistocene (northern part of the delta), the safe yield is estimated as two-third of the exploitable volume of non-fresh groundwater divided by 10 years (to compensate for the travel time of sea water).
- For the coastal aquifers, the safe yield is estimated as two-third of the exploitable volume divided by 20 years (to compensate also for the travel time of sea water).
- For the other aquifer systems, the safe yield is estimated as two-third of the exploitable volume dived by 50 years (economy of utilization), after which no water will be available.
- *In fact, the term safe yield does not apply to such systems. Stage sustainable development could be a more appropriate term.*
- Based on the previous assumptions made for the safe yield, the total rate has been estimated at about 1,744 million cubic meters per year from all aquifer systems.
- The salinity of groundwater is estimated to range from 2 to 20 dS/m, at the beginning of development, and is expected to increase with time, especially for the Nile alluvium and the coastal aquifer systems.
- The major present utilization of non-fresh groundwater is mainly by resorts and hotels after desalination (South Sinai and the northern part of the Eastern Desert).
- Agriculture dependence is very limited; while use for cattle is very recognized.
- The total utilization is estimated at about 60 million cubic meters per year, mainly from the upper ranges of salinity (2-15 dS/m).

2.5 ESTIMATES OF NON-FRESH GROUNDWATER PER REGION

- Since the main aim of this report is to help sustain the livelihood of poor, another estimate is made for non-fresh groundwater in the regions suffering the most from poverty. These include:
  1) The North-West coast (Matruh-Sallum);
  2) West delta;
  3) North Sinai;
  4) Middle Sinai;
  5) North delta; and
  6) South Eastern Desert.
- For each of the previously mentioned regions, a number of aquifers can be used for the supply of non-fresh groundwater, as shown below.

Region	**Aquifer system**	**Community**
North-West coast	Coastal aquifers and carbonates	Bedouins (natives)
West delta	Moghra	Poor farmers and graduates
North Sinai	Coastal aquifers and carbonate	Bedouins (natives)
Middle Sinai	Carbonate and sandstone	Bedouins (natives)
North delta	Nile alluvium	Fishermen (locals)
South Eastern Desert	Coastal aquifers, carbonate and sandstone	Bedouins (natives)

- Based on the previous assumptions, the safe yield for the regions mentioned above can be estimated at about 540 million cubic meters per year from all aquifer systems.
- The salinity of groundwater is estimated to range from 2 to 25 dS/m, at the beginning of development, and is expected to increase with time, especially for the Pleistocene and the coastal aquifer systems.
- The major utilization of non-fresh groundwater at present is mainly by Bedouins (natives) for small agricultural activities and as a drinking source for cattle.
- The total utilization is estimated at about 19 million cubic meters per year, mainly from the upper ranges of salinity (2-15 dS/m).
- Further development can be made by introducing suitable types of agriculture and fish farming, especially in the regions located along the coasts. An example is already in place in Hurghada (Eastern Desert), as shown in Figure 13.

2.6 ESTIMATES OF OTHER POSSIBLE SOURCES OF NON-FRESH WATER

- Other sources of non-fresh water include agricultural drainage and domestic sewage.

Agricultural Drainage Water

- Agricultural drainage water is at present reused for irrigation all over the Nile valley and delta, either officially or non-officially.
- The total reuse at present is estimated at 5 billion cubic meters per year. This policy is approved by the Ministry of Water Resources and Irrigation due to the low water use efficiency of irrigation water. However, with the implementation of irrigation improvement projects in the old land, the available drainage water is expected to decrease and its quality will deteriorate.
- Another use of agricultural drainage till now is in fish farms. However, due to the poor quality of this water and its negative impacts on fish, several fish farms are planning to shift to non-fresh groundwater.

Domestic Sewerage

- The use of domestic sewage is still limited due to various reasons, mainly the location and quality of effluent, as well as the continuity of the source at the required quality.
- Efforts (through piloting) are taking place at various locations at present, aiming at coming with an appropriate policy.

RURAL POVERTY

3.1 NATIONAL

Definition of Poor

- The approach followed is based on "*household Income, Expenditure and Consumption Survey (HIECS).*
- Poverty in Egypt is generally a function of various factors. It depends on regions of the country, rural/urban, size of families, level of education, etc.
- Most of the poors are found:
  1) In Desert regions;
  2) In Large families, especially those headed by female;
  3) They have low level of education;
  4) They work in an informal sector (mostly private, including agriculture).
- Education is a key dimension of welfare in Egypt; about one third of poor households are headed by an illiterate person.
- The largest proportion of poor is concentrated in agriculture and construction.

Poverty Parameters

- Concerning income distribution and poverty parameters (National Report on human development, UNDP, 2003):
  1) The Gross Domestic Production (GDP) for the country was L.E. 246 billion (1997); being L.E. 300 billion (2001/2002).
  2) The average per capita GDP is L.E. 5,537.6 (2000/2001).
  3) The total percent of people with the least 40% of the income (year 2000) is 22.7; being 25.3% for the rural people.
  4) The percent of the highest 20% to the lowest 20% for the same year was 4.4 (total), being 3.3% in the rural area.
  5) The Gini indicator is 29.3 (total average), being 23.6 in the rural area.
  6) Percent of poor is 20.1 (2000).
  7) Percent of very poor is about 5.1 (2000).
  8) Wages of poor families, as a percent of their income are about 45.1%; being 12.4% of the total wages.
- Other important poverty parameters (2001 census) include:
  1) Infant mortality rate per 1,000 living at birth is 30.
  2) Households with access to piped water account for 91.3%.
  3) Households with access to sanitary drainage are 40%.
- The educational status distributed according to sex (10 years and over) is as follows (1996 census):

Educational status	**Total (%)**	**Male (%)**	**Female (%)**
Illiterate	39.36	29	50
Read and Write	18.6	14.64	22.66
Primary	9.27	8.34	10.16
Less than university	26.92	22.92	30.75
University	5.68	3.89	7.40
N.S.	0.03	0.03	0.03
TOTAL	100	100	100

3.2 REGIONAL

Poverty Distribution by Region

- For the purpose of poverty analysis, the country can be divided into seven distinct regions:
    1) The Metropolitan, including Cairo, Alexandria, Port said and Suez;
    2) Lower (the delta) Urban Egypt;
    3) Lower Rural Egypt;
    4) Upper (the valley)Urban Egypt;
    5) Upper Rural Egypt;
    6) Border (Red Sea, Sinai, Matruh and New Valley) Urban; and
    7) Border Rural.
- The following table summarizes some of the indicators, per region for the year 2001(National Report on human development, UNDP, 2003):

Region	Life at birth (years)	Education Index	% share in GDP	Index of GDP
Metropolitan	68.1	0.796	9,216.5	0.755
Lower Egypt	67.5	0.685	4,623.3	0.640
Upper Egypt	66.2	0.623	4,580.8	0.638
Border governorates	67.2	0.724	6,848.4	0.705
Egypt	67.1	0.682	5,060.9	0.655

- Among the regions mentioned above, indicators for the Border governorates do not reflect the sub-regional situation. For example, the average for two main regions suffering poverty (North Sinai and Matruh) is as follows:

	Life at birth (years)	Education Index	% share in GDP	Index of GDP
Border Governorates	67.2	0.724	6,848.4	0.705
North Sinai	67.8	0.703	5,720.8	0.675
Matruh	55.7	0.701	5,720.8	0.678

- Similarly, differences between urban and rural communities are very pronounced.
- Gini index also differs from one region to the other.

