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AGRICULTURAL POTENTIAL AND PROSPECTS IN SINAI

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SINAI DEVELOPMENT STUDY - PHASE I

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OF THE MINISTRY OF DEVELOPMENT

BY DAMES & MOORE

(in association with Industrial Development Programmes SA)

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I - INTRODUCTION

The Existing Agriculture

The agriculture of Sinai consists basically of two subsectors: (a) traditional agriculture, based primarily on nomadic or seminomadic herding, plus a limited amount of rainfed, or dryland, farming, and (b) irrigated crop production.[1/]

The largest concentration of crop production in Sinai is near El Arish, where irrigated farming has been practiced for several decades. Some rainfed crop farming also exists near El Arish, particularly east of El Arish toward Raffaa.

About 2,100 feddans of area in and immediately surrounding El Arish are farmed by irrigation. Until recently, it was irrigated by the basin technique. Several farmers have been using drip irrigation for five years or more; and where they have their own wells, they are experiencing very few problems. Olives dominate in the cropping patterns, with exports of olive oil to Cairo being a major element. Something over 400 feddans of the area is in vegetable production; even so, roughly half the vegetables consumed in El Arish are brought in from the Delta. Vegetables and some barley are intercropped among olive trees, particularly among the young trees. Some fruit and grapes are also produced.

A second fairly large area of intensive crop production is in the early stages of development, east of Bitter Lakes, using Nile water for irrigation. Total production in 1981 was less significant than that near El Arish, but potential production within the next decade could be several times that of El Arish; about 30,000 feddans are believed to be reclaimable in this area.

Aside from these two concentrated reclamation areas, near El Arish and east of Bitter Lakes, there are many small, almost garden-like, plots scattered throughout Sinai, which, in total, may produce as much as the area around El Arish. The most important existing crops in these areas are:

(a) - date palms, mostly along the southern coast, but also along the

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1/ For a more complete description of the existing agriculture and the supporting infrastructure in Sinai, see:

1 - "Livestock Production in Sinai: A Preliminary Assessment," Working Paper No. 11, June 1981.
2 - "Crop Production in Sinai," Optional Working Paper No.18 , August 1981.
3 - "Agricultural Support Infrastructure in North Sinai," Optional Working Paper No. 12 , August 1981.

coasts of the Gulf of Suez and the Gulf of Aqaba.

(b) - vegetables and fruits for local consumption, where supplemental irrigation water is available.

(c) - small grains, mostly barley.

In the context of the total economy of Egypt, livestock production in Sinai is not of great economic importance. However, within Sinai, the traditional livestock subsector is of relatively high importance, especially to the Bedouin. Goats, camels and sheep are the main species of domestic animals. They provide milk, meat, wool, hair, hides and -- in the case of camels -- transportation for the herders and their families, with occasional small amounts for sale or barter.

Agricultural support institutions and infrastructure in Sinai include two agricultural cooperatives at El Arish, which provide both fertilizers and other inputs to farmers, and assist with marketing of produce; the Agricultural Directorate of the Ministry of Agriculture, which includes departments of agricultural extension, animal production, agricultural affairs (land tenure, legal matters and statistics) and pest control; the Green Revolution Society, of the Ministry of Development; and a branch of the Principal Bank for Development and Agricultural Credit (PBDAC), which, in addition to providing credit to farmers, provides production inputs, feed, machinery and tractor services. A limited amount of agro-industrial activities also exist, such, as olive presses at El Arish and cold storage units at El Arish and Bir El Abd.

Prospects for Agricultural Growth

Section II of this chapter on agriculture, and the attachments, go into considerable detail on the natural resource base for agricultural growth. In brief, the main constraint is lack of water in sufficient quantities and of high enough quality. Except for the extreme northeast of the penninsula, near Raffaa, where the average annual rainfall is 200 to 300mm, only a very limited rainfed agriculture is possible. In general, water from shallow wells is slightly saline at best, and is frequently too saline for crop farming. Little information is available yet on the extent of deep groundwater availabilities, although exploratory drilling programs are planned to get more information on this.

Land reclamation using Nile water is technically possible for Sinai. In this case, though, the main limiting factor is the poor quality of soils in those areas which would be reasonably accessible with Nile water, causing the prospective returns in Sinai to be lower than for most of the candidate plots for land reclamation in the rest of Egypt. Of the five candidate plots for reclamation that have been identified for Sinai, the one east of Bitter Lakes, which is currently under development, is clearly the most promising.

Despite the inherent limitations of water and soil, several opportunities exist for both enhancing productivity of the existing agriculture and initiating new, potentially productive activities. The main purposes of the agriculture sector study was to identify those opportunities and to suggest the steps that are needed to begin to bring them to fruition, within the context of a coherent, overall strategy for Sinai.

Strategy Considerations for Agriculture

Within the context of the general strategy options for Sinai, as articulated in the main report, following are considerations for agriculture that evolved during the study period and that served as a set of guiding principles in the formulation of projects and recommendations for development.

1. Other things being equal, the major emphasis should be on areas where population is now or will likely become centered. Besides El Arish, these might include places such as El Tor, the new capitol of South Sinai; the oil and mining towns in western and southwestern Sinai; and tourist locations, such as St. Catherine's and the southern tip of Sinai.

2. Focus on opportunities for land reclamation using well water, with earliest emphasis near existing population centers.

3. Strengthen the supporting institutions which are prerequisites to sustained agricultural growth, with urgent attention being given to the system of agricultural experimentation and extension.

4. Put early emphasis on improving productivity of the most significant existing agriculture. This would include olives at El Arish, date palms along the three major sea coasts, vegetables for population centers, and the traditional crop and livestock activities.

5. Give early attention to the reclamation area east of Bitter Lakes, which is an area with the largest near-term potential in Sinai for which the potential can only be effectively realized if the main water conveyance and drainage system receives urgent attention.

II - CURRENT DEVELOPMENT POTENTIAL FOR AGRICULTURE

A - Natural Resource Base for Agriculture

An assessment of the natural resources available to support sustained agriculture in Sinai was made. This assessment included water, soils, native vegetation and ecology, livestock, climate and imported water available from the Nile river system. Much of this work was accomplished by the Desert Institute from March to September 1981, under contract to the program and will be identified in following sections.

1 - Water

The principal resource which limits agriculture in Sinai is availability of good quality water. Precipitation is low. It ranges from 75 to 300 mm per year in the northeast Mediterranean coastal area to less than 24 mm per year in the central, western and southern areas. Although approximately 3 billion M^3 falls as precipitation annually in Sinai, about 2700 million M^3 runs off into the sea and gulfs or evaporates, and 300 million M^3 infiltrates to groundwater aquifers(1) Shallow wells (less than 40 M in depth) and springs are common, especially in the northern and western extremes of Sinai. Over 600 have been identified, and their position mapped as of August 30, 1981(2). Yields of these sources are low in terms of irrigation requirements, averaging under $60M^3$ per day.

The quality of groundwater from such wells and springs is variable, and the majority of wells produce poor quality water with a TDS of 1500ppm or higher. In fact, over time, many wells have been abandoned since the water was or became unfit for any local purpose.

The A.R.E. has long been aware of the scarcity of high quality groundwater in Sinai. At least two major projects have been undertaken to improve the situation. In 1946, the El Rawafaa dam was constructed in Wadi El Arish, which has subsequently silted up and is now abandoned. In 1966-67, a series of siphons were laid under the Suez Canal to convey Nile river water from the Cairo-Ismailia canal to Sinai. Full development of that project was interrupted in 1967 by war. Since 1978, a new set of siphons has been under construction, and Nile water is again available to an area east of Bitter Lakes for agricultural land reclamation.

Although many wells exist in the Al Arish area, and more are being drilled, water quality in those is deteriorating at an alarming rate(4). A fresh water pipeline from El Quantara is in the planning stages, which could assure an increased supply of potable water for the city. A smaller pipleine to convey potable water to Bir El Abd is under construction from El Qantara at this time.

Long Term A.R.E. plans and developments project the completion of the El Salaam Canal to convey Nile river water to northern Sinai in a quantity sufficient to reclaim 400,000 feddans(5).

A desalinization plant was in operation in Ras Sudr which served the potable water requirements of oil production operations in that city. Further desalinization units are to be established to meet other localized special requirements perhaps 9 in the near future(6).

The construction of these systems of siphons, canals, pipelines and desalinization units and the major investments they represent attest to the critical shortage of quantity and quality of water available in Sinai.

The single potential local source of water which has not been explored is the deep groundwater aquifers in Sinai. Given the fact that annual precipitation may contribute up to 300 million M^3 per year and that leakage through springs and pumpage from shallow wells in Sinai remove only about 15 million M^3/year, it is conceivable that vast quantities of largely fossil waters are contained in deep goelogical formations in Sinai. An exploratory drilling program for such resources has been recommended as a high priority project by this Phase I program(7).

Although the major deep aquifers, Middle Cretaceous, Nubian and Crystalline, represent the most significant potential groundwater resources in Sinai, the quality of water they contain can be expected to range from 300 to 8,000 ppm TDS. Thus, it is likely that much, if not a majority, of this water may be of unacceptable quality for agriculture(8).

2 - Soils

The "soils" of Sinai consist principally of non-consolidated deposits formed under alluvial, aeolian, or lacustrine conditions. There may be as much as 15,000 Km^2 of such soils with occurrence widely dispersed in and along basins drained by Wadis El Arish, El Giraf, the Gulf of Suez, the Bitter Lakes, Nile Delta Northeast Extension and Lake Bardawil.(9)

All soils of Sinai are located in an arid zone as defined by Meigs(10) and Koeppe and Long(11). Those which have agricultural potential are of alluvial or aeolian deposition. All have very low organic matter content from slightly above 0 to 0.2%. Water retention capacity is low. They are well drained except for the deltaic lacustrian clay deposits of El Tina Plain (East Lake Manzala area) and low areas along the Suez and Bitter Lakes. These deltaic soils are high in impermeable clay and very saline. They lie at sea level or slightly above, with high water tables and are difficult to drain and leach.

Dregne (11A) has stated that: "It appears that everyone knows what a desert soil is but no one can define it." There is a lack of scientific agreement on classification of desert soils which confuses the synthesis of previous soil surveys done in Sinai.

The soils of Sinai have been sampled and studied in specific areas by many scientists over the past 100 years. Such studies involved various methods and differing degress of detail. For purposes of this project - Sinai Development Study - Phase I - further soil sampling and analyses were considered necessary.

Areas of Sinai were selected broadly on the basis of land capability for agriculture(12). A "Good" capability indicated 0 to 8% slope, 0 to 50 meters of local relief and a deep (1M) soil cover. A "Fair" capability indicated the same degree of slope and relief but was usually more bisected and has a stonier surface and probably more gravel in the upper one-meter level. The "Good" capability class is believed to contain 50% or more area of arable soil. "Fair" capability indicates from 20 to 49% arable soil area.

The Desert Institute conducted soil testing and analyses on approximately 1200 samples, taken from the eleven pilot areas shown on Figure No. 1. These pilot areas were selected on the basis of field reconnaissance by the Agricultural Team and Desert Institute staff. The above mentioned "Good" and "Fair" capabilities were among criteria used in selection of pilot areas. Special attention was also given to areas presently in cultivation or under present and proposed reclamation.