Regions	Gini 1996	Gini 2000
Metropolitan	0.374	0.396
Lower Egypt Urban	0.316	0.288
Lower Egypt Rural	0.280	0.248
Upper Egypt Urban	0.383	0.406
Upper Egypt Rural	0.268	0.273
Border Urban	0.254	0.308
Border rural	0.365	0.283
All Egypt	0.345	0.378

[El-Laithy and others, World Bank Policy Research Working Paper 3068 (2003)]

3.3 INFORMATION OF REGIONS WITH POTENTIAL NON-FRESH GROUNDWATER

The North-West Coast Region

- The North-West coast region of Egypt is part of Matruh Governorate. It comprises a land strip extending about 450 Km along the Mediterranean coast from Burg El Arab (50 Km west of Alexandria) to Sallum on the border with Libya, with an inland width of 10-50 Km.
- The total population of Matruh Governorate is 254,976 (2003 Census), with a growth rate of 2.48%. The majority are Bedouins (51% male and 49% female).
- The rural population is about 45% of the total.
- The labor force of Matruh is 74,000 (2003), representing about 38% of the total population of the governorate, distributed among various sectors (%):

Agriculture And hunting	Mining and manufacturing	construction	Retail and whole sale	hotels	Transport and communication	Education	health	services	others
2	10	7.6	13.5	3	10	12	6	3	33

- About 46% of the NWC population is in the active age (20-60 yrs); the majority (46%) of the population is illiterate or semi- illiterate (23%) with more illiterate females (61%) than males (33%) (DRC, 2002).
- Most of the male work in rainfed agriculture, 20% in rangeland activities, and 33% in other occupations.
- Because Female suffers the most from illiteracy, only 20% participate in economic activities. They are mostly involved in handcrafts, wool carpets, milking. They may share in the operation of grazing processes, harvesting and handling crops.
- In 1990, there were about 14,000 land holdings; of which 1.8% were less than one acre, 16.8% between 10 and 29 acres, and 9% from 30 to more than 100 acres.
- Cultivated areas are as follows:

Crop	Cultivated area (acres)
Winter crops	
Wheat	47,766
Barley	164,915
Broad beans	7,545
Onions	445
Potatoes	54
Tomatoes	903
Other vegetables	-
TOTAL WINTER	**221,628**
Summer crops	
Maize	5,166
Peanut	577
Sesame	157
Potatoes	30
Tomatoes	8,710
Other vegetables	16,181
TOTAL SUMMER	**30,821**

- The difference between summer and winter cultivated area is attributed to the lack of water during the non-rainy season.
- The average per capita income from agriculture is about 109 L.E, of which 46% come from plant production and 63% from livestock production (DRC, 2002).
- Infant mortality is 31.6/1000 birth; while household with access to piped water is 88%.
- The total number of cattle is about 470,000 (68% sheep, 26% goats and 2.2% camels).
- The Average size of household was 5 persons (1996), with an average number per room being 1.3 persons.
- Major constraints to a better life include, among others:
    1) The drastic fluctuation in feed resources and water availability;
    2) Severe shortages of feed, especially between September and December, reduce the productivity of small ruminants and increase the risk of animal disease problems that peak during summer;
    3) The generally high salinity in well water available for stock drinking (ranging from 2440 to 10343 ppm);
    4) Lack of adequate well-aerated shelters;
    5) Increasing animal populations and shrinking range resources resulting in continuous range degradation from overgrazing.

The West Delta Region

- The West delta region belongs mainly to Beheira Governorate. It is bordered by the Mediterranean Sea from the North, Giza Governorate from the South, Rachid branch from the East and Alexandria and Matruh Governorates from the West.
- The cultivated area is about 795.2 thousands acres, representing about 11.4% of the whole cultivated lands of Egypt. The governorate is famous in the production of cotton, rice, wheat, corn, a variety of fruits and vegetables.
- The total population is (2003) 4,515,102 (about 51% male); and the growth rate is 1.96%.
- The rural population is about 10% of the total population.
- The total labor force is 1,515,000 (2003), engaged in a variety of activities, namely agriculture (30%), mining and manufacturing (10%), construction (5%), retail and whole sale trade (8%), education (8%), and the rest distributed between hotel and restaurants, transport and communication, health and services.
- The total animal population is about 1,529,745 constituting of cows (31%), buffaloes (22%), sheep (30%), goats (14.3%), camels (2%) and draft animals.
- Concerning income distribution and poverty parameters:
    1) The GDP per capita is L.E. 4,673 (2001), the lowest 40% being 27.4.
    2) The Gini coefficient is 19.9 (2001).
    3) Percent of poor persons of total is 10.4 (2000); and ultra poor form 1.5%.
- The region has a large area of desert fringes which is not fully utilized due to the lack of fresh water.
- The area of interest with respect to saline agriculture is Wadi El Natrun which forms an elongated depression located in the north-eastern portion of the governorate, opposite to Km 100 from Cairo.
- The depression is about 50 Km long and 7-10 Km width.

- A series of salt lakes and sabkhas occupy the central portion of the depression (seepage water from the delta).

North Sinai

- The Sinai Peninsula is bordered by the Mediterranean Sea to the North, the Red Sea to the south, Palestine to the East and the Suez Canal to the west, with a total land surface of about 61000 km^2.
- The total population of North Sinai Governorate (2003) was 294,945 (51% male); with a growth rate of 2.42%.
- Urban population accounts for about 60% of the total.
- The labor force was 84,000 (2003); engaged in a variety of economic activities, namely agriculture (8%), mining and manufacturing (15%), retail and whole sale trade (18%), education (20%), and others.
- The average household size is 5 persons, with 1.6 persons per room.
- GDP per capita is about L.E. 6,259/year.
- Infant mortality rate (per 1000 live births) is 53.0; while households with access to piped water is 92.8%.
- Most agriculture activities are concentrated in the Eastern areas of the northern coastal region due to the higher rainfall and availability of groundwater.
- About 122,000 acres are cultivated by the natives (most of it is located in Wadi el Arish and east of it (1999/2000 North Sinai, Dept. of Agriculture Statistics).

Crop	Cultivated area (acres)
Winter crops	
Wheat	6,388
Barley	16,692
Broad beans	15
Lentil	337
Onions	4
Garlic	4
Tomatoes	3,046
TOTAL WINTER	**26,486**
Summer crops	
Maize	204
Potatoes	10
Tomatoes	594
Other vegetables	1,764
TOTAL SUMMER	**2,572**

- Similar observation can be made as to the case of the NWC with respect to the big difference in cultivated area between summer and winter.
- The total animal population (2001) is estimated at about 330,000; the majority being sheep and goats (accounting for 97.2%.

Middle Sinai

- Middle Sinai region is part of the Governorate of South Sinai, which is mainly inhabited by Bedouins.
- The total population of South Sinai is 62,447 (CAPMAS, 2003), with about 61% male; reflecting the nature of the region (mainly hotels).

- In 1996, 50% of the population was urban and 50% rural (expectations are that urban has increased).
- The labor force is about 43% of the population (2003); engaged as follows: 4% agriculture and hunting; 4% mining and manufacturing; 3% construction; 4.5% retail and whole sale; 2.3% hotels and restaurants; 20% transport and communication; 13% education; 1% health; 3% services and the rest in different other activities.
- The population of the Bedouins in Middle Sinai is about 41,333 (52.6% male) distributed among two main centers, Al-Hasana (74% of the population) and Nakhl, with a growth rate of about 1.1%.
- To reduce the expenses of agricultural labor, the family members, especially women, participate in plowing and spread of seeds.
- The percent of illiteracy in Middle Sinai is 72.8%.
- The average family income is L.E. 18,000, with an individual share of L.E. 400 per person.
- The GDP per capita is L.E. 1,557.8 (2001).
- Infant mortality rate at birth is 32.5 per 1000.
- Women in the family provide the daily food requirements (dairy products and protein related to raising poultry). Women and children also participate in raising livestock.
- Seasonal transhumance is still a basic characteristic of the Bedouins' method of living. Main reasons include: looking for grazing areas, water and other jobs.
- The local administration in Middle Sinai undertakes a great responsibility in providing potable water. The major part of potable water is provided by water tanks (46%). Other sources are local storage means (shallow wells, deep wells and small reservoirs). The quality is not high.
- Irrigation water is also provided by the government. Sources include dams on wadis, harrabat (storage reservoirs on wadis) and deep wells.
- Main crops include:

Crop	Cultivated area (acres)
Winter crops	
Wheat	233
Barley	125
Tomatoes	142
TOTAL WINTER	**500**
Summer crops	
Tomatoes	10
Other vegetables	54
TOTAL SUMMER	**64**

- Similar observation can be made as to the case of the NWC with respect to the big difference in cultivated area between summer and winter.
- The total animal population (2001) is estimated at about 40,982; the majority being sheep and goats (accounting for 92.6%).
- The Bedouins passed through essential stages in their lives which give them positive attitudes towards settlement. Main reasons include:
  1) The wish to work in settled agriculture as a basic profession and permanent economic activity; and

2) The wish to live in a brick house and give their children opportunities for education.

North Delta

- The northern delta region consists of a strip extending between the two branches of the Nile, Rachid and Domiat with an average inland depth of 18 Km parallel to the Mediterranean coast line.
- The region belongs to three main governorates, Port Said, Domiat, Kafr el Sheikh and Alexandria.
- The population is a mixture of fishermen, civil servants, traders, etc.

South Eastern Desert

- The Eastern Desert extends between Suez and the borders with Sudan, a distance of about 1,080 Km; the major portion belongs to the Red Sea Governorate; being bordered by the Red Sea from the East and the Nile valley from the West.
- The total population of Red Sea Governorate is 178,818 (CAPMAS, 2003); with about 57% male and a growth rate of 2.83%.
- The urban population of the governorate forms about 75% of the total population (1996).
- The total labor force is 61,000 (2003 Census); engaged in: agriculture and hunting (1.3%); mining and manufacturing (5%); construction (3.8%); retail and whole sale (7.5%); hotels and restaurants (2.7%); transport and communication (13.6%); education (11.6%); health (3.7%); services (4.9%) and others.
- The northern coastal portion of the region is occupied by cities and resorts; while the southern and internal portions are mainly occupied by natives (Bedouins).
- The South-Eastern Desert region is divided into three major watersheds viz., Barnice, Shalatin-Abu Ramad and Halayeb; each of which is dissected by a series of wadis of variable length and width originating in the Red Sea mountains and flowing east to sea shore.
- Three main tribes dominate the Ababda in Shalatin, the Bashaaria and the Rashaida (El-Shaer et al., 1996).
- Raising livestock is the most important economic activity of the Bedouins though coal manufacture and trading in medicinal plants are practiced by the Bashaari.
- Bedouin women make rugs and blankets from hair and wool. The region is also an important trading centre for camels from Sudan sold to Egyptian merchants.
- Limited areas of grain sorghum and millet are cultivated on wadi runoff for food and feed.
- There is no accurate record of the animal population in region; however, reported estimates for the Red Sea Governorate (MALR,2001) indicate 137,357 Sheep, 55213 goats and 43,590 camels.
- The main constraints to animal production include (El-Shaer et. al.,1996):
    1) The shortage of feed resources during summer and spring;
    2) High cost of feed concentrates;
    3) Lack of drinking water at proper sites in the range areas (most water sources are close to sea coast); and
    4) Lack of adequate veterinary and extension services.

PROSPECTS FOR BIOSALINE AGRICULTURE

4.1 PRESENT STATUS IN TARGET REGIONS

The North-West Coast Region

- The North-West coast region of Egypt is part of Matruh Governorate. It extends from Burg El Arab to Salum on the border with Libya for about 400 Km, with an inland depth of about 20 Km (10-15 Km).
- It consists of a coastal plain parallel to the Mediterranean Sea followed in the south by the limestone plateau.
- The total area of agricultural land is about 2.5 million acre, of which 93% is rangeland and 7% (along the coast) is potentially arable land producing cereals and horticultural crops.
- The total area of rainfed agriculture increased from 76,000 acre (1982) to about 312,000 acre (2000).
- Perennial fruit crops are mainly grown in depressions having deep soil with a relatively large capacity to retain moisture from rainfall and runoff.
- In 1990 there were about 14000 land holdings of which 1.8% was less than one acre, from 1-14 acre, 16.8% from 15-29 acre, and 9% from 30 to more than 100 acre.
- The main soil types include (Mostafa, 1991):
  1) **Soils of cultivated depressions**; deep, uniform soil profile, loamy surface texture grading into clay-loam, rich in organic matter, medium $CaCo_3$ content, non-saline; used for orchard and barley cultivation;
  2) **Soils of alluvial fans**; found at Wadi ends, moderately deep, sandy loam texture changing to sandy clay loam with depth, low organic matter content, $CaCO_3$ exists as soft and hard concretions and round nodules, non-saline; used for barley cultivation;
  3) **Dry sandy soils**; frequently deep soil, coarse texture, low $CaCO_3$ and organic matter contents, non-saline; occasionally cultivated with barley;
  4) **Soils of catchments areas**; surface with complex slope, crusted and covered with gravel and stones, shallow profile, sandy texture changing into sandy subsurface, up to 60% $CaCO_3$, saline, grazing shrub vegetation;
  5) **Inland sandy sheets;** extensive sheets of hummocks, shallow soil over a cracked bedrock, non-saline, grazing shrub vegetation; and
  6) **Upland plateau soils**; shallow loamy soil on hard bedrock, moderately salty, sparse shrub vegetation for camel grazing.
- Natural vegetation consists of sparse stands of shrubs, sub-shrubs and herbaceous perennials, with a winter-spring cover of ephemerals (short-cycle annuals).
- About 50 % of the total indigenous flora of Egypt (800 species) are represented in the region (Kassas, 1955); but floristic diversity has considerably reduced in recent times due to overuse of the vegetation.
- Six different habitats are recognized:
  1) *Ammophila arenaria* on mobile and partially stable dunes; *Plantago albicans* on inland silicious sands; *Crucianella maritima* and *Echinopus spinosissimus* on stabilized dunes;

2) *Globularia urabica* and *Thymus capitatas* on very rocky sites; while on less rocky sites species such as *Thymelaea, hirsuta, Gymnocarpus decandra, Asphodelus inicrocarpus* and *Anabasis articulata* are found;
3) Salt-tolerant species dominate in saline depressions including *Arthrocnemum glaucum, Halocnemum strobilaceum;* while *Limoniasterum monopetalum dominate* marshy sites. Sites of high salinity and deep water table have communities of *Sueda monoica, Zygophyllum album, Limoniastrum ,nonopetalus, A leuropus lagopoides* and *Frankenia revolute;*
4) Sites of relatively low salinity and deep water table have communities *of Atriplex halimus, Hammada scoparia, Anabasis articulata, Lycium europium* and *Salsola tetrandra.* Common annuals in saline depressions include *Mesemberyanthemum nodiflorum, Schismus barbatus* and *Trigonella stellata.*
5) Wadis are dominated by shrubs such as *Hammada scoparia, Vartheinia candicans, Atr. halimus, Thy. hirsuta,* and a dense growth of ephemerals in winter and spring. Cultivated fields: farming stimulates the growth of threophytes including *Achillea santolina mareoticurn, Chrysanthemurn corornarium* and *Papaver rhoes.* Uncultivated surrounding areas have *Plantago albicans, Thy. hirsuta* and *Asphedelus microcarpa.*