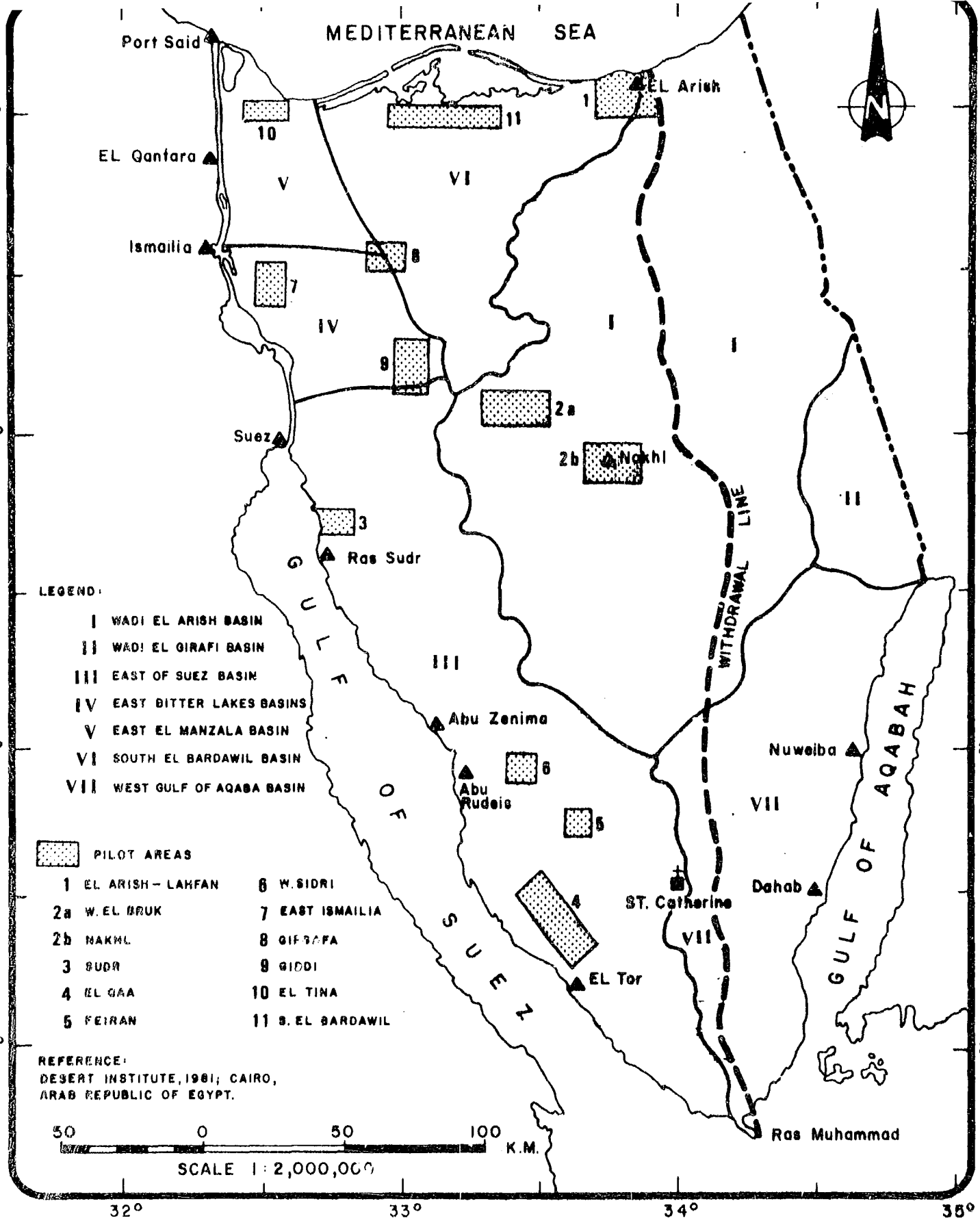
Soil sampling was further delineated by acknowledged water availability and improved road systems. Thus, large areas of "Good" capability soils in the wadis of central North Sinai were either ignored or sampled very lightly.

Wadi El Arish Basin

This basin and its associated wadis drains approximately two-thirds of Sinai. The greatest proportion of arable soils are located in this basin of approximately 22,000 Km^2. However, rainfall is inadequate to support permanent agriculture. Improved roads are located only on the fringes, as shown in Figure No. 2. Thus, lack of water and transport within the region severely limit the agricultural potentials of this region for the near term.

Nevertheless, the sandy Regosols of this basin are well drained and have good physical characteristics. The mild saline content of some can be readily leached. Water spreading techniques and groundwater development may make possible the sustained use of much of this land in the future. Given the lack of communications, at least improved grazing lands could be seriously considered for the region.

In the extreme north of this basin, from the city of El Arish extending inland about 30 kilometers, an area of soils of alluvial formation has developed through deposition from run-off waters of Wadi El Arish. These soils have excellent physical and good water-retention characteristics and relatively deep profiles of arable soil (approx. 2.0 m).



Sinai Development Study Phase 1
Ministry of Development

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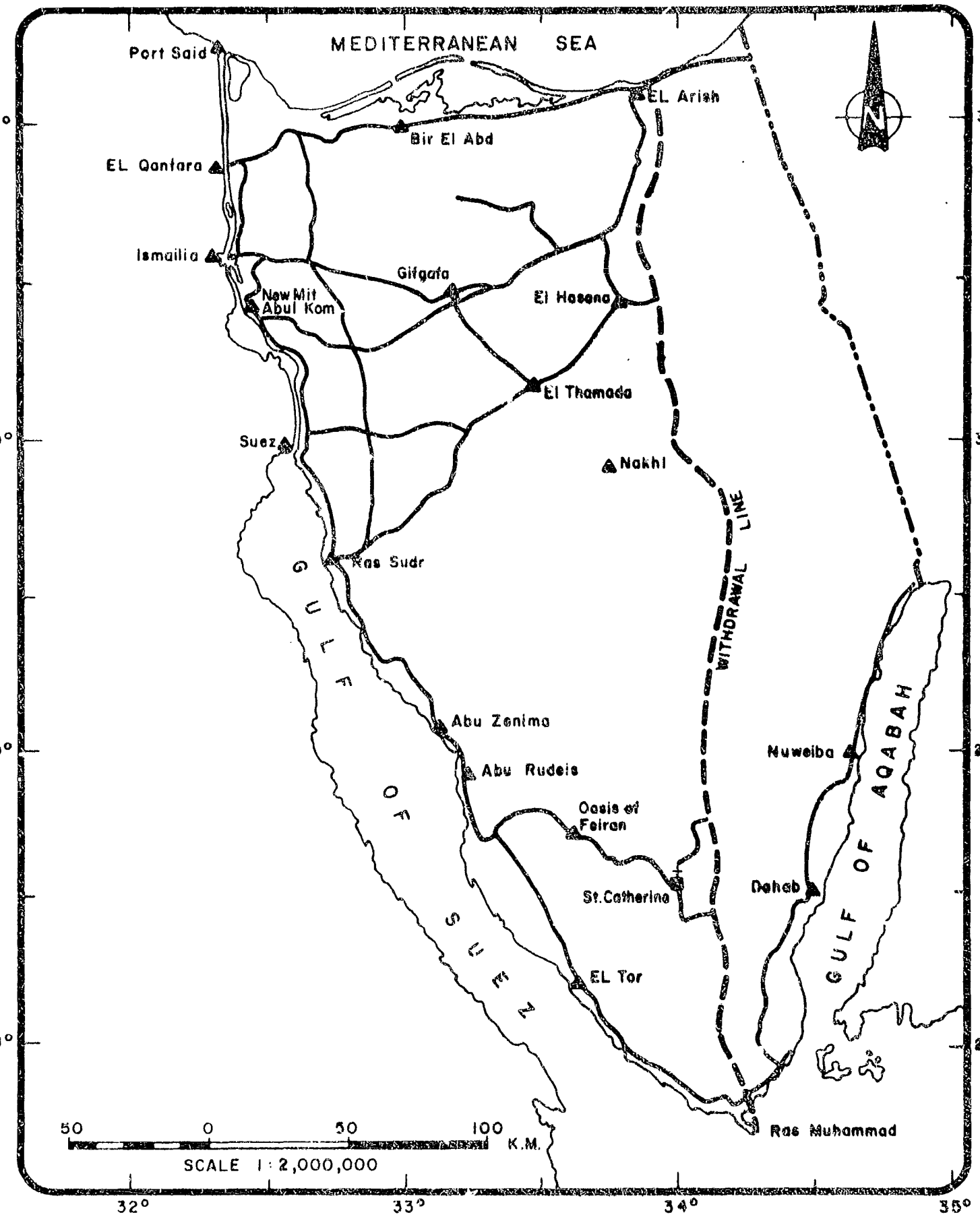
DRAINAGE BASIN AND PILOT AREAS IN SINAI

FIGURE 1



Sinai Development Study Phase I
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MAP OF IMPROVED ROADS IN SINAI

FIGURE 2

About 1,000 feddans are under cultivation now, and plans are underway to reclaim another 3,500 feddans(13). There is a major concern regarding their long term productivity. Irrigation water available is of low quality and is apparently deteriorating(14). Continued use of this water will lead to salinization and abandonment of the soil.

Eastward to Raafa, rainfall increases to 200 to 300 mm per year. Numerous small agricultural farms and orchards have been developed in this area which lies beyond the scope of this study.

South Bardawil Basin

To the south of Lake Bardawil, there is a narrow non-continuous band of arable soils of acceptable agricultural quality. These soils are truncated and in some cases more or less surrounded by shifting sand dunes. The area is quite inaccesible beyond the main highway, El Arish to Qantara. The water table is generally high and quality brackish in this area. Date palms are the most significant agricultural feature. Little hope can be extended for any crop production on a sustained basis beyond dates. These soils may be usefully planted to expanded date palm production.

Nile Delta Northeast Extension

The soils of this extreme northwest region of Sinai has limited agricultural potential. Sandy Regosols suitable for crop production may amount to 33,000 feddans. However, these lands are bordered on the southwest and east by shifting sand dunes and on the north by El Tina Plain. Elevation is below 20 meters, and drainage can only be expected to be fair to poor. The lacustrian clays of the Tina Plain underlay much of this land. They are highly salinized and almost impermeable to water percolation. This is a high risk area which has been considered for irrigation by the Salaam Canal. Given the limited extent of arable land and high risks associated with drainage and salinity, this area cannot be recommended for intensive development.

Bitter Lakes Basin

An area of approximately 30,000 feddans has been under reclamation since the early 1960's. Interrupted by the war, these lands are once again being developed(15). Much of this land is sandy and sandy gravel with good physical qualities for agriculture. Much care must be exercised in the reclamation of this land to assure adequate drainage where required and land leveling where indicated.

Gulf of Suez Basin

The drainage systems of this region have resulted in the formation of a massive alluvial deposit, known as the El Qaa Plain, and several other smaller sandy, gravelly terraces. Although agriculture is confined to patchy, small areas near El Tor, Sudr, Abu Zenima and Ayoun Musa, the soils of El Qaa Plain clearly have great crop production potential, if water was available. Considerable areas of sandy, well-drained soils exist, and access to the area is via one of the best improved roads in Sinai. It appears that, of all Sinai soils which are most accessible, this area holds the greatest promise for agriculture, if large supplies of good quality water can be found.

3 - Climate

The climate of Sinai is considered arid in the north and extremely arid from an agricultural standpoint in the south - annual precipitation ranging from as low as 10mm south and west to 100mm in El Arish. A Mediterranean semi-arid belt is located in the extreme northeast area of the peninsula, where rainfall may be as high as 300mm per year.

Temperatures are high. Mean daily temperature varies in El Arish from 12° C. in January to 26.2^{o} C. in August, with a mean of 24° C. The highest temperature recorded was 48.6^{o} C. in May 1941. The lowest was 0.0^{o} C. in February 1950. Temperature ranges are even more extreme in the central mountain area. In the south and southwest, temperatures range slightly higher than in El Arish(16).

Solar radiation is intense in all of Sinai, contributing to high evapotranspiration ratios.

Standards and definitions of arid lands have not been broadly accepted. Many such classifications are used. Within the agricultural sector of this program, it is believed that the most useful definition is that of Meigs(17). This bases the definition on whether or not precipitation is adequate for sustained crop production. In Sinai, it is not adequate and must be supplemented by full scale irrigation techniques and/or very specialized techniques for capture of runoff water, spreading and timing and site specific planting systems.

Following Meigs' definition, the northern littoral region of Sinai is arid, and the balance of the peninsula is extremely arid.

Complete weather data for purposes of determining long range patterns of precipitation, temperature and wind speed are not available. However, weather records are available for temperature and precipitation from the following locations: Port Said, Ismailia, Suez, El Arish, Rafaah, El Maghara, El Qusayima, El Konttella, Nakhl, Abu Rudeis, El Tor and Sharm El Sheikh. Other information is available regarding ambient humidity, wind velocity and direction, cloud cover, etc. The sequences of all data, however, are broken for all sites(18). A recommendation has been made for the establishment of a uniform network of meteorological stations (19).

In any event, the aridity of Sinai has existed for millenia and will continue into the foreseeable future. Drought is the normal condition, not the exception. Irrigation by groundwater wells, water capture and spreading and importation of Nile water will not change the climate of Sinai nor make it a humid agricultural region. Intense solar radiation, high temperature, wind blown sand and low relative humidity in most of the peninsula combine to both restrict and favor agricultural practices.

4 - Plants

The deliberate cultivation of crops in Sinai probably began with dates and barley - crops which are indigenous in this mid-eastern region. They were important in earliest transhumance systems and continue to be cultivated. Both crops continue as food and livestock feed, particularly within the Bedouin economy. Dates have become an item of commerce within and beyond the Sinai borders. Barley is, as it probably always has been, a short season crop grown on residual moisture in wadi soils following winter rains. This somewhat salt-tolerant crop can be relied upon to produce some harvest even under adverse environmental conditions.