- Current production mixed systems in the region provide different levels of integration and complementarities between animal/range and crop production systems depending on the size of farming operation, number of animals raised and the quantity of farm-produced feed.
- The current production systems may be divided, according to type of animal and type of available feed resources to the following:
  1) The Small-Ruminant/Horticultural Production System; which is the main system prevailing in the coastal plain where rainfall and soil conditions are more favorable for the production of fruit trees and winter and summer vegetables. Small sedentary flocks of sheep and goats are raised. \feed resources comprise crop residues, grazing in adjacent non-cultivated areas and purchased green fodder, barley straw, hay and concentrates.
  2) The Small-Ruminant/Cereal/Horticulture Production System; which is the main system prevailing in areas extending south of the coast (20-30 Km), where cereal crops (barley and wheat) are mainly grown. Relatively small areas are devoted to the production of orchards and vegetables in wadis. Valuable quantities of local barley grains are used for animal feeding. Other feed resources include barley straw and stubble, residues and by-products of other crops, grazing in between barley fields and fallows, purchased concentrates and range grazing.
  3) The Pastoral Production System; which prevails in inland areas further beyond the rainfed farming belt. In the northern area of this system, flocks of sheep and goats are raised by semi-nomadic herders. The rest of the zone is devoted to camel herding utilizing the shrub vegetation for year-round grazing. The small ruminant flocks depend, to a large extent, on range grazing especially after the development of watering points that allow for the utilization of the range well after the rainy season. Some barley grains, straw and stubble are also used by small ruminants along with purchased concentrate feeds and straw.

The West Delta Region

- The region is part of Beheira Governorate, extending from south of Alexandria to near Giza.
- The region has a large area of desert fringes which is not fully utilized due to the lack of fresh water.
- The most well-known area is Wadi El Natrun which extends to the west of the Governorate.
- Potential use of non-fresh groundwater in the region for the future is fish farming.

North Sinai

- The Sinai Peninsula is bordered by the Mediterranean Sea to the North, the Red Sea to the south, Palestine to the East and the Suez Canal to the west, with a total land surface of about 61000 km^2.
- Soils in North Sinai can generally be grouped into:
  1) Soils of the salt marshes;
  2) Soils of the littoral sand dunes and sandy plains;
  3) Soils of the alluvial plains; and
  4) Soils of the wadi bans and outwash soils.
- Range vegetation, dominating the western portion, is generally characterized by the dominance of perennial shrubs with some trees in the middle plateau and the southwest coastal ranges. Annual herbs represent a significant component of the vegetation in winter and spring.
- The range types recognized in the north-east rangelands include the *Artemisia monosperma* and *Cornulaca monocantha* types on sandy soils, *Noaea nucronota* in wadi beds, *Zvgophyllum album* in salt marshes, *Thimelaea hirsuta* and *Lygos raetum* in rocky sands, and *Nitraria retusa and Tamarix mannefera* in wadi al Arish.
- Wadi beds in the north and middle parts of Sinai represent a valuable source of grazing for sheep and goats on account of the lush spring growth of the herbaceous vegetation. The major range types in these wadis include the *Acacia raddiana, Lygos raetum, Lvcium shown, Thymelaea hirsuta, Fagoina arabica, Achillea fragrantissima, Hammada scoparia and Anabasis articulata* types.
- Range types in the sandy plains in the south-west of Sinai include *Hammada elegans, Artemisia judaica, Panicum turgidum, Zilla spinosa, Acacia raddiana, Lygos raetum, Convolvolus lanatus and Lycium shown.* Annuals are abundant but are generally of low palatability for small-ruminants.
- The livestock raised in Sinai comprises 125000 sheep, 172200 goats, 10,900 camels and 6,000 equines (MALR 1999 figures). Most sheep and goats are local breeds; but the local x Damascus goats hybrid is often raised for milk production.
- Due to the dominance of shrubs in the range vegetation, the range-dependent small ruminant comprises population more goats than sheep (1.4:1). In the northern coastal plains, where agriculture is concentrated, farmers raise very few animals.
- There is presently little integration between animal and crop production. Dry land farmers tend to keep few animals. Barley straw and aftermath, and residues of water melon and other vegetables are purchased by Bedouins from farmers as supplement roughages for livestock.

Middle Sinai

- Middle Sinai region is part of the Governorate of South Sinai, which is mainly inhabited by Bedouins.
- The local administration in Middle Sinai undertakes a great responsibility in providing potable water. The major part of potable water is provided by water tanks (46%). Other sources are local storage means (shallow wells, deep wells and small reservoirs). The quality is not high.
- Irrigation water is also provided by the government. Sources include dams on wadis, harrabat (storage reservoirs on wadis) and deep wells.
- The Bedouins passed through essential stages in their lives which give them positive attitudes towards settle. Main reasons include:
  1) The wish to work in settled agriculture as a basic profession and permanent economic activity; and
  2) The wish to live in a brick house and give their children opportunities for education.
- This needs, in the first place, a sustainable resource base, mainly water.

North Delta

- The delta region is bounded by the Mediterranean Sea in the North, the apex of the Delta in the South, the Suez Canal in the East and the Wadi El-Natrun fault in the West.
- The two branches of the Nile River form a triangle with its base along the Mediterranean Sea in the North and the peak at the Delta Barrage in the South.
- The water resources system in the area consists of complex irrigation and drainage networks which are hydraulically connected to the underlying Quaternary Deltaic aquifer system. The great barrages built on the Nile control the surface water levels in the Nile branches and the irrigation canals.
- The lands of the delta were converted to perennial irrigation at the beginning of the last century. Open and tile drains in the delta are used to drain the excess irrigation water and divert this water to the Northern lakes and the sea.
- The study area is in an arid climate region with an annual rainfall ranging from 25 mm in the South of the Delta to a maximum value of 100 mm in the North along the Mediterranean Sea. These low values of rainfall do not contribute by any means to the aquifer recharge.
- The land slope is from South to North and from East and West towards the two River branches. The ground surface elevation varies between 18 meters above mean sea level in the South to less than one meter in the North forming a slope of 0.01%.
- The region is covered by recent and Quaternary sediments that were transported for more than ten thousand years by the Nile River to the Delta during the flood seasons before the construction of the High Aswan Dam.
- The hydrogeologic units forming the Deltaic aquifer consist of three distinct layers.
  1) The first layer is a top clay and fine sand that acts as a cap for the main Quaternary aquifer. The maximum thickness of this layer is 20 meters in the north and it is totally absent in the south and in the fringes. The vertical hydraulic conductivity of this layer varies between one and five mm/day;

while the horizontal hydraulic conductivity varies between 50 and 500 mm/day, RIGW (1980).

2) The second layer is considered the main aquifer system in the Nile Delta with a thickness that varies between 150 meters at the apex of the Delta to more than 1000 meters at the coast. This layer consists of coarse sand and gravel with occasionally clay intercalations. The aquifer thickness decreases in the southeast and the west of the delta fringes. The hydraulic conductivity of this aquifer varies between 50 m/day in the south and increases northward and in the east to more than 100 m/day, RIGW (1980). The aquifer porosity ranges between 25 and 40%. According to the thickness and the hydraulic conductivity of the top clay layer, the second aquifer unit exhibits unconfined and semi-confined conditions. For the unconfined aquifer condition, the specific yield is 0.20, and for the semi-confined aquifer condition, the storage coefficient ranges between 10^{-3} and 10^{-4}, Shahin (1985).
3) The third layer is the Basal unit, which forms the base of the Quaternary aquifer. It is dense clay and acts perfectly as an impervious layer.

- The northern portion of the delta region consists of a strip extending between the two branches of the Nile, Rachid and Domiat with an average length of 18 Km parallel to the Mediterranean coast line.
- The major part of the area is occupied by complex lagoonal (sabkha), aolean and deltaic sand bar deposits and lakes.
- Various efforts have been made by the government to cover part of the lakes and transfer the land to agricultural land. However, due to the complex hydrogeological conditions (upward leakage of non-fresh groundwater), these efforts have not been yet very successful.
- Some activities include farm fishing which are essentially based on agricultural drainage. However, some initiatives are starting replacing agricultural drainage by non-fresh groundwater.