It is not known when vegetable crops were first cultivated in Sinai. At the present time, a very large number of vegetables and field crops are grown in gardens, small farms and in reclamation projects. These species include tomato, eggplant, okra, pepper, fresh beans, squashes, watermelon, cataloupe or musk melon, onions, lettuce, cabbage, horse beans, corn, sunflowers, alfalfa, peanuts, citrus, olives, grapes and potatoes. Most of these crops are grown on sandy soils near springs or hand dug wells. Reclamation projects near Al Arish and east of the Bittler Lakes will expand the acreage of a number of these crops, including alfalfa and other forages, olives, citrus, grapes, peanuts and perhaps oil seed crops as well as certain vegetables.

A successful system of watermelon production has been developed in the northern coastal region by the Bedouin which adapts specifically to the climate and environment of the sandy soils of that area.

The date palm is remarkably well-adapted to the moderately saline, high water tables of low lying areas within the north coast sand dune area. The potential for sharply expanded area of production of this species appears very promising. The crop as presently grown, an estimated one million tree (20), represents very low investment costs per unit of return and may be one of the most efficient means of utilizing extensive scattered areas of high water table soils in Sinai.

Although Bedouin livestock systems maintain a reasonable balance of man and animals to available resources, over the long term, major species of trees, grasses and browse plants have been eliminated. This pattern of slow continual destruction can be expected to continue as human population grows in Sinai. It appears critical to initiate programs aimed at rangeland management, grazing reserves and water catchment and spreading systems to increase the forage supplies and livestock potential of Sinai.

The Desert Institute undertook a project to evaluate principal constituents of native and introduced plants in Sinai. About 680 samples were collected from the same pilot areas, as mentioned above in the Soils Section of this report (Appendix 3).

In addition to the constraints on vegetative productivity due to water soils and climate,[1] previously discussed, many common diseases and pests attack crops and plants in Sinai. These include late blight of tomatoes and potatoes, powdery mildew of barley, cucumber and squashes, die back diseases of citrus, leaf spots of olive, barley, castor beans and clover, smuts of date palm and barley. Very little definitive work has been done on pests and diseases in Sinai. However, little has been done on any agricultural investigation to improve productivity.

Agricultural investigation and effective extension or communication of results to the growers is critically needed, if development is to proceed.[21] Selection of the best native varieties, introduction and testing of improved varieties, and production systems designed for maximum yield are fundamental to an expanded agriculture. Of equal importance will be control of pests and diseases and definition of fertilizer regimes for principal crops.

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[1] Water scarcity and low quality, soils low level of native fertility, organic matter, low water retention capacity and slightly saline nature, a climate which is arid to extremely arid with temperature ranging from below 0° C to over 48° C.

The native vegetation of Sinai reflects climatic conditions of low annual rainfall and hot dry summers, soil quality and the influence of nomadism as practiced for millenia in this fragile environment. Although, as mentioned above, the Bedouin/animal production system is in reasonable balance with the natural resource base, there is no reason to believe that it will continue to be so in the future as development proceeds and population increases. The Desert Institute undertook a broad survey of plant production and Plant Ecology for the Sinai Development Study - Phase I. (Appendix 3)

The vegetation of northern Sinai, the area with higher rainfall and perhaps least climatic extremes is characterized by open shrub vegetation. With the exception of population centers, springs and windbreaks in crop cultivation areas, the region has no trees. Ephemerals (annuals) can be seen in abundance for a brief period during and following the rainy season.

The production of forage and browse plants is low, due to climate, soil and nomadic animal pressures. In southern Sinai, natural vegetation is even more sparse.

In spite of the rigors of climate, soil and animal pressures on the natural range plants of Sinai, in the wadis of the north (El Bruk and El Arish), where runoff water is of considerable volume and soils exist, a number of palatable species with good vegetative production year-round are common.

The presence of many species of halophytic plants and some xerophytes reflects the saline nature of water supplies and adaptation of the xerophytes to extremely arid conditions. Many species of halophytes are dominant in salt marshes and in saline depressions, especially along the Mediterranean coast.

5 - Livestock

The estimates of the livestock population in Sinai are variable, but the most recent authoritative attempt by the Department of Agriculture, 1980-81, and reported by the Desert Institute Survey, 1981, Appendix 3 reports the following:

	SHEEP	GOATS	CAMELS	DONKEYS
North Sinai	25,159	75,713	3,766	1,230
South Sinai	12,698	44,917	16,282	5,092
TOTAL	37,857	120,630	20,048	6,322

These estimates are higher than those made previously and, in all likelihood, were made on a more thorough and precise basis. Most of the animals are owned by the Bedouin population and are managed, to a large extent, under the transhumant system. Marketing of animals and animal products, at present, is haphazard with little assistance or control by any authoritative body. A survey by the Desert Institute in South Sinai indicates that the proportion of young sheep and goats in the flocks is fairly small (around 14%), signifying that young animals are sold off or slaughtered, leaving those which form a nucleus for the breeding herd. The survey also indicates that a drought has been in existence in North Sinai for the past 10 years, thus decreasing the plant coverage due to annuals which are normally consumed, to a large extent, by sheep and young animals of all species. Consequently, it can be assumed that flock owners have paid attention to conserving the breeding animals so that even further expansion can occur if pastoral conditions permit.

However, having given due consideration to the written information on resources for animal development (water, pasture, crop production and the present philosophy of human intentions for retaining the animal oriented way of life in Sinai) and after having had a cursory visual appraisal of most of Sinai, it can be said with some degree of confidence that the Bedouins are making near maximum use of the resources presently available. If water for irrigation does become available for crop production and additional forages are produced and agricultural by-products are available at reasonable costs to livestock producers, some expansion could be expected. The degree of expansion depends on the degree of expansion of a crop agriculture.

Given the present resources, there appear to be four areas where some improvement may be made in the traditional sector even though small:

a - Pasture improvement through use of grazing reserves, perhaps created where water spreading techniques are employed and on experimentation programs on introduction of new and improved species of drought resistant forages (the latter to be included in the agricultural research program);

b - The use of improved sires made available, either by the import of known drought resistant breeds and/or an intensive selection program within Sinai where the "best" available sires in Sinai are made more utilitarian;

c - The creation of a marketing system whereby livestock owners can expect a fair return for their products, thus producing an incentive for ridding their herds and flocks of those animals of less than average potential; and

d - The strengthening of the animal health program in Sinai, whereby the facilities and assistance of the program are improved and made available to wider range of livestock producers.

Intensive modern development of dairy production depends, to a great extent, on the development of water availability for the production of forages and small grains. Modern poultry units can be based on imported (from the rest of Egypt) concentrates, if such are not available within Sinai; however, it would not be economically feasible to do so for intense dairy production.

SUMMARY

Several significant biogeographic and agronomic inferences may be drawn from the information available. These are critical to agricultural development in Sinai. The intense solar radiation in Sinai assures maximum light for photosynthetic processes associated with high yield. A long frost-free growing season in all promising agricultural areas assures full plant development. Relative humidity is favorable for a low incidence of many infectious diseases. The relative isolation of agricultural lands suitable for development strongly suggests the possibility of a seed industry for those crops requiring isolation to maintain purity of elite, foundation and certified stock. This same relative isolation is expected to reduce the natural infestation of insect pests and some disease agents. The excellent drainage characteristics of the sandy soils in Sinai reduce the possibilities of water logging and usually concurrent salinization of soils.

Having enumerated the principal advantages of the area, the balance of comments are largely negative for agriculture.

No natural sources of fresh water [illegible] quantities sufficient to irrigate more than two or three thousand feddans in t[illegible]e known to exist. Brackish or even slightly saline water will cause eventual salinization of probably all soils in Sinai, unless special care is used in application and drainage. The import of Nile water is costly and can be expected to remain so.

The intense solar radiation and low relative humidity of most of Sinai cause high evapotranspiration ratios. This, together with sandy, porous soils, means that the consumptive demand of plants will be high; and irrigation losses through percolation may be large. Thus, irrigation requirements will be higher per feddan than in the Delta.

Soil organic matter is extremely low in Sinai soils. High temperatures which cause rapid breakdown of organic matter will make it essentially impossible to buildup so-called "improved" soil textures and modify favorably the ion exchange and water holding capacity of these soils.

A desert agriculture is possible in Sinai in spite of these physical and climatic limitations and economic considerations. However, it will be a unique agriculture requiring constant attention to soil and water relationships above all and special techniques for economizing in use of water and fertilizer to assure adequate plant nutrition.

It is clear that crop production in this region must strive for maximum yields, using advanced technology if it is to be economically competitive and self-sustaining. For these reasons more than anything else, a special committment to investigation and extension (communication) is seen as indispensable for agriculture in Sinai (22).

BIBLIOGRAPHY

1. Groundwaters of the Sinai Peninsula. M. Paylor and M. Ayuty. Report to the General Desert Development Authority Gov. of U.A.E. 1961.

2. Andy Mills paper on groundwater resources, spring, wells etc. (reported preliminarily at August 30 meeting of Advisory Board).

3. Project Summary Code: 5-A, Serial No: 171; Land Reclamation Using Nile Water, Sinai Development Project - Phase I - Aug. 1981.

4. Preliminary Evaluation and Recommendations Regarding Groundwater Conditions at El Arish. Optional Working Paper No. 13 Sinai Development Study Phase I June 1981.

5. Economic Evaluation of Land Reclamation; Ministry of Irrigation - March 1981.

6. Memo from Dr. A. Shata to W.W. Moore, regarding trip to Sinai; August 10, 1981.

7. Drilling Program for Hydrological Investigations, Project Summary Code No. 3-A,B. Serial No. 1 Sinai Development Project Phase I, February 1981.

8. Evaluation of the Physical Characteristics of Terrain for Land Capability Planning. Final Report Sinai Development Project, Phase I 1982.

9. Development of Natural Agricultural Resources in the Sinai Peninsula. A.A. Shata. In Advances in Desert and Arid Land Technology and Development. Edited by Bishay, A. and McGinnies, W.G. Harwood Academic Publisher, pp 59-66 1979.

10. World Distribution of Arid and Semi-Arid Homoclimates. Arid Zone Research, 2, 203-10; 1953.

11. Weather and Climate. Koeppe, C.E. and Long, G.C. de McGraw-Hill, New York; VII + 449pp 1958.

11A. Inventory of Research on Surface Materials in Desert Environment. In Deserts of the World. McGinnies, W.G., Goldman, B.J. and Paylore, P. eds. University of Arizona Press 1968.

12. (8 above, same as).

13. Project Summary. Land Reclamation - El Arish, Code No. 5-A & B, Serial No. 170; Sinai Development Project, Phase I,1981.

14. Preliminary Evaluation and Recommendations Regarding Groundwater Conditions at El Arish. Optional Working Paper No. 13, Sinai Development Study; Phase I -1981.

15. Land Reclamation Using Nile Waters; Project Summary Code No. 5-A, Serial No. 171; Sinai Development Study, Phase I; 1981.

16. Climatic Elements/Sinai Peninsula; 1979.

17. (Same as No. 10 above).

18. Meteorological Authority of Egypt.

19. Network of Meteorological Stations in Sinai.

20. Enhanced Date Production. Project Summary, Code No. 5-A & B, Serial No.168; Sinai Development Study - Phase I; 1981.

21 Agricultural Experimentation and Extension. Project Summary; Code No. 5-A&B Serial No. 25; Sinai Development Study, Phase 1;1981.

22. Same as No. 21.

TECHNICALLY FEASIBLE POSSIBILITIES

By "technically feasible," we mean agricultural projects which can be undertaken in Sinai, because:

1 - Knowledge of a crop livestock breed or practice exists in Sinai to permit expansion of production, improved productivity or ease the introduction of change;

2 - The crop livestock or production practice has been widely tested successfully in other similar desert areas;

3 - The Sinai ecological characteristics suggest that the new technique could be successful even though presently unknown in Sinai; and

4 - No major biological or technical constraints are known at present in Sinai which would restrict the crop livestock or practice from use in that region.

The introduction of such technically feasible projects must be sensibly guided by economic realism. In addition, it is known that social structures, educational facilities, manpower, and physical inputs for expanded agriculture in Sinai are limited in quantity at this time.

Within these variable constraints, which may lessen as development proceeds, a rather large number of "technically feasible" projects have been identified for early implementation. In addition, the early development of a Sinai Regional investigation and extension and training institution will open up many possibilities for the development of projects, requiring preliminary or extended field trials and/or trained manpower for accomplishment.

A - <u>Traditional Crop and Livestock Improvement (technically feasible for early introduction)</u>

Increased vegetable production for population centers has been identified as a high priority project which is technically feasible and could be undertaken immediately(1). Many vegetables are grown in Sinai and Egypt. General knowledge of their production is known. These vegetables include tomato, onion, watermelon, potato, squash ("summer" and "winter" types), cucumbers, melons, green peppers, beans, cauliflower, cabbage, carrots, spinach, lettuce, eggplant, okra, garlic, globe artichoke, cow peas and broad beans. Onions and potatoes have been export items from Egypt for a number of years but not from Sinai.

It was observed that many varieties of these crops are not ideally adapted to a) the high summer temperature, b) have little or no resistance to virus and nemotodes, c) are late maturing, d) are of lower yield than varieties in other arid zones and e) are of variable quality.

It is believed that much improvement in the qualities or characteristics noted above could be attained by simply testing foreign varieties and germ plasm for adaptation to the special conditions of Sinai and substituting improved material. The germ plasm base in Sinai is very limited and; since no systematic evaluation of available international germ plasm has ever been made for Sinai, it is certain that increased production and quality would result from such simple proceedures.

The same is true for forages, fruits, date, peanuts, cereals, sesame and olives, although the process of identifying improved material of the perennials, especially tree crops, will be a much longer process.

The possibilities for improving the traditional livestock production sector are few because of the limitations caused by a predictably low annual precipitation. The domestic animal species in Sinai (goats, sheep, camels and donkeys) have become adapted to the rigors of continual drought and, indeed, reproduce. However, their rates of reproduction are low and allow little magnitude for growth in numbers or genetic improvement under the environmental conditions which exist. Consequently, until a greater crop production is possible through irrigation, giving a greater scope to forage production and the use of by-products for feed, any improvement will have to come about by more articulate management of the resources. Since the lands are more or less public domain utilizable by all at anytime and livestock are privately owned, it behooves owners to get all they can from the land and to move on. Little thought is given to conservation or any type of improvement, since those instigating such actions may later arrive back to take advantage of their foresight to find that others have already reaped the benefits.

Therefore, rather than government embarking on range and breed improvement, nutritional supplementation and the like which would probably be short lived, the highest priority for improvement of the traditional livestock sector should be given to trying to obtain the backing and cooperation of those people in Sinai, presently raising livestock. This resource, the

people, offers the greatest opportunity to affect change. Although under their present systems of management, the livestock producers do not act but plan like their resources are finite; they are limited. Better use of them can be made but only through the cooperation of those concerned.

Of highest priority in the traditional sector is the formation of livestock/grazing associations and a council of representatives of each association. All, then, can be made aware of the activities of the other, in order to plan the cooperative use of their limited resources rather than compete for them. Having established the associations, other projects to assist the traditional sector can then be implemented, but they should be put into operation concurrently or as much so as possible. For example, if an improved animal health program is implemented and is successful without likewise measures in management of range resources, herd and flock numbers may increase without an increase in the feed base causing extra pressure on the ranges and further deterioration. It follows, then, that an improved marketing system should be implemented so that producers have an incentive to sell the less productive animals and to sell the market animals at a younger age so that more forage is left for the producing herd. In the Bedouin society, all these types of activities and the decisions which have to be made are connected with beliefs and traditions, where a man's wealth and prestige is measured by the number of animals he keeps and where his insurance against disaster is measured in numbers of animals.

Since it appears that private ownership and/or control of pasture land by the livestock producers is not possible in Sinai, one way to overcome this dilemma is through the cooperative management of their communal resources, their private resources and their business negotiations. Through livestock associations, they can have input into decision-making concerning improvement of livestock production through such projects as grazing reserves, improved range conditions through water spreading, "pitting" and reseeding, animal health clinics, livestock markets and goat, sheep and camel stations, where improved breeding stock is produced. Acting along and independently of others, each producer could accomplish little in any of these endeavors.

The amount of improvement in production through these efforts may be small at first but should multiply fairly rapidly if an organized thrust is put forward. Experience in other developing arid zone countries has shown that

the introduction of exotic breeds of livestock is highly expensive and largely unsuccessful over the long term. There may be some usefulness in trying some of the species of drought resistant grasses and salt bushes from other countries but only in small trials at first. It appears that the principal avenue for improvement in Sinai is to continue with those animal and plant species that presently survive there and, through selection and environmental means, to try to increase production. Although the magnitude of improvement will not be great in terms of gross pounds, any increase will be a large benefit to the livestock producers living in Sinai.

The expansion of olive and date production presents special opportunities. Both crops are traditionally common in Sinai. The date palm shows some degrees of adaptability to saline groundwater and is grown in areas otherwise not highly desirable for vegetables, forage, cereal or oil seed crops. It has been recommended that date palm plantings be substantially increased(2). Improved germ plasm should be imported from abroad where varieties of high quality and yield are produced for the processed export market. A processing facility should be developed so that advantage could be taken of favorable international prices. Sinai, it is believed, would have an economic advantage in meeting the continuous high demand for quality dates abroad. Climate, soils and production capability exist in Sinai. Present expansion is severely limited by low wholesale price for fresh fruit. Since local markets appear staturated, the opportunity in the export market appears very attractive. A processing and marketing system would also provide more employment.

Somewhat the same situation exists with the olive crop. Oil extraction plants are of low capacity, and export marketing systems are primitive. The international demand continues high. The crop is well adapted and production techniques well known in Sinai. Expanded processing facilities and an international export marketing system would open up many opportunities for expanded production and employment.

These two crops have been singled out for export possibilities because both are less perishable than vegetables. Since no export facilities exist in Sinai at present, commodities must be transported to Port Said or Alexandria to enter the world market. As this may change in the future, at least as far as air freight is concerned, development should be aware of future possibilities for perishable, winter season vegetables and cut flowers.

B - Non-traditional Crops and Livestock Improvement Practices

One of the most promising development potentials is seen in seed production in Sinai. Climate and relative isolation of the region from major crop production areas (sources of contamination, pest and disease problems) are very favorable. Elite, foundation and certified seed production of certain vegetables, field crops, forages and oil seed crops might be successfully developed over time in Sinai.

Such a development presupposes the earlier establishment of an experimental system which evaluates germ plasm, determines control procedure for pest and diseases, and defines fertilizer, soil and water management regimes for major crops. The level of technical expertise required is high. Labor requirements for some crops requiring hand pollination is also high but represents an attractive employment opportunity.

Joint ventures with international seed production firms may be the most practical means of initiating such a program. Other export possibilities which are technically feasible include dried flaked onions, tomato paste, and perhaps peanut butter. Onion varieties in Egypt command a favorable place in European imports. They may be adaptable to processing to flakes, which bring greatly increased revenue to processor and grower alike and are non-perishable. Tomato paste on the international market has a good demand. Sinai may have some competitive advantage because of long growing season and lower labor costs than some other western nations. The peanut possibility deserves at least preliminary investigation, regarding potential market, since the crop is so widely grown in Egypt and is of high quality. Every advantage should be taken of processing possibilities for Sinai agriculture in order to bring greater economic returns to growers and to provide additional employment opportunities. At present, many products which could be locally produced are imported, including olive oil, olives, peanut butter and processed tomatoes.

A number of production techniques are feasible and, to some extent, already in limited use in Sinai, including drip and sprinkler irrigation systems. In view of the critical shortage of quality irrigation water and the soil characteristics - low water retention capacity, moderately saline conditions, and sodium and calcium carbonate concerns - immediate attention must be given to development of agricultural porduction practices which conserve water and maintain productivity of the soils. This will require intensive

investigation in the field by full time scientists and extension personnel.

In view of the infrequent but intense brief rainfall pattern in Sinai, effort should also be devoted to investigation of runoff capture and water spreading techniques. Some of these are or have been known and used in Sinai and may be usefully expanded in the future.

Investigation of possible farm production of castor beans, guayule, jojoba and halophytic species should be undertaken to determine the real potential of these plant materials. The castor bean has been grown in Sinai and is readily adaptable. Varieties as such do not exist but wild plants abound in certain areas. There is an international demand for oil which might be attractive if productive varieties and systems of production can be devised to supply the quantities needed to justify a processing facility.

There is also a developing international market for guayule and jojoba. Both of these plants are being grown in small nurseries in Sinai. There is no evidence that germ plasm sources have been systematically tapped nor is there an experimental facility capable of continuing trials and evaluation of plant materials. Again, climatic conditions favor these crops, and they may contribute to development following thorough experimentation.

A number of halophytes (salt tolerant plant) are native to Sinai and are consumed in part by browsing livestock. Research is presently well advanced at the University of Arizona on a wide range of world germ plasm. These plants promise much for desert regions, where saline soil and water conditions severely limit production of conventional animal feed crops. The potential use in terms of per cent of animal ration, nutritive value, possible production levels and propagation techniques are under intensive study(3). Collaborative investiagtion by a Sinai institution would greatly speed the probably usefulness of these plants for Sinai (and Egyptian) use in animal feeding systems.

As in the crop sector of agriculture, advances in non-traditional livestock production in Sinai,to any great extent, depends on the availability of water for irrigation either transported from the Nile or from underground sources. Intensive livestock production and finishing (dairy and beef) depends on the availability of fodder and concentrates at reasonable prices,

which, in turn, depends on irrigation water in Sinai. The importance of large amounts of water is not so great in the case of commercial poultry production in Sinai, since the necessary feedstuffs can be transported from the Nile Delta. However, the technical knowledge needed for such intensive production operations is available and successfully operating elsewhere in Egypt.

Besides the present uncertainty of available water in amounts needed in Sinai, another possible bottleneck for intensive livestock production in Sinai is the continual availability of enthusiasm and insitiative in the overall management of the operations. Such a problem seems to be of a lesser magnitude if operations are managed by private enterprise than by government. At present, enthusiasm is high, and there is no lack of initiative; but given a few bad years and experiences, the continual financing of large intensive production may face certain limitations which would cause enthusiasm and initiative to falter. At present, private enterprise is importing technical managers for intensive livestock operations at fairly high costs, but the question as to how long this will continue and whether it will continue to be acceptable in labor circles in Egypt if needed, must be addressed. Indeed, at present, there are Egyptian nationals who are technically qualified to manage such operations but apparently are reluctant to live in remote areas where such livestock operations may be located and are not overly enthused about the constant surveillance which such projects require.

There is little doubt that properly managed intensive dairy and poultry operations can be productive and economically profitable in Sinai, but they should be planned so as to meet the needs of existing and growing potential of the needs in Sinai. There is little or no potential for operations based on the premise that their production would be exported from Sinai to other parts of Sinai or other countries. There is valuable experience already available in the Nile Delta on the breeds of animals, the types of feed, the design of buildings and the type equipment needed.

These and other promising lines of investigation will be required by a Sinai institution if full advantage is to be taken of the few favorable characteristics of the region for agriculture. Further, lack of experimentation and extension of results to farmers will almost certainly result

in a decrease in productive capacity of Sinai, since soils are so susceptible to damage and water quality is generally so low.

Finally, it is proposed that controlled environment agriculture is technically feasible but, as indicated in the attached Optional Working Paper(4), it appears marginally economical at this time. The advantages and disadvantages have been enumerated. Most important among them being the tremendous increase in annual productivity, attainable per unit of land and water. The principal disadvantages are high capital and operating costs in an area where wholesale prices of vegetables are very low,and no real premium is placed on quality. However, a detailed study is recommended to determine the feasibility of CEA units, since it is expected that specialty markets for tourism and industrial development will occur with concurrent discrimination in quality and increases in price.

REFERENCES

1 - Vegetables for Population Centers; Project Summary, Serial No. 169; Sinai Development Study - Phase I - 1981.

2 - Enhanced Date Production; Project Summary Serial,No. 168; Sinai Development Study - Phase I - 1981.

3 - Agricultural Experimentation and Extension; Project Summary,Serial No. 25; Sinai Development Study - Phase I - 1981.

4 - Seawater-based Agriculture as a Food Production Defense Against Climate Variability; Hodges, C.N., et al; A paper presented at the International Workshop on Climate/Food Interactions; Aspen Institute; Berlin, Germany; Dec. 1980.

5 - Controlled Environment Agriculture in Sinai; Optional Working Paper No.23 ; Sinai Development Study - Phase I - 1981.

6 - Controlled Environment Agriculture; Project Summary, Serial No. 173; Sinai Development Study - Phase I - 1981.

III - DEVELOPMENT GOALS AND ISSUES IN AGRICULTURE

A - Present Goals of ARE

1 - Establishment of Agricultural Services Infrastructure

The immediate goal of the Government of Egypt in the Sinai agricultural sector, as reflected in the 1980-81 plans of public investment projects for Sinai (Table 2.3.1), seems to be the establishment of agricultural services infrastructure on a level comparable with that of the Nile Valley. Projects like the Directorate of Agriculture Headquarters, Agricultural Information Center and Agricultural Development Bank offices and warehouses in El Arish, or the cold storage facilities in El Arish and El Tor, fall into this category. The scale of investments is such that the goal of establishing the basic agricultural services infrastructure will be largely achieved within 2-3 years, although completing the staffing and establishing effective services may take longer.