South Eastern Desert

- The Eastern Desert extends between Suez and the borders with Sudan, a distance of about 1,080 Km; the major portion belongs to the Red Sea Governorate; being bordered by the Red Sea from the East and the Nile valley from the West.
- The permanent vegetation comprises trees, shrubs, and semi shrubs. Annual flora may be present with high frequency in favorable sites following winter rainfall.
- The wadi systems present a number of habitats varying in soil salinity, moisture and texture. At wadi ends, *Avicennia marina* is frequent. The salt marshes close to sea are dominated by the salt-tolerant *Arthrocnemum glaucum and Sueda monoica*. Further inland in the dry salt marshes *Salsola baryosma, Sueda monoica and Anabasis* set are dominant. In the sandy plains along the elevated wadi beds, *Salsola baryosma* is dominant, accompanied by *Anabasis setifera, Heliotropium and Acacia tortilis*. At the foothills, *Crotalaria aegyptiaca* is dominant and accompanied with *Panicum turgidum*.
- Wadi Hederbah in Halayeb has the richest range resources and the greatest potential for improvement of all wadis. *Panicum turgidum and Artistida mutablis* are two major species in this wadi providing good range for small-ruminants in winter and summer, along with *Lythium shawii and Artemisia* which are useful for camel grazing.

- There is no accurate record of the animal population in the region. However, for the whole Red Sea Governorate, animals comprise shhep (137,357), goats (55,213) and camels (43,590).
- The most common breed of sheep is the Manaeit breed (also called Barki) which has a small body covered with white hair. Goats are available but are generally of small bodies covered with thick hair of different colors. Camels are mainly of the Zubeidi breed which are fairly large animals (300 Kg) and the Ashab breed which is small racing camel.

4.2 PROSPECTS FOR NON-FRESH GROUNDWATER AGRICULTURE IN TARGET REGIONS

Introduction

In this section, the prospects for utilizing non-fresh groundwater in agriculture are discussed.

- Impacts on rural livelihood are considered.
- Recommended usages of available water resources are made according to available quantities and salinity level, linked with the relevant production systems.
- *However, other factors, including change in salinity with time and other constituents are not considered.*

- Salinity levels in prevailing soils and in irrigation water are the most critical factors that are significantly impairing agricultural production in most salt-affected regions in Egypt.
- The area of salt-affected soils in the country is estimated at about 1.8 million acres.
- Salt sensitivity at germination and seedling stages is considered a critical factor in crop growth and germination.
- Salinity affects negatively the yields of all cereals, vegetable and fruit crops. The high salinity level of irrigation water, even under controlled water application results in soil deterioration.
- Salinity in drinking water and fodder crops has also an impact on livestock production and reproduction. The influence varies between animal species and the different physiological status.

Constraints

- Various factors have constrained the appropriate/beneficial use of non-fresh water resources, among which:
  1) Lack of efforts on improving existing agriculture crops through specific breeding programs to high tech genetic engineering or molecular biological studies.
  2) Social/cultural and economical aspects with respect to the acceptance of biosaline agriculture.
- This calls for actions, including:
  1) Introduction of water and soil management practices (water, plant spacing, harvesting methodologies, etc.) to provide economical incentives to farmers.

2) Evaluation of some plant species for multi-uses which could increase the return from biosaline agriculture.

- The major constraints for livestock raised on salt-affected lands may include:
  1) Fluctuation in feed resources and water availability.
  2) Shortage of feed which reduces the productivity of small ruminants and increases the risk of animal diseases (peak during summer).
  3) Continuous range degradation.
  4) Problems related to poor drinking water quality.

4.3 POTENTIAL BIOSALINE AGRICULTURAL SYSTEMS IN THE SELECTED REGIONS

The north delta region (Nile alluvium) has been withdrawn due to many reasons, namely, complexity of the population activities (mainly fishermen) and lack of adequate information on possible acceptance to changes.

North-West Coast

- The annual water potential for the region is estimated at 6 million cubic meters (safe yield-present use), assuming the following distribution:

Salinity (dS/m)	2-5	5-15	15-25
Rate (million cum)	2	2	2

- The area that can be cropped with such an amount of water is about 1,860 acres, with vegetables, cereal crops, forage and fodder.
- Distribution of the area among the various crops and salinity ranges are proposed as follows

Crops	**Area (acre)**	**Water Requirement Thousand cum/year**
Salinity range 2-5 dS/m		
Tomatoes	300	1,160
Peas	100	210
Onion	100	230
Melon/Water Melon	40	100
Fenugreek	100	160
Bean	60	124
SUBTOTAL	**700**	**1,984**
Salinity range 5-15 dS/m		
Wheat	300	810
Barley	100	260
Millet	100	274
Forage crops*	260	660
SUBTOTAL	**760**	**2,004**
Salinity range 15-25		
Shrubs and wood trees**	400	2,000
SUBTOTAL	**400**	**2,000**
GRAND TOTAL	**1,860**	**5,988**

*Recommended forage crops are fodder beet, buffalo grass, lolium spp., Panicum spp. and Phalaris spp.
**Recommended shrubs are saltbushes, Kokhia indica, Tamarix spp., Suada ssp., Nitraria retusa and Salsola spp.

- Selection of the type of crops and area cultivated by each has been made to result in the highest possible/acceptable revenue from land and water, based on the following:
    1) One acre of tomato irrigated with water in the salinity range of 2-5 dS/m, produce about 10,000 kg (fresh water irrigated acre produces about 11,580 kg in the average), with a net income of about L.E. 4,000 in one season.
    2) One acre of wheat irrigated with water in the salinity range of 5-15 dS/m, produce about 1,500 kg of grains (fresh water irrigated acre produces about (2,670 kg in the average), with a net income of about L.E. 1,500 in winter.
    3) The recommended cereal and vegetable crops would produce (by-product) feed for the animals.
    4) The recommended forage crops and shrubs could also contribute to animal feed resources.
- The feed calendar in the system may progress through either one of the following two patterns:

Period	Pattern I	Pattern II
January-March	Annual weeds/green barley	Range annuals/perennials
April-June	Fallow/cereal shrubs	Fallow/cereal stubble
July-September	Range shrubs	Straw/By-product
October-December	Straw/concentrate	Straw/concentrates

- Each pattern has its own advantages and disadvantages:
    1) In the first, animals can utilize the short-lived annuals occurring in cultivated fields, but may face shortage of drinking water while grazing the southern rangelands during the hot summer.
    2) In the second, animals make full use of the lush winter growth closer to watering points in summer, but are deprived of additional grazing from cultivated winter crops and have to rely on concentrates and crop by-products during the major part of the summer.

Beheira (West Delta)

- The annual water potential for the region is estimated at 14 million cubic meters, distributed as follows:

Salinity (dS/m)	2-5	5-15	15-25
Rate (million cum)	10	4	-

- The area that can be cropped with such an amount of water is about 4,820 acres, with vegetables, cereal crops and forage crops.
- Distribution of the area among the various crops and salinity ranges are proposed as follows:

Crops	**Area (acre)**	**Water Requirement Thousand cum/year**
Salinity range 2-5 dS/m		
Wheat	1,500	4,000
Citrus	100	500
Onion	100	230
Peanut	100	285
Potatoes	100	290
Soybean	70	200

Sunflower	100	400
Tomatoes	500	1,600
Maize	750	2,500
SUBTOTAL	**3,320**	**10,505**
Salinity range 5-15 dS/m		
Barley	1,000	2,700
Millet	100	260
Forage crops*	400	1,150
SUBTOTAL	**1,500**	**4,110**
GRAND TOTAL	**4,820**	**14,615**

*Recommended forage crops are fodder beet, lolium spp., Panicum spp. and Phalaris spp.