2 - Self-sufficiency in Perishable Products

A parallel short-term goal reflected in the 1980-81 Investment Plan is making the Sinai self-sufficient in perishable agricultural products -- particularly vegetables, poultry, eggs and milk. For El Arish, present vegetable production on about 440 feddans covers very roughly one-third of the demand; the present deficit in vegetable production relative to demand is likely to turn into surplus in 1982, if the El Arish-Sheikh Zuweid-Rafah coastal strip (estimated to contain about 15,000 cultivated feddans, largely planted to vegetables) will be returned to Egypt with its irrigation systems in working order. Self-sufficiency in vegetables in El Tor will depend on the rate of development of local groundwater sources. The nine 5,000-bird poultry units budgeted for El Arish, plus the one existing and several planned private-sector units, indicate that self-sufficiency in poultry, meat and eggs could be achieved in 1983. Progress toward self-sufficiency in milk and meat would depend on developing local sources of animal feed (perhaps in the El Arish-Rafah coastal strip), as the cost of dairy and feedlot operations based entirely on feed imported into Sinai is prohibitive.

3 - Medium and Long-term Goals

The medium- and long-term agricultural goals for the Government of Egypt in the Sinai seem to be the reclamation of as much as possible of an area totalling up to 735,000 feddans in the crescent formed by the North Sinai plain and the strip east of the Suez Canal, based on massive transfers of Nile water. These goals are revealed by the evidence of current preparatory activities: enlargement of the Ismailia Canal, construction of El Salaam Canal (planned with a capacity for irrigating 400,000 feddans in the North Sinai coast strip), soil surveys in the North Sinai plains, and accelerated development of the area east of the Bitter Lakes (3,000 feddans are at present in the process of reclamation or initial cultivation). The medium-term goal is to reclaim by 1985 all or most of the 30,000-feddan area east of the Bitter Lakes; the long-term goal is to reclaim the rest of the "Northwest Sinai Crescent" by extensions of the Salaam, Ismailia and Salhiyeh Canals (Table 2.3.2).

These short- and long-term goals fit into a logical pattern: making the Sinai, institutionally and physically, an extension of the Nile Valley. All of the above goals may be interpreted as having the superior objective of firmly establishing the Egyptian character of Sinai so that at no future time could there be any question of its being an integral part of Egypt. This superior goal explains the priority currently given to Sinai in national planning and the willingness to allocate to it more investments than would be indicated by considerations of pure economic efficiency. Consequently, this superior objective should be kept well in mind by the planners, and development policies, strategies and projects formulated so as to maximize its realization.

B - Possible Development Strategies

Three strategies have been considered for the agricultural development of Sinai:

a - efficient acceleration,
b - moderate growth, and
c - maximum population absorption.

The salient characteristics of these strategies are discussed in turn below.

1 - The Efficient Acceleration Strategy

This strategy is based mainly on development of the local groundwater, agricultural and livestock resources of the Sinai, with minimal Nile water imports, and includes only these projects which would be economically viable elsewhere in Egypt. Table 2.3.3 shows that this strategy would comprise the following projects:

a - Agricultural experimentation in El Arish, Ras Sudr and the East Bitter Lakes area to develop appropriate agricultural technologies to Sinai conditions, and extension services to transmit them to the producers.

b - Recuperation of the El Arish-Rafah Strip, which is scheduled to be returned to Egypt in April 1982 and is estimated to contain 15,000 feddans under cultivation, mostly in vegetables. The investment necessary for resettling this area and maintaining its production level will depend on the condition in which it is returned to Egypt. Since it is a matter of maintaining the production of a currently highly productive area, this is a topic of obviously high priority.

c - Enhanced production of olives and dates, the main agricultural products of North Sinai, by introduction of improved varieties and husbandry.

d - Vegetable production to the extent necessary for self-sufficiency of the Sinai population centers.

e - Land reclamation, using well water of the 1,200 feddans currently under development near El Arish, 5,000 feddans in El Qaa Plain, and 2,000 feddans in other locations.

f - Traditional livestock sector: Animal health clinics, livestock/grazing associations, livestock grazing reserves, goat improvement stations, and stud ram breeding stations to serve the nomad livestock population.

g - Dairy and beef farms (some of them possibly located in the Rafah Strip) to provide fresh livestock products to the Sinai urban population.

h - Poultry farms for making the Sinai self-sufficient in eggs and poultry.

i - Controlled environment agriculture to provide year-round supply of high-quality vegetables to specialized markets.

j - Reclamation of 10,000 feddans east of the Bitter Lakes by various irrigation methods: surface, portable sprinkler pipes, center pivots and drip.

k - Establishment of a policy and planning forum to help direct future Sinai reclamation based on Nile water.

The above efficient-acceleration strategy, which is mostly oriented to the development of local resources, will result in the reclamation of 18,200 new feddans till the year 2000 (including the 3,000 already partially developed feddans in East Bitter Lakes), plus 15,000 feddans recuperated in the Rafah Strip. The total cost of this strategy until the year 2000 (including investment, O M & R) will be about LE 103 million, and it will furnish (including the Rafah Strip) about 11,300 employments.

2 - The Moderate Growth Strategy

Table 2.3.3 shows the projects included in this strategy. The moderate growth strategy includes all of the projects proposed in the "efficient acceleration" strategy. Agricultural experimentation and extension will be conducted on a considerably larger scale. The livestock projects (animal health clinics, goat improvement stations, stud ram breeding stations, dairy and beef farms)will be increased in scope, and camel improvement stations added. The largest difference of the moderate-growth as compared with the efficient-acceleration strategy lies in the larger extent of land reclamation: 10,000 feddans in El Qaa Plain, 20,000 feddans east of the Bitter Lakes, the 1,200 feddans presently under development near El Arish, and 4,000 feddans elsewhere, for a total of 35,200 feddans (plus the 15,000 feddans to be recuperated in the Rafah Strip). The total cost of this strategy until the year 2000 will be about LE 155 million, and it will provide (including the Rafah Strip) about 17,200 employments.

3 - The Maximum Population Absorption Strategy

This strategy is also depicted in Table 2.3.3. It includes all of the projects considered in the "moderate growth" strategy; the difference lies in the ambitious land reclamation goals it sets, mainly based on extension of El Salaam Canal into Sinai. The population absorption strategy would reclaim the 1,200-feddan area presently under development at El Arish plus the 2,500-feddan area south of the airport; 20,000 feddans in El Qaa Plain and 4,000 feddans based on groundwater elsewhere; the full 30,000-feddan area east of the Bitter Lakes; and, most importantly, 50,000 feddans of class III land and 50,000 feddans of Class IV land in El Tina Plain and the North Sinai coastal strip, through extension of El Salaam Canal east of the Suez Canal.[1/] Thus, the new area to be

[1/] The area to be developed in El Tina Plain and the North Sinai coast has been limited to 100,000 feddans until the year 2000 in view of the serious doubts which exist regarding the suitability of the soils in these areas for viable agriculture, and the likelihood that even under an accelerated construction program El Salaam Canal water will not be available for irrigation at the field level east of the Suez Canal much before 1990.

reclaimed under the maximum strategy would be 157,700 feddans (not including the 15,000 feddans to be recuperated in the Rafah Strip). The total cost of the maximum-population strategy until the year 2000 would be LE 432 million (including an estimated LE 80 million for extension of the El Salaam trunk canal, which would be called for only under this strategy). The maximum strategy will provide about 58,200 employments.

C - Issues

1 - Which Areas to Reclaim in Sinai?

This issue may best be taken up in parts, namely:

a - Reclamation based on groundwater,
b - Reclamation east of the Bitter Lakes, and
c - Reclamation based on El Salaam Canal extension.

a - Reclamation Based on Groundwater

There should be little question about the land reclamation areas based on groundwater which are included in the efficient acceleration strategy (8,200 newly developed feddans, mostly near the population centers of El Arish, Bir el Abd and El Tor, plus 15,000 feddans recuperated in the Rafah Strip). These areas would be utilized mainly to assure self-sufficiency in perishable products to the population which would be maintained in Sinai by activities in the other sectors (industry and mining, tourism and services). This is inherently an economically viable goal (if efficiently executed), considering the large distances over which perishable products must otherwise be transported to supply this population, in Sinai temperatures.

Following irrigation of the 1,200-feddan block in Wadi El Arish, development of the 2,500-feddan block south of the airport depends on groundwater availability. If a safe supply is found at a reasonable depth (less than about 20m), the area could be efficiently developed for root crops (peanuts, potatoes, etc.), fruit, forage and other crops which are in demand in the El Arish market. There would be a large number of local residents willing to cultivate land in this area.

The chief doubt in groundwater-based development concerns increasing the reclaimed area in El Qaa Plain from 5,000 feddans (efficient acceleration strategy) to 10,000 feddans (moderate growth strategy) to 20,000 feddans (maximum population strategy). The 5,000 feddans would adequately supply the needs of the local (mining, tourism, services) population for perishable products. Most production over and above that limit would have to be exported toward the larger urban centers (especially Suez). Even assuming that sufficient groundwater of good quality is found to irrigate 20,000 feddans and that the cost of groundwater development is written off, El Qaa Plain would be in a series of disadvantages compared with desert reclamation projects near Suez and Ismailia: higher transport costs for inputs and products, necessity for incentive payments to technical personnel, deficient management and supervision, and probable difficulties in finding settlers from the Nile Valley who would be willing to live as small farmers in this isolated location. In any larger-scale groundwater development of El Qaa Plain, the experiences of the New Valley are likely to repeat themselves with a vengeance. The same reasoning applies even more strongly to reclamation in more isolated locations such as Nakhl.

b - Reclamation East of the Bitter Lakes

The 10,000 feddans east of the Bitter Lakes included in the efficient acceleration strategy are a different case, as they form part of the Ismailia agricultural zone and would probably market most of their product through Ismailia. Thus, from an economic-efficiency point of view, reclamation east of the Bitter Lakes should logically be weighed against reclamation of similar soils (sandy to calcareous sandy soils which require sprinkler or drip irrigation) west of the Suez Canal. The main alternatives are the Salhiya Desert and Youth Province. An economic comparison ("Economic Evaluation of Land Reclamation," MOI, March 1981) reveals that both regarding productivity of investment (economic rate of return or ERR) and productivity of water, the East Bitter Lakes area is superior to the Salhiya Desert and Youth Province areas, chiefly owing to its lower altitude, as shown in the following table:

COMPARISON OF EAST BITTER LAKES AND ALTERNATIVE AREAS

PROJECT	GROSS AREA, FD.	AVERAGE ALTITUDE, M	RANKING (AMONG 63 RECLAMATION PROJECTS) ERR	WATER
East Bitter Lakes	30,000	8	51	36
Salhiya Desert	120,000	14	54	45
Youth Province	100,000	50	55	46
West of Suez	40,000	10	36	28
East of Suez	55,000	23	56	44

The East Bitter Lakes area is also favored by lower trunk canal investments (not included in the above table) and by the non-economic consideration of bringing population into Sinai. This situation gives Egyptian decision-makers the interesting option of leap-frogging Youth Province and the higher parts of the Salhiya Desert and concentrating the available resources on the East Bitter Lakes area. Both economic efficiency and non-economic considerations argue in favor of this strategy.

The "efficient acceleration" strategy calls for reclaiming 10,000 feddans east of the Bitter Lakes. This is about the target currently planned for 1985, and would signify stopping development at this level. However, in view of the superiority of the East Bitter Lakes area to El Qaa Plain, the Salhiya Desert and Youth Province area, and its absolute superiority to the Tina Plain and Sinai North Coast areas (discussed below), any land reclamation in Sinai over and above that proposed in the "efficient acceleration" strategy should take place first of all in the East Bitter Lakes area.

The above considerations are especially applicable to the approximately 220 center pivot systems currently being purchased by the Arab Contractors. These systems (with drip systems to fill the spaces among the circles) will irrigate about 40,000 gross feddans. Of this area, current planning calls for about 13,000 feddans (70 units) to be located in the Salhiya Desert, 10,000 feddans east of the Bitter Lakes and 18,000 feddans in Youth Province. The relative advantage of the East Bitter Lakes area over the high-altitude (40-70m) Youth Province indicates the desirability of eliminating the Youth Province reclamation and using the equipment instead for accelerated development of the entire 30,000-feddan East Bitter Lakes area.

c - Reclamation Based on El Salaam Canal Extension

Preliminary findings of the REGWA Co. reconnaissance soil survey of the areas which might be irrigated by extension of El Salaam Canal east of the Suez Canal indicates that, of the 1,000,000 feddans surveyed, 60,000 feddans were in Land Use Class III, 240,000 feddans in Class IV and 700,000 feddans in Class V (not suitable for agriculture). The semi-detailed soil survey to be soon undertaken is likely to further limit the extent of cultivable soils. Table 2.3.2 shows that El Tina Plain and the North Sinai Coastal area are nearly the worst areas which can be irrigated with Nile water, ranking as No. 60 and No. 62 respectively out of 63 possible sites. El Tina Plain consists of Delta-like sediments and, at the time of the Moslem conquest of Egypt (ca. 700 A.D.), was a part of the cultivated Nile Valley. However, a shift of the Nile branch since that time caused this area to be dried, and today it consists of salt flats devoid of any vegetation, with groundwater at 0-40 cm below surface level and covered with a 3-5 cm salt crust. There is doubt about the technical feasibility of leaching these heavy soils; and in any case, this is bound to be a time-consuming and costly process. In the case of the North Sinai Coast, the cultivable areas are saline, sandy-clayey patches surrounded by shifting sand dunes. The higher parts of the North Coastal Area, which are being considered as a possible alternative to El Tina Plain for irrigation with El Salaam Canal water, are nearly as deficient, ranking in Table 2.3.2 as No. 57 out of 63 possible sites.

Additional factors which argue against extension of El Salaam Canal east of the Suez Canal are:

(1) - The finger-like shape of the command area and the necessity for lining the canal in the light soils east of El Tina Plain would signify unusually high construction costs.

(2) - The matching of extremely saline soils with poor quality water of El Salaam Canal (which gathers the outflows of agricultural drains in the East Delta) would bring about low yields and a constant danger of losing the entire area to resalinization.

Extension of El Salaam Canal into the Sinai is thus an extremely high-risk, low-return undertaking which is proposed only under the maximum population strategy, and with strong misgivings at that. A laboratory test should be taken of leaching El Tina Plain soils with water of El Salaam Canal quality; this should immediately be followed by establishing a pilot project of adequate size (say 100 feddans) in El Tina Plain to acquire field experience in leaching these soils and to determine their yield potential. No further planning for El Salaam Canal extension into Sinai should be undertaken unless and until this pilot project has shown positive results.

2 - Sinai Development vs. National Food Self-sufficiency

In the 1990's, shortage of Nile water will become an increasing constraint to agricultural development. National water policy recognizes this, placing an emphasis on developing new water sources in the Upper Nile Basin and conserving water in Nile Valley irrigation. The Ministry of Irrigation (MOI) study mentioned above ranked the 63 sites considered for reclamation with Nile water according to the value of agricultural product generated by a given quantity of water. Table 2.3.2 shows that the East Bitter Lakes area ranks about average regarding the value of water (No. 36 out of 63), while El Tina Plain and the North Coastal Area rank very poorly (No. 59 and No. 63 respectively). The latter sites were calculated to produce a value of LE 2.15 and LE 1.66 respectively per cubic meter of water, as opposed to over LE 9.00/m^3 for the best sites. Reclaiming El Tina Plain and the North Coastal Area would, therefore, consume water which could produce over four times more agricultural products elsewhere in Egypt. This implies that reclaiming El Tina Plain and the Sinai North Coast Area would militate against the goal of national food self- sufficiency.

3 - What Organizational Structure Makes Sense?

Three settlement patterns are likely candidates for Sinai reclamation:

(a) - smallholders with 5 fd or less (in the case of vegetable farms) each;

(b) - large, capital- and management-intensive operations (e.g. the Arab Contractors); or

(c) - graduates with 10 fd each.

(A) - Five-feddan Smallholders

This is the only settlement pattern which has so far proven its long-term viability in Egypt. It has prospered mostly where conditions in the reclaimed areas were similar to Delta conditions (e.g. at Mariut), and where farmers had control of their water supply. In the case of Sinai, this pattern seems most suitable to the heavy soils of El Tina Plain (if they could be successfully leached and the drainage pumping assured), or for small (mainly drip-irrigated) vegetable farms around El Arish, Bir El Abd and other population centers.

Calculations based on observed New Lands cropping patterns[1/] show that a five-feddan farm (with the area in vegetables starting at 5% and increasing to 16% of the total) will provide full employment to a family having the equivalent of two adult farm workers. The target yields assumed would give farmers a product value about equal to what they would have obtained with average 1979 Delta yields. With such yields, and assuming no payment for water and a 25-year period for repayment of land and housing costs following a 3-year grace period, the smallholder would have a net return of LE 675 in year one, increasing to LE 1,139 at year ten and LE 1,559 at year 29 (after termination of payments). The above yields are considered optimistic, considering the inherently poor soils of the New Lands and the water supply difficulties experienced. However, even at 75% of target yields, farmer income will be LE 525 in year one, increasing to LE 617 in year ten and LE 1,037 in year 29. The above calculations indicate that the financial results for smallholders are likely to be sufficient to assure their staying on the project, to enable them to repay the land development cost and (especially after the development period) a part of the irrigation O & M charges.

(B) - Large Capital- and Management-intensive Operations

Large, high-technology farms such as the Arab Contractors' center pivot/drip systems in Salhiya and East Bitter Lakes hold the promise of greater returns but are associated with higher

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1/ "New Lands Productivity in Egypt - Technical and Economic Feasibility," Pacific Consultants, January 1980.

risks. The yield levels may be substantially higher than for smallholders if they have efficient management which can fine-tune the varieties and agricultural practices applied. The source cited above estimated that, at the end of a six-year development period, a 6,000-fd. farm using center pivots would have a net cash flow (after payment of labor, inputs, administration, equipment and O & M costs but before amortization of physical infrastructure) of 228 LE/fd/yr at target yields or 63 LE/fd/yr at 75% of target yields. Assuming that drip systems would result in a 25% higher yield, their net cash flow would be 393 LE/fd/yr. Thus, this model has the promise of satisfactory financial returns. Moreover, such large farms with drip irrigation were the only settlement form which showed, in the study cited above, an acceptable (16.3%) economic rate of return, i.e., considering the real (unsubsidized) costs of water and energy.

The most significant development to date in high-technology reclamation in Egypt is the massive involvement of the Arab Contractors, who currently operate ten center-pivot systems (with drip systems among the circles) in Salhiya and five in New Mit Abul Kom (east of the Bitter Lakes), and have reportedly ordered about 220 more such systems for a total area of about 40,000 fd. in Salhiya, Youth Province and East Bitter Lakes.

(C) - Graduates with 10 Feddans Each

During the last few years, a priority land reclamation objective of the Government of Egypt has been to settle agricultural university graduates (and other interested graduates) in reclaimed areas. As settlement on 30-fd. farms has run into severe labor shortage problems which resulted in much of the land being left fallow, the current policy (e.g. in the Youth Farms graduate settlement east of the Bitter Lakes) is to allocate ten feddans per graduate.

The Government of Egypt objective [illegible] tling university graduates as productive farmers rather than creating for them unproductive office occupations is praiseworthy. However, the problem yet to be solved with this organizational form is that

university graduates, while willing to drive a tractor and even to lend a hand with the physical work during peak seasons, basically see themselves as farm managers rather than workers-cum-managers, whereas a ten-feddan farm is much too small to support a full-time manager. The only likely way to make the graduate farms viable in the long-term is to devote a considerable area to tree crops. The study cited above calculated that from year ten onwards, net revenue of a 10 fd farm, including 5 fd of orchards and 2.25 animal units (before any payment of water charges or land and housing installment payments), will be LE 2,403/year at target yields or LE 1,388/year at 75% of target yields, assuming all work is done by hired labor; full-time work by the graduate would add LE 385/year to the above net revenue. (The target yields assumed are considered optimistic, being comparable to 1979 Delta yields, so that 75% of target yields is the more likely figure.) However, deducting land and housing payment would leave the graduate at year ten a net income of only LE 1,565/year at target yields, or LE 450/year at 75% of target yields. The government may assist the graduates by waiving land and housing payments; this is indeed what happened so far in practice. However, if one assumes a graduate income target of LE 1,000/year, and assuming that land, housing and water payments are waived, this income target will be reached only in the seventh year (at 100% yields) or the ninth year (at 75% yields). During the initial period, the graduate will need an additional sum of LE 5,445 (at 100%yields) or LE 10,045 (at 75% yields) from his own on- or off-farm work, family assistance and government loans to maintain his income target. The above considerations point out that the ten-feddan graduate model has slim chance of financial viability unless the government (beside providing tree crops and waiving land, housing and water charges, at least during the first ten years) will provide additional funding to the graduates to help them survive the period until the orchards mature.

4 - Efficient Technology vs. Population Absorption

The East Bitter Lakes area is currently a test site for several different irrigation technologies and organizational forms: ten-feddan graduates with surface irrigation, the Akkaria Co. with portable sprinkler lines and the Arab Contractors with center pivot/drip

systems. Although it is too early to judge the results, the Arab Contractors seem to have by far the best chance of success. However, the center-pivot system naturally lends itself to mechanization and centralized management: it would be next to impossible to operate a 150-fd center-pivot by 15 graduates using animal ploughing. The difficulties of finding agricultural labor willing to work in the reclaimed areas, which lack the amenities of the Old Lands, also push reclamation in Sinai toward capital-intensive technologies. However, according to the study quoted above, center pivots employ only about one person per 22 feddans; of these employees, only about one per 33 feddans are unskilled laborers. These figures should be compared to the employment of one person per 4 fd (one unskilled farmer per 5 fd) generated by projects using surface or portable-sprinkler technology and small-farm settlement pattern. Thus center pivot technology, which promises to be the most successful in the East Bitter Lakes area and many of the other reclamation sites in Sinai, is the one which serves least well the overriding goal of Sinai reclamation, namely population absorption.

5 - Fertilizer Quotas

Fertilizer is distributed to farmers by the Principal Bank for Development and Agricultural Credit (PBDAC) according to quotas which, for any given crop, are uniform for all Egypt. These quotas have been estimated on the basis of crop requirements in the Nile Valley and may be quite insufficient for the light, nutrient-poor soils of North Sinai, causing low yields. It is recommended that the PBDAC would establish zone-specific fertilizer quotas for the Sinai and other reclamation areas. Committees, including PBDAC, agricultural research and agricultural extension representatives, could determine the quotas for each zone, which would then be introduced into PBDAC norms. This would be a rapid and simple measure for increasing yields in Sinai and other reclaimed areas.

6 - Maintenance of Drip Irrigation Systems

Most of the equipment on the approximately 340 drip-irrigated feddans in the El Arish area is pre-1979, and some of it is up to seven years old. The useful life for this equipment is usually 4-5 years, so that much of it will soon be needing replacement. At present, drip irrigation equipment cannot be bought in Egypt off the shelf but must be

imported in lots for specific, previously-approved projects. Thus small farmers are effectively barred from finding replacements for their drip irrigation systems. Continuation of this situation will bring about a deterioration of the existing productive areas. To avoid this, it is recommended that the Bank for Development and Agricultural Credit in El Arish should maintain a stock of drip irrigation components sufficient for equipping about 100 feddans, which would be sold to farmers on cash basis and periodically replaced. Egyptian-made spare parts of adequate quality should replace imported spare parts as soon as they are available, but the creation of a stock of spare parts should not wait the establishment of a national manufacture of drip irrigation equipment.

7 - Land Tenure on Government-financed Reclamation Projects

Graduates and smallholders on government-financed reclamation projects presently receive at the time of settlement an "Ownership Certificate" for their land. They have then a 15-25 year period of installment payments of the land development cost, preceded by a 3-4 year grace period. The beneficiary must complete this 18-28 year payment schedule, and furthermore all members of a given New Lands Co-op must complete their payments, before the Ministry of Development will grant a definitive "Deed of Ownership" to members of that co-op. In practice, few if any New Lands settlers have received deeds of ownership.

The present ownership certificate is little more than a right of usufruct. Without a Deed of Ownership, a beneficiary cannot offer his land to the Development and Agricultural Credit Bank as collateral. Thus, he is not eligible for medium-term credit for livestock purchase and other improvements, other than the severely restricted credit (about LE 200 per beneficiary) offered through the MOD land reclamation co-ops. There are no arrangements for beneficiaries to get a second lien on the part of the land they have already paid for. Worse yet, since in certain land reclamation sites (e.g. Youth Farms in the East Bitter Lakes area) even the land value has not yet been determined, beneficiaries were reportedly afraid to plant orchards and make other investments which might result in their land being assessed at higher value. The present land tenure situation creates a dependence of the smallholders and graduates on the MOD, but acts as a strong disincentive to individual investments and sustained development.

At a minimal realistic interest rate of 15% annually, the present value of the current repayment schedule (a four-year grace period followed by 15 annual, presumably interest-free payments) is 20% of the nominal value. Considering also loan collection charges and the possibility of default, the MOD would recuperate a larger part of the land development costs by offering the reclaimed land for cash sales to the beneficiaries at 20% of its assessed value as an alternative to the present 20-year repayment schedule. Many beneficiaries are likely to take up such an offer, since a clear title would enable them to obtain loans (based on market land value) for farm improvements, as well as give them pride of ownership. Later arrangements may be also made with the BDAC to offer those beneficiaries who completed a part of their payment schedule a second lien on the part of the land already paid for.