- Selection of the type of crops and area cultivated by each has been made to result in the highest possible/acceptable revenue from land and water, based on the following:
    1) The net return from one acre of onion irrigated with water in the salinity range of 2-5 dS/m is about L.E. 3,750.
    2) The net return from one acre of barley cereals (famous in the region for beer industry) irrigated with water in the salinity range of 5-15 dS/m is about L.E. 1,500 in one season (this does not include the feed ingredients produced from crop residues and agro-industrial by-products).
- The proposed farming system would be intercropping between fruits and vegetables like citrus with green beans.
- Cattle, sheep and goats could be raised under this system as the fodder crops and agricultural residues would represent the main feed resources.
- The feed ingredients resulting from different field crops (agricultural by-products) could also be used for feeding animals after being well processed to improve their nutritive values and utilization.

North and Middle Sinai

- The annual water potential for the region is estimated at 15 million cubic meters, distributed as follows:

Salinity (dS/m)	2-5	5-15	15-25	>25
Rate (million cum)	3	4	5	3

- The area that can be cropped with the first three categories of salinity is about 4,070 acres, with vegetables and field crops; while for water salinity exceeding 25 dS/m fish farming is very recommended
- Distribution of the area among the various crops and salinity ranges are proposed as follows:

Crops	**Area (acre)**	**Water Requirement Thousand cum/year**
Salinity range 2-5 dS/m		
Tomatoes	300	1,000
Peas	150	315
Onion	100	230
Melon/Water melon	360	900
Pepper	30	110
Lentil	30	45
Fenugreek	100	160
Beans	100	250

SUBTOTAL	**1,170**	**3,010**
Salinity range 5-15 dS/m		
Barley	300	810
Wheat	350	940
Millet	300	810
Forage crops*	400	1,580
SUBTOTAL	**1,700**	**4,140**
Salinity range 15-25 dS/m		
Fodder shrubs and wood trees**	1,200	3,800
SUBTOTAL	**1,200**	**3,800**
GRAND TOTAL	**4,070**	**10,950**

*Recommended forage crops are fodder beet, Buffalo grass, Lolium spp., Panicum spp., Stepa spp., and Phalaris spp.

**Recommended shrubs are: Atriplex spp., Kokhia indica, Tamrix spp., Suada spp, Steppa spp., Nitraria retusa and salsola spp.

- Selection of the type of crops and area cultivated by each has been made to result in the highest possible/acceptable revenue from land and water, based on the following:
    1) One acre of tomatoes in the region, irrigated with water in the salinity range of 2-5 dS/m, will produce 10,000 kg, being one of the most important crops in the region (the average production in Egypt with fresh water is about 11,580 kg/acre), with a net return from one acre of about L.E. 4,000 per season.
    2) The net return from one acre of wheat, irrigated with water in the salinity range of 5-15 dS/m is about L.E. 1,500 in winter (1,500 kg/acre compared with the national average of 2,670 kg/acre). This is in addition to the by-product ingredients from the different crops.
- There is considerable potential for greater integration between livestock and crop production, especially in North Sinai.

South-Eastern Desert

- The annual water potential for the region is estimated at 20 million cubic meters, distributed as follows:

Salinity (dS/m)	2-5	5-15	15-25
Rate (million cum)	5	10	5

- ***Due to the high risks of starting with such a large amount in a remote area with very little knowledge and the lack of potable water, the first category (2-5 dS/m) is not included for agriculture.***
- The area that can be cropped with water of categories (5-15 and 15-25 dS/m) is about 4,600 acres.
- Distribution of the area among the various crops and salinity ranges are proposed as follows:

Crops	Area (acre)	Water Requirement Thousand cum/year
Salinity range 5-15 dS/m		
Wheat	1,800	4,800
Forage crops*	1,800	5,200
SUBTOTAL	**3,600**	**10,000**
Salinity range 15-25 dS/m		

Fodder shrubs and wood trees**	1,000	4,000
SUBTOTAL	**1,000**	**4,000**
GRAND TOTAL	**4,600**	**14,000**

*Recommended forage crops are Buffalo grass, Lolium spp., Panicum spp., Stepa spp., and Phalaris spp.
**Recommended shrubs are: Atriplex spp., Tamrix spp., Suada spp, Steppa spp., Nitraria retusa and salsola spp.

- Selection of the type of crops and area cultivated by each has been made to result in the highest possible/acceptable revenue from land and water, based on the following:
    1) The net return from one acre of wheat, irrigated with water in the salinity range of 5-15 dS/m is about L.E. 1,500 in winter (1,500 kg/acre compared with the national average of 2,670 kg/acre); being also important as local essential food. This is in addition to the by-product ingredients.
    2) Shrubs and wood trees help protecting the land from erosion and degradation and produce fuel and wood for manufacturing.
    3) The net income from one acre of fodder shrubs is estimated at about L.E. 2,500.

4.4 RECOMMENDATIONS

- It is highly recommended to implement proper rain water and flash flood harvesting means together with the establishment of biosaline agriculture, making use of the possible available fresh water in leaching the soils (or intermittent irrigation).
- Sustainable economic production of different crops requires reliable methods of seedling establishment, including soil and seedbed preparation and seeding.
- It is recommended, especially under saline agriculture, to carry out:
    1) Effective management during seeding and early growth.
    2) Appropriate nutrition and fertilizer application.
    3) Appropriate irrigation water management.
    4) Follow proper crop harvesting and handling practices.
    5) Apply integrated pest (diseases, insects and weeds) management.
- Management practices for a wide range of forage and fodder crops have to be developed and tested under production conditions using varying salinity level of irrigation water.
- Research programs are needed for production and management systems as well as genetic resources, information management and training.

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

General

- The Egyptian territory is almost rectangular, with a N-S length of approximately 1,073 km and W-E width of approximately 1,270 km (Figure 1). It covers an area of about one million square kilometers.
- The country consists of Metropolitan cities, Lower (the delta) Urban Egypt, Lower Rural Egypt, Upper (the valley) Urban Egypt, Upper Rural Egypt, Border (Red Sea, Sinai, Matruh and New Valley) Urban, and Border Rural.
- Egypt's population is about 67.3 million (2003); with 51% male and 49% female and an average growth rate of 1.99%.

Demography

- The population is unevenly distributed over the country's physical area; which reflects both historical population distribution and the uneven distribution of fresh water resources (general trend).
- The urban population accounts for about 42% and is expected to increase in the future (2017) to 48%; which will pose more pressure on the most populated regions (cities of the Nile valley and delta); thus increasing urbanization and decreasing arable lands.
- The total Gross Domestic Production (GDP) of Egypt is estimated at L.E. 299,623 million (2001-2002). Agriculture accounts for about L.E. 49,600 million (or about 17%); while it contributes for about 32% of the jobs (The total number of labor force in Egypt is estimated at about 20 million in 2003).
- The main objective for socio-economic development is to enlarge the inhabited space from about 5% (at present) to 25% (in 2017). The main constraint is the availability of resources (water on the top), and main services (roads, housing, schools, health services, etc.).
- The regions suitable for expansion are distinguished according to their comparative advantages. They include the desert fringes of West Delta and the Valley, the Western Desert, Sinai, the North coast, and the Eastern Desert.

Water Resources

- The main source of water in Egypt is surface water available from the Nile. *This source of water is totally consumed; being mainly confined to the Nile valley and delta.*
- The second source of water is groundwater in the Nubian sandstone. The aquifer extends over 79% of the country physical area; however, groundwater in such formation is almost non-renewable.
- Other sources of fresh water include rain and flash flood which together amount about 1.5 billion cubic meters per year if properly harvested and conserved.
- Groundwater in the Nile valley and delta can not be considered a resource in itself since the aquifer is recharged as a result of activities based on the Nile water.
- The situation calls for efforts to augment available water resources to ensure healthy life. This dictates the search for additional water resources. However, due to the limitations imposed on fresh water (Nile water constant and deep groundwater non-

renewable), the only way out is the development of non-fresh water in addition to the increase of water use efficiency.