8 - Agricultural Experimentation and Extension

Experimentation and effective extension are crucial to the successful development of agriculture in Sinai. The success of each project in the agricultural sector depends on an effective system of experimentation and extension. Much is known in other parts of the world which is relevant to Sinai and could be quickly adapted. Farmers will respond rapidly to improved techniques which promise profitable production gains; the payoff on this activity can be quite high.

Two agricultural experiment stations exist in Sinai: a 16-fd station at El Arish (operated jointly by the Green Revolution Organization and the Desert Institute), which has been in operation for many years; and a 25-fd station at Ras Sudr (under jurisdiction of the Desert Institute), which was established about four years ago. The El Arish station does mostly adaptation trials of imported forage plants, olives, beans and vegetables, and maintains a very good tree nursery; it needs resident scientific staff. The Ras Sudr station urgently needs levelling and a drainage system (or relocation) before useful experimental work could be done; it would also need resident scientific staff.

A program with a total cost of roughly LE 6.87 million up to the year 2000 (including LE 3 million in foreign exchange) is proposed in order to upgrade the existing stations, develop one to three new

ones, and provide the technical assistance and operating expenses necessary to develop and adapt agricultural technology suitable to Sinai conditions. This would include identification of the vegetables, olives, dates and forage varieties with highest yields under Sinai conditions; experimentation with their fertilizer requirements and agricultural practices; investigation of their pest and disease problems and control methods; introduction of promising crops (jojoba, castor bean, etc.) which are not presently grown in Sinai; and research of water and soil salinity (in the areas presently irrigated and those proposed for reclamation) and its control.

The urgent first step in the proposed program is to commission a team of Egyptian and international experts (about 20 person-months over a six-month period) to design a Master Plan for Agricultural Experimentation and Extension.

TABLE 2.3.1

Approved Agricultural-Sector Projects for Sinai, 1980-81

	LE 1000
1. Agriculture	
Animal Protection	22
Extension Services	200
Institutional Support	315
Veterinary Center	180
Institute for Zoological Research	2
Desert Institute	40
Green Revolution Authority	320
Land Reclamation	248
Village Development	328
Cattle Fattening	75
Chicken Production	85
Fishing Industry - Water resources	295
Olive Processing and Canning Plant	70
Subtotal	2180
2. Irrigation and Drainage	
Subtotal	2260
3. Agro-industries	
Bakery and Grain Storage, El Arish	1410
Ice Plant, El Arish	500
Ice Plant, N. Sinai	30
Ice Plant, S. Sinai	30
Fish Processing	90
Subtotal	2060
4. Electricity	
Electricity for Land Reclamation	100
Electricity for Food Processing	20
Subtotal	120
5. Transportation and Communication	
Green Revolution Authority	60
Ministry of Agriculture	195
Completion of El Arish Refrigeration Plant	250
Completion of El Tor Refrigeration Plant	250
Subtotal	215

TABLE 2.3.1 (Cont'd)

6. Trading and Finance	
Food Warehouses	100
Transportation Center for Fish Marketing Co.	115
Subtotal	215
7. Housing	
Construction of Units for Green Revolution Authority	90
8. Manpower	
Training Center for Green Revolution Society	60
Total, agricultural-sector projects	7740
Grand Total, approved projects for Sinai	54982
Share of agricultural-sector projects in total investment	14%

Note: This table understates agricultural-related investments by not showing investment in Agricultural Directorate & Agricultural Bank buildings and other facilites .

Source: Ministry of Development

TABLE 2.3.2

PROPOSED SINAI RECLAMATION PROJECTS BASED ON NILE WATER

NO.	NAME	WATER SOURCE	MAXIMUM AREA, FD.	DEV. AND IRRIG. COSTS (1980)[a] LE/FD.	TOTAL, MILL. LE	RANKING[b] ERR[c]	WATER
1	N. Coastal area (0-5m)	El Salaam Canal	265,000	1446.7	383,373	62	63
2	N. Coastal area (5-60m)	Salhiyeh Canal	250,000	1795.3	448,823	57[d]	49
3	El Tina Plain	El Salaam Canal	135,000	1388.6	187,460	60	59
4	E. of Bitter Lakes	Ismailia Canal	30,000	1737.2	52,116	51[d]	36
5	E. of Suez	Ismailia Canal	55,000	1789.5	98,421	56[d]	44
			735,000		1,170.193		

a Not including trunk canal costs, which may add (considering time discount) up to 100% to the real costs, esp. for projects 1, 2 and 3.

b On a scale of 1 (best) to 63 (worst) among 63 projects proposed for reclamation with Nile water (all New Valley projects are worse, ranking from 64 to 70).

c Economic rate of return.

d The operation cost of these sprinkler irrigated projects were underestimated by assuming only a 25m pumping lift, and the benefits probably overestimated by assuming 1/3 of the area in vegetables, 1/3 in grapes and 1/3 in alfalfa. Thus, the real ranking is even lower.

SOURCE: "Economic Evaluation of Land Reclamation," Ministry of Irrigation, March 1981.

TABLE 2.3.3

CHARACTERISTICS OF THE THREE AGRICULTURAL STRATEGIES

PROJECT	ECONOMIC EFFICIENCY	MODERATE GROWTH	MAXIMUM POPULATION ABSORPTION
		(LE '000)	
Agricultural Exp. & Ext.	2,870	6,870	6,870
Recuperation of El Arish/Rafah Strip	29,760	29,760	29,760
Enhanced Olive Production	560	560	560
Enhanced Date Production	460	460	460
Vegetables for Population Centers	1,150	1,150	1,150
Land Reclamation, Using Well Water			
Reclamation Near El Arish	3,120	3,120	8,260
Reclamation in El Qaa Plain	13,020	20,660	35,940
Other Reclamation	5,210	8,270	8,270
Animal Health Clinics	2,800	5,550	5,550
Livestock/Grazing Associations	230	230	230
Livestock Grazing Reserves	370	370	370
Goat Improvement Stations	1,400	2,680	2,680
Stud Ram Breeding Stations	1,400	2,680	2,680
Dairy & Beef Farms	245	990	990
Camel Improvement Stations	-	3,890	3,890
Controlled Environment Agriculture	2,706	4,448	4,448
Land Reclamation Using Nile Water:			
Establish Policy & Planning Forum	250	400	550
Reclaim East of Bitter Lakes	37,830	63,030	82,230
Extension of Salaam Canal			
Extension Trunk Canal & Siphons	-	-	80,000
Reclaim 50,000 fd. (Class III)	-	-	93,810
Reclaim 50,000 fd. (Class IV)	-	-	63,550
Total investment, LE 1,000	103,381	155,118	432,248
Total power requirements, Kwh/day	128,395	202,617	741,971
Water requirements, m^3/day	665,458	1,019,953	3,672,183
Employment, person-years	11,335	17,242	58,188
Total area reclaimed, fd.	33,200	50,200	172,700

IV - STUDY METHODOLOGY FOR AGRICULTURE

The agriculture team for Sinai Development Study, Phase I, consisted of five persons (Figure 3), with complementary backgrounds. One member of the team was a resident in Egypt during the course of the Study; the other members made two to four trips to Egypt, partly to observe the agricultural situation in Sinai during a complete cycle of seasons.

Each member of the team made numerous visits to Sinai to make first-hand observations of the resources, crops and livestock and to discuss issues and potentials with whomever was appropriate: farmers; Bedouin herders and leaders; national, regional and local government officials; local and foreign technical advisors; and plant and animal scientists familiar with Sinai and desert agriculture.

All during the course of the Study, team members reviewed whatever written material was available locally that provided background on the agricultural resources of Sinai and the plans and policies of the ARE that are pertinent to Sinai. For his own fields of specialty, each team member brought to bear on the subject for Sinai the most relevant international sources of literature and international developments in agriculture. The most pertinent sources are cited in various sections of the agriculture chapter.

To gain a better understanding of the natural agricultural resources in Sinai, the Desert Institute was asked to do a sample survey of those resources in areas which were judged, based on existing knowledge and experience, to have the best potential for agricultural development. (See Figure 1, page 9 .) Data obtained from the sample survey were used to help confirm or reject beginning hypotheses about which areas showed the most promise, so that these areas might be identified for more detailed investigations in anticipation of project preparation and implementation.

The development of the strategic considerations for agriculture in Sinai and the process of defining projects within that strategy context to take advantage of the opportunities for agricultural development were parts of the iterative process. Throughout the study period, team members tested ideas and concepts with each other, with study-team

SUBJECT MATTER AREAS OF SPECIALTY

OF AGRICULTURE TEAM MEMBERS

Subject Matter Area of Specialty	HESSER	RICHARDSON	TEMPLE	ASMON	DAVIS
Agricultural Development Strategy	XX	XX	X	XX	
Agronomy					
Field Crops	X	XX	X		X
Vegetable Crops		XX			
Fruit Crops		XX			
Desert Plants (forage)		X	X		
Desert Soils		XX	X		X
Irrigation Technology		X		X	XX
Controlled Environment Agriculture		XX			
Livestock					
Sheep, Goats & Camels			XX		
Dairy & Beef	X		XX		
Poultry			X		
Socio-Economics					
Farm Management	XX				
Marketing	X			X	
Credit	XX			X	
Land Tenure				XX	
Economics	XX			XX	
Agricultural Research, Experimentation, Extension & Training Institutions	X	XX	XX		

X = Working knowledge

XX = Expert knowledge

persons concerned with other sectors, with members of the Steering Commitee, and with local, regional and national Government officials.

Recommended Agricultural Development Program

The following series of development projects, listed more or less in order of priority, is recommended for the agriculture sector:

1 - Agricultural Experimentation and Extension

2 - Enhanced Olive Production

3 - Enhanced Date Production

4 - Vegetables for Population Centers

5 - Land Reclamation, Using Well Water

6 - Livestock/Grazing Associations

7 - Poultry Production

8 - Animal Health Clinics

9 - Livestock Grazing Reserves

10 - Camel Improvement Station

11 - Goat Improvement Stations

12 - Stud Ram Breeding Stations

13 - Dairy and Beef Farms

14 - Controlled Environment Agriculture

15 - Land Reclamation, Using Nile Water

Most of the agricultural projects depend for their success upon having a sound experimental base. Therefore, the highest priority project for early implementation is the Agricultural Experimentation and Extension project. Agricultural technologies that are specifically adapted to Sinai conditions will begin to flow from the experimental work, and the improved practices can then be demonstrated and recommended to farmers through the Extension component of the project. In the Efficient Acceleration strategy, the two existing experimental stations should be developed, and a few selected field

experimental units (e.g., one in the East of Bitter Lakes area) should be installed. Under the Moderate Investment strategy, one or more new experimental stations should be added to the system, and perhaps the existing stations should be expanded somewhat. For this project, the level of activity would be essentially the same under the Moderate and the Maximum Population Absorption strategies.

The next two projects on the list -- Enhanced Olive Production and Enhanced Date Production -- are relatively low-cost, low-risk projects that can have a high payoff over time. The potential volume of olive and date production is large enough to have a growing and significant impact on the Sinai economy. These projects should be fully implemented under the Efficient Acceleration strategy.

The project on Vegetables for Population Centers should also be fully implemented under the Efficient Acceleration strategy. It is a relatively low-cost project with potentially substantial benefits.

Land Reclamation, Using Well Water has different priorities for different locations. The level of activity over the next 20 years depends almost entirely on the results of exploratory drilling programs and the extent to which good water is found. The timing, or priority, for action will depend to a great extent on where the water is found. If additional economic sources of good water are found near El Arish, land reclamation there should have highest priority -- first for the 1,200-feddan area and then for the 2,500-feddan area, depending on the quanitities of new water discovered. Whatever additional land reclamation is determined to be feasible at El Arish should come entirely under the Efficient Acceleration strategy. The next highest priority area, depending on whether or not and how much usable

water is found, is the El Qaa Plains area, which has the largest contiguous and reasonably accessible area of potentially cultivable land. Again, water is the big unknown. Pending the results of exploratory drilling, reclamation of 5, 10, and 20 thousand feddans is suggested, respectively, for the three strategy levels. Obviously, these number will need to be adjusted as more become known about the availability fo water. Similarly, the amount and the timing of land reclamation in other areas, which may have cultivable soils, but be less accessible than the El Qaa Plains, will depend on the results of water investigations.

The highest priority activity among the livestock projects is to establish Livestock/Grazing Associations: (a) the success of some of the other livestock projects depends to a large extent on having the Associations in place and functioning, and (b) the possibility of reversing the trend of deterioration of the environment and the productive potential of the grazing areas depends on a more rational grazing system. This low-cost project should be implemented in the Efficient Acceleration strategy.

The Poultry Production project for El Arish is important, because it has the potential to produce quality protein -- eggs and poultry -- at feed conversion ratios that are quite favorable. Even if most of the feed must be brought in from outside Sinai, the favorable feed conversion ratios will likely make it more attractive to import feed (grain) rather than to import the much more perishable poultry and egg produce. This project should be implemented at the Efficient Acceleration strategy level.

The project on Animal Health Clinics is important because these clinics will help improve the productivity of traditional livestock enterprises by reducing the incidence of internal and external parasites and other debilitating

diseases. Half of the six clinics should be implemented in the Efficient Acceleration strategy and the remainder in the Moderate strategy.

The Livestock Grazing project is a very low-cost project and should be implemented as soon as livestock/grazing associations have been formed, in the Efficient Acceleration strategy.

The Camel Improvement Station project, which would provide about 50 improved bulls per year for distribution among camel herds in Sinai, has the potential of significantly increasing the milk-producing capacity and other important traits of camels. Although the potential return through time is high, it is suggested that this project be fully implemented in the Moderate strategy, but be omitted from the Efficient Acceleration strategy, partly due to its higher investment cost compared with the other livestock projects.

Both the Goat Improvement Stations and the Stud Ram Breeding Stations projects are important because of the potentially substantial increases in efficiency of goat and sheep enterprises among Bedouin herders. These are both low-cost projects. It is suggested that half the stations in each project be started in the Efficient Acceleration strategy and that the remainder be implemented in the Moderate strategy.

The Dairy and Beef Farms project, for El Arish, is difficult to judge in terms of priority. The need exists for a local source of supply of fresh milk and meat for the relatively large population at El Arish. However, one of the main constraints in dairy and beef production is an adequate supply of forages. As long as fresh vegetables are in deficit supply at El Arish, as they are under existing circumstances, it would not be good economics to take land out of vegetable production to grow forage. Only if it becomes feasible to reclaim much, or all, of the 1,200 and 2,500 feddan plots near El Arish will it likely make sense to produce substantial amounts of forages. Neither is it likely to be economically attractive to transport large quantities of forages to El Arish from the Delta. So, the feasibility of the Dairy and Beef Farms project depends to a very great extent on the degree to which new sources of good water are found, in quantities sufficient to justify reclaiming more land at El Arish. Unless additional land reclamation becomes possible, it will be better to bring in meat and sterilized milk from outside Sinai and to emphasize vegetable production at El Arish. One factor that might change the situation would be the possibility of growing forages

in the "Raffaa Strip," to support dairy/beef production for El Arish. Because of the uncertainties noted above, only a 50-cow dairy/beef project is suggested for the Efficient Acceleration strategy. At the Moderate investment level, a 250-cow herd is suggested, with no additional expansion recommended for the Maximum Population Absorption strategy.

Controlled Environment Agriculture is lower on the list of priorities than most other activities, partly because it may be a few years before events converge so that the time is appropriate and the economics are favorable. In El Arish, that time may occur when the new hotels and other developments are in place to support the European tourist trade. The demand for fresh, quality produce by institutions supporting the tourist business, together with the already large population at El Arish, would likely justify a CEA system. A 5-feddan unit, which would provide vegetables year-round for approximately 15,000 people, is recommended for consideration in the Efficient Acceleration strategy, probably coming into operation in the second 5-year planning period. In the Moderate strategy, another two to three smaller units might be installed for special situations in the petroleum and mining communities, which are remote from agricultural areas, and at St. Catherine's, where only a very small amount of vegetables can be produced for only part of the year. This latter one would support the tourist trade as well as the local population.

Land Reclamation, Using Nile Water is the lowest priority project in the agriculture sector, although at least part of the 30,000-feddan area, East of Bitter Lakes, demands early attention and deserves relatively high priority. It is recommended that 7,000 feddans, in addition to the 3,000 already reclaimed, be reclaimed East of Bitter Lakes in the Efficient Acceleration strategy. This assumes that appropriate attention as recommended elsewhere will have been given to rehabilitating the main canal and pumping stations, and that a Master Plan for development of the area will have been carefully prepared. In the Moderate strategy, it is recommended that an additional 10,000 feddans be reclaimed East of Bitter Lakes, assuming that detailed feasibility studies indicate that returns would be reasonable. Only at the Maximum Population Absorption level would the full 30,000 feddans be recommended for reclamation. Reclaiming the third 10,000-feddan area, East of Bitter Lakes, would push the area into the least desirable soils, and it would require not only rehabilitating the main canal system but would

also require completely redesigning and rebuilding the pumping station, which was designed originally for 20,000 feddans. Distribution canals would, obviously, also have to be extended. These additional investments in the infrastructure would have to be weighed against the lower marginal returns to poorer soils, on the one hand and, on the other, the already "sunk costs" in the new set of siphons across the Suez Canal, which presumably has a capacity to provide water for 30,000 feddans.

Except for the area East of Bitter Lakes, no additional land reclamation, using Nile water, is recommended for Sinai. On the basis of a growing body of evidence about the extremely poor quality of the soils, the productivity is bound to be so low (both absolutely and relative to alternative candidate plots for land reclamation west of the Suez Canal) that the investments would be unattractive even when social and political factors are considered.

EARLY ACTION RECOMMENDATIONS

Figure 4 summarizes the initial actions needed for each of the projects and gives an indication of the timing.

A most urgent action needed in the agriculture sector is to define a Master Plan for Agricultural Experimentation and Extension, because the success of virtually every agricultural project depends on a viable system of experimentation and field testing to provide guidance to Extension agents and farmers. A consultant team with members experienced in designing and managing similar institutions in other countries should be engaged to define the plan. Ideally, this should proceed even before Sinai Development Study, Phase II is initiated. (See Project Summary No. 25 .)

Equally urgent is the need to prepare a Master Plan for reclamation of the area East of Bitter Lakes. The Master Plan should define the feasibility studies that will be required for various components of the total reclamation scheme. Of the latter, it is most urgent that the main water conveyance system -- from the east end of the new siphons, through the main lift stations, and extending on out through the distribution and drainage canals -- be redesigned and rehabilitated or rebuilt. Otherwise, breakdowns and an eventual shut-down, while the system is being rebuilt, will be prohibitively costly. This work should proceed even before Sinai Development Study, Phase II is initiated. (See Project Summary No. 171 .)

To reiterate a point made in the chapter on water, it is most urgent that the exploratory well drilling program be initiated, especially in the El Arish vicinity. Until this is done and until the results for El Arish are known, land reclamation in the 1,200-feddan area at El Arish should be deferred. Otherwise, the risk is very high that the entire water supply -- municipal and agricultural -- will be seriously and perhaps irreversibly damaged by salinity.

As soon as the exploratory drilling program yields sufficient results about groundwater availabilities in Sinai, a master plan for land reclamation should be designed. This would indicate the areas where soil and water characteristics appear tentatively to be favorable for agriculture and would attach priorities on areas to be reclaimed. Starting first with the highest priority areas, feasibility studies, including detailed soil analyses would be conducted and implementation plans prepared. The master plan and initial feasibility studies should be done as

FIGURE 4

INITIAL ACTION NEEDED

PROJECT	FEASIBILITY STUDY	MASTER PLAN	BASE STUDY	DETAILED SOIL STUDIES	IMPLEMENT WITHOUT STUDY	TIMING
1 - Ag. Experimentation & Ext.		YES				Urgent
2 - Ennanced Olive Production			YES			1982
3 - Enhanced Date Production			YES			1982
4 - Vegetables for Pop. Centers			YES			1982
5 - Land Rec.,Well Water	YES	YES		YES		Soon as exploratory drilling program yields sufficient results on water.
6 - Poultry Production	YES					1982
7 - Traditional Livestock						
Associations					YES	1982
Grazing Reserves					YES	After Associations are functioning.
Health Clinics		YES				" Grazing Reserves are "
Camel Station		YES				" " " " "
Goat Stations		YES				" " " " "
Sheep Stations		YES				" " " " "
8 - Dairy & Beef Farms	YES					When it is known how much land rec. is possible at El Arish.
9 - Controlled Env. Ag.	YES					When tourism is about to flourish at El Arish.
10 - Land Rec.,Nile Water						
East of Bitter Lakes	YES	YES		YES		Urgent
Salaam Extension				YES		Before further thought is given to extending Salaam Canal to Sinai.
11 - El Arish,/Rafah Strip			YES			1982
12 - Fisheries						
Lake Bardawil			YES			1982-83
Bream Marketing		YES				After Bardawil base study completed.
Fishing Wharf (El Tor)	YES					1983-84
Aquaculture		YES				1982-83
13 - Drip Irrigation Spare Parts					YES	As soon as possible.
14 - Fertilizer Quotas for Desert Soils					YES	As soon as possible.
15 - Land Titles to New Land Settlers					YES	As soon as possible.

part of Sinai Development Study, Phase II. (See Project Summary No. 170 .)

The base studies indicated for the olive, date and vegetable projects would be largely descriptive analyses of the size of the areas where the crops are grown, location, cultural practices, types and varieties grown and their relative productivities, problems encountered by farms, and existing marketing, processing and transportation facilities. These base studies should be carried out soon -- as part of Sinai Development Study, Phase II -- and would constitute much of the background information on which the production projects would then be designed. (See Project Summaries, Nos. 167 , 168 , and 169 .)

Feasibility studies for the commercial poultry production project and the dairy and beef farms project should be conducted before implementing the projects. Particularly in the case of poultry, the "feasibility study" would not need to be exhaustive. It should include a realistic cash flow analysis and should contain an analysis to determine the appropriate size of enterprise initially, as well as a projected rate of growth. This venture would likely attract private investment and may not require government financing. The feasibility analysis could begin as soon as possible, with implementation to begin soon after the analysis is completed. As noted earlier in this report, the scale of dairy and beef farms project hinges on the extent to which additional land reclamation is possible at El Arish; the feasibility study would best be conducted after the results of the exploratory water drilling program at El Arish become known. (See Project Summaries, Nos. 23 and 93 .)

The initial action needed in the traditional livestock subsector is to begin the process of formulating livestock/grazing associations. It is suggested that this process, which might take six months or more, be started without first having conducted a formal study. However, a major part of the process will be to analyze the best locations in which to form associations, taking account of both the natural resources and the interest of the people in particular areas in becoming members of the associations. This process should be initiated in 1982, as part of Sinai Development Study, Phase II. One or more expatriate technical consultants who have had experience in helping to formulate livestock associations in other countries under similar circumstances will be needed. (See Project Summary No. 139 .)

As soon as one or more associations are functioning, the grazing reserves in those vicinities should become operational. Again, this will be a process of

negotiation, education and supervision. As a part of the whole process of formulating associations and establishing grazing reserves, logical sites for the health clinics and the camel, sheep and goat improvement stations will be identified. Outlining the master plans for these stations will be an integral part of the task of establishing the associations and grazing reserves. The successful implementation of the grazing reserves is a prerequisite to establishing the clinics and livestock improvement stations, because, unless there is an improvement in the feed base for the livestock, the payoff from health facilities and improved breeding will be minimal. The technical consultants that assist with forumlating the associations and grazing reserves should also assist with developing the master plans for the health clinics and livestock improvement stations. This should all be part of Sinai Development Study, Phase II. (See Project Summaries, Nos. 125 , 136 , 161 , 163 and 166 .)

A feasibility study will be required prior to building a controlled environment agriculture (CEA) system. El Arish is suggested as the logical site for the first installation. The timing will depend on the pace of tourism development at El Arish; the feasibility study will need to be coordinated with plans for construction of hotels and restaurants that will service the tourist trade. (See Project Summary No. 173.)
One of the first tasks in Sinai Development Study, Phase II, will be to do a base study of the agricultural situation between El Arish and the eastern border of Sinai at Rafah, the "El Arish-Rafah Strip." It is known that a considerable agricultural potential exists there, both rainfed and irrigated. However, no details are available as to the extent of the existing agriculture or its potential. This area is especially important as a factor in the food situation for El Arish. For instance, the deficit in vegetables at El Arish would likely be more efficiently filled from The Strip than from Ismailia. Equally as important, if ample forages can be produced in The Strip to support a sizable dairy/beef operation, the feasibility of that project will be enhanced considerably.

In the fisheries subsector, an early action in Sinai Development Study, Phase II, should be to do a base study of the resources and the potential for fisheries development at Lake Bardawil. Following the base study, a master plan for bream marketing could be prepared. A feasibility study for a fishing wharf at El Tor and a master plan for aquaculture development should both be carried out in Sinai Development Study, Phase II. (See Project Summaries, Nos. 7 , 34 , 39 and

Except for the area of East of Bitter Lakes, no further land reclamation in Sinai, using Nile water, has been recommended, because of the apparently low quality of soils. If additional evidence on the quality of soils is desired before a final decision is taken by the government on whether or not to extend the Salaam Canal into Sinai, then detailed studies of those soils