Non-Fresh Water Resources

- Non-fresh groundwater exists in almost all aquifer systems. However, the exploitation of this resource is still limited for a number of reasons, including: occurrence of brackish groundwater is in low demand areas, desalination had always the label of being expensive, unfamiliarity with the operation of RO plants for brackish water, and questions with respect to disposal of the brine (the hyper saline effluent).
- The safe yield of non-fresh groundwater in regions with poor communities (which are also the regions suitable for population redistribution) is estimated at about 325 million cubic meters per year from all accessible aquifer systems in the regions.
- The salinity of groundwater is estimated to range from 2 to 25 dS/m, at the beginning of development, and is expected to increase with time, especially for the Pleistocene and the coastal aquifer systems.
- The major utilization of non-fresh groundwater at present is mainly by Bedouins (natives) for small agricultural activities and as a drinking source for people and for cattle.
- The total utilization is estimated at about 19 million cubic meters per year, mainly from the upper ranges of salinity (2-15 dS/m) and the shallow depths of the aquifers.
- Further development can be made by introducing suitable types of agriculture and fish farming, especially in the regions located along the coasts. An example is already in place in El Gouna, Hurghada (Eastern Desert).
- Other sources of non-fresh water include agricultural drainage and domestic sewage. The total reuse at present is estimated at 5 billion cubic meters per year. This policy is approved by the Ministry of Water Resources and Irrigation due to the low water use efficiency of irrigation water. However, with the implementation of irrigation improvement projects in the old land, the available drainage water is expected to decrease dramatically and its quality will deteriorate.
- The use of domestic sewage is still limited due to various reasons, mainly the location and quality of effluent, as well as the continuity of the source at the required quality.
- Efforts (through piloting) are taking place at various locations at present, aiming at coming with an appropriate policy.

Poverty

- The approach followed is based on "*household Income, Expenditure and Consumption Survey (HIECS)*".
- The poor in Egypt are generally distinguished according to regions of the country, rural/urban, size of families, level of education, etc.
- Education is a key dimension of welfare in Egypt; about one third of poor households are headed by an illiterate person.
- The largest proportion of poor is concentrated in agriculture and construction business.
- Concerning income distribution and poverty parameters:
    1) The average per capita GDP is L.E. 5,537.6 (2001/2002).
    2) The National poverty measures (population below poverty line) for the year (1995/1996) are (%):
        - 23.3 for the rural areas;

- 22.5 for the urban areas; and
- 22.9 average for the country.

3) The Gini index was 0.345 in 1996, becoming 0.378 in 2000.

- The distribution of the poor is quite uneven across the regions. In rural areas poverty rates reach 22.1%; most of them in Upper Egypt (34% of total); while in the urban Upper Egypt, poverty rate is lower (19.3% of the total).
- Other important poverty parameters (2001 census) include:
  1) Infant mortality rate per 1,000 living at birth is 30.
  2) Households with access to piped water account for 91.3%.
  3) Households with access to sanitary drainage are 40%.

Present Potential Use of Non-Fresh Water Resources

- The present use of non-fresh groundwater is very limited. In the identified regions include: agriculture production, drinking of cattle, and fish farming.
- The use of agricultural drainage is more common, but is restricted to the Nile valley and delta. It is mainly used to cover the gap between the supply and demand in irrigation, and partly in fish farms in the northern Governorates.
- The use of treated domestic sewage is still very limited and is mainly used in agriculture.
- Utilization of non-fresh water in the early stages of land reclamation for the leaching of soils is also experienced in some regions.
- Finally, but very limited at present, is the use of brackish groundwater in the production of Jojoba.

Prospects for Non-Fresh Groundwater Agriculture

- Various factors have constrained the appropriate/beneficial use of non-fresh water resources in the country, among which:
  1) Lack of efforts on improving existing agriculture crops through specific breeding programs to high tech genetic engineering or molecular biological studies.
  2) Social/cultural and economical aspects with respect to the acceptance of biosaline agriculture.
- This calls for actions, including:
  3) Introduction of water and soil management practices (water, plant spacing, harvesting methodologies, etc.) to provide economical incentives to farmers.
  4) Evaluation of some plant species for multi-uses which could increase the return from biosaline agriculture.
- The major constraints for livestock raised on salt-affected lands may include:
  5) Fluctuation in feed resources and water availability.
  6) Shortage of feed which reduces the productivity of small ruminants and increases the risk of animal diseases (peak during summer).
  7) Continuous range degradation.
  8) Problems related to poor drinking water quality.
- Prospects for non-fresh groundwater agriculture are high in almost all identified regions.
- The total initial area for biosaline agriculture is estimated at about 41,000 acres in the various regions, in addition to drinking water supply and fish farming.

5.2 RECOMMENDATIONS

- Assessment of non-fresh groundwater, as presented in this report, is very tentative both in terms of initial salinity and the future changes in salinity and potential. *More investigations should take place in priority regions.*
- In the future, and parallel to the application of IWRM, a matching between supply and demand should take high priority. Also Regional aspects (water resources, poverty, activities, etc.) should be considered.
- Preparation of people in regions suffering from water shortages to switch to activities that depend on lower quality water (biosaline agriculture and others) is highly recommended.
- *It is recommended to investigate the possible multi-use of fresh water, especially in closed basins (oases in the western desert and in wadi systems).*
- It is highly recommended to implement proper rain water and flash flood harvesting means together with the establishment of biosaline agriculture, making use of the possible available fresh water in leaching the soils (or intermittent irrigation).
- Sustainable economic production of different crops requires reliable methods of seedling establishment, including soil and seedbed preparation and seeding.
- It is recommended, especially under saline agriculture, to carry out:
    1) Effective management during seeding and early growth.
    2) Appropriate nutrition and fertilizer application.
    3) Appropriate irrigation water management.
    4) Follow proper crop harvesting and handling practices.
    5) Apply integrated pest (diseases, insects and weeds) management.
- Management practices for a wide range of forage and fodder crops have to be developed and tested under production conditions using varying salinity level of irrigation water.
- Research programs are needed for production and management systems as well as genetic resources, information management and training.

APPENDICES

Appendix 1.
Background information and information on groundwater resources

EGYPT	
Background information	
Demography	
Total population	64.1 (1999/2000); being 67.3 million (2003)
Rural population	58% of total (differences between regions are high)
Proportion of rural population active in agriculture	32% of the job opportunities (about 5 million)
Population trends	51% male and 49% female, average growth rate 1.99%
Climate	
Brief general description	Arid to extremely arid climate. Air temperature frequently rises over 40 degrees centigrade in daytime in summer and seldom falls to zero in winter.
Rainfall	The average rainfall over Egypt is 10 mm/year; Being 140 mm/year on the Mediterranean coast, falling to zero in the south.
Agriculture in the economy	
Contribution of agriculture to GDP	L.E. 49,600 (17% of total)
Impact of salinity on agriculture	o Regions that are suffering from salinity are those located near the coast (upward leakage of brackish to saline groundwater. o In the old land, the implementation of drainage projects has considerably improved the situation.
Water rights/issues	
Ownership of water	Mainly applies to areas irrigated with groundwater. Land ownership prevails in the Nile valley and delta.
Water legislation	Several laws apply, including intakes from delivery systems, water selling, pollution control, proper of water bodies/ways, etc.
Water policy	Water is a socio-economic good, owned by the nation and managed by the Ministry of Water Resources and Irrigation (MWRI)
Water pricing	No water pricing for irrigation, but cost sharing (infrastructure and O & M).
National groundwater monitoring system	➢ There is an old monitoring system (sixties) that has been essentially designed to monitor levels and estimate potential, recharge, etc. ➢ Well inventory is made every 3-5 years for licensing purpose. ➢ The first reference groundwater monitoring system for quality has been in place since 1997. It consists of about 250 points (battery of wells)

Appendix 1 (Cont.)
GROUNDWATER RESOURCES
INFORMATION BASED ON REGIONAL DISTRIBUTION OF AQUIFERS

	NILE ALLUVIUM	NUBIAN SANDSTONE	COASTAL AQUIFERS	MOGHRA	CARBONATES
Geographical extent (square km)	30,000	700,000	20,000	30,000	500,000
Total water storage (million m^3)	60,000	20,000,000	2,000	3,000	5,000
Recharge rate (million m^3 $year^{-1}$)	7,000	0	1,500**	0	0
Source of recharge	Nile (indirect)	-	rain	-	-
Water salinity range (dS/m)	500-80,000 0.8-126	200-2,500 0.3-4	600-15,000 0.9-24	1,000-12,000 1.6-19	2,500-10,000 4-16
Saline water availability/exploitable volume (million m^3) 2-5 dS/m 5-15 dS/m 15-25 dS/m > 25 dS/m	 200 400 800 2,500	 100,000 100,000 - -	 300 600 1,000 -	 400 600 800 -	 3,000 2,000 - -
Depth to saline water (m)	0-5	0-5-	0-70	50-250	0-800
Safe yield* (million cum/year)	260	1,330	60	24	70
Current abstraction rates (million cum/year)#	0	30	10	0	20
Current utilization	Small scale irrigation, drinking, cattle, etc.				
Trends in water supply and demand					
Potential for further development	Long-term availability, in terms of quantities and quality needs to be investigated				
Any other relevant information					

* Safe yield is defined as the rate of recharge. This could be on an annual basis or annual average over the development period that does not result in adverse impacts. Based on this definition, the only rechargeable aquifers are the Nile alluvium and the coastal aquifers; taking into consideration both the source and the transmissivity. In the table, the following assumptions are made in the estimation of the safe yield:

1. For the Nile alluvium, it is taken as two third of the total exploitable volume divided by 10 years (assuming that the recharge is achieved through replacement by sea water intrusion);
2. For the coastal aquifers, it is taken as two third of the total exploitable volume divided by 20 years (assuming that the recharge is achieved through replacement by sea water intrusion);

For the remaining aquifers, it is taken as two third of the total exploitable volume divided by 50 years (assuming a complete exploitation; i.e., that the volume is totally abstracted and not recovered during this period).

** if appropriate harvesting structures are in place.

Appendix 1 (Cont.)
GROUNDWATER RESOURCES
INFORMATION BASED ON REGIONS WITH GENERAL POVERTY
(all aquifers available)

	North-West Coast	West Delta (Wadi el Natrun)	North and Middle Sinai	North Delta	South Eastern Desert
Geographical extent (square km)	1,000	15,000	10,000	7,500	25,000
Recharge rate (million m^3 $year^{-1}$)	?	0	?	?	?
Source of recharge	Sea and rain	-	Sea and rain	Sea and rain	Sea and rain
Water salinity range (dS/m)	1,000-16,000 2-25	2,000-9,000 2-15	2,000-30,000 1.5-35	3,000-80,000 4.5-126	1,500-13,000 2-20
Saline water availability/exploitable volume (million m^3) 2-5 dS/m 5-15 dS/m 15-25 dS/m > 25 dS/m	 50 70 130 -	 60 50 - -	 30 70 90 60	 200 400 800 2500	 400 700 900 -
Depth to saline water (m)	0.5-55	50-250	0-800	0-5	0-70
Safe yield* (million cum/year)	8	14.5	18	260	25
Current abstraction rates (million cum/year)#	2	-	3	0	5
Current utilization	Small-scale agriculture and drinking	-	Small-scale agriculture and drinking		Small-scale agriculture and drinking
Trends in water supply and demand					
Potential for further development	Long-term availability, in terms of quantities and quality needs to be investigated				
Any other relevant information					

Appendix 2.
Prospects for biosaline agriculture

COUNTRY						
Prospects for biosaline agriculture						
Target area	**North-West Coast**	**West delta**	**North Sinai**	**Middle Sinai**	**North delta**	**South Eastern desert**
General description of area, population and livelihoods	Coastal strip along the Mediterranean Sea	Along the western fringes of Nile delta	Coastal strip along the Mediterranean Sea	Desert, mountainous	Coastal strip along the Mediterranean Sea	Coastal strip and inland high plateau
Saline water availability (million cum/year) 2-5 dS/m 5-15 dS/m 15-25 dS/m > 25 dS/m	See Appendix 1					
Soil type	Various	Various	Salt marshes	Various	Salt marshes	Various
Soil salinity	Various	Various	Various	Various	Various	Various
Current farming system						
Plant production						
▪ Field crops	Wheat/barley					
▪ Forage crops	Berseem	Barley	Berseem	Berseem	-	Berseem
▪ Greening/agroforestry	Figs, grapes	Horticulture	Dates	Vegetables		Vegetables
▪ Other						
Livestock	Sheep, goats	-	Sheep, goats	Sheep, goats		Sheep, goats, camels
Trends in the current farming system						
▪ Crops	mixed					
▪ Livestock	mixed					
Average farm size	<one acre	10-100 acres	1-10 acre	<one acre	-	<one acre
Number of households involved in agriculture	Majority	Majority	Majority	Majority	-	Majority
Number of women-headed households						
Role of rural women in the farming system	-	-	Seeding, harvesting	Seeding, harvesting		-
Potential biosaline agricultural systems						
Estimated area	1,860	4,820	4,070		-	4,600
Proposed cropping system (classified by category of water quality)	See section 4.3 in the report					
Likely effects on rural poverty	Initially positive, as discussed in section 4.3					
Possible constraints to adoption of biosaline agriculture (social, economic, legislative, technical)	Fresh water harvesting means (rain and flash flood) are highly recommended to prevent accumulation of salt in the soils					

Appendix 3.
Rural poverty

COUNTRY						
Rural poverty						
Average per capita income	L.E. 5,537.6 (2001)					
Proportion of population below poverty line ($2/day)	(1995-1996): 23.3% from rural; 22.5% from urban; (22.9% national); with the lowest 20% accounting for 9.8 and the highest 20% accounting for 39. (1999-2000): 16.7% national [differences are high between regions)					
Literacy rates ▪ Male ▪ Female	 71% 50%					
Percentage of population completing education ▪ Primary ▪ Secondary	 48% 27%					
Infant mortality	30 per 1000					
Percentage of population with access to piped water	94%					
Other poverty criteria	Gini index 28.9 (1995-1996); being 29.3 (2000)					
Poverty information specific to target areas						
Target area	**North-West Coast**	**West delta (Beheira)**	**North Sinai**	**Middle Sinai**	**North delta**	**South Eastern desert**
Average per capita income	L.E. 109/y (from agriculture)			L.E. 400/y		
Population Urban % Rural% Male% Female%	254,976 55 45 51 49	4,515,102 90 10 51 49	294,945 60 40 51 49	41,333 - 100 52.6 47.4		178,818* 75 25 57 43
Proportion of population below poverty line ($2 per day)	Majority	10.4%		All		
Literacy rates ▪ Male ▪ Female	 67% 39%		 77% 23%	37.2%		
Percentage of population completing education ▪ Primary ▪ Secondary				 28.2		
Infant mortality	31.6 per 1000		53 per 1000	32.5 per 1000		
Percentage of population with access to piped water	88%		92.8%			
GDP/capita		L.E. 4,673	L.E. 6,259	L.E. 1,557.8		
Gini index		19.9				
Other poverty criteria (please specify)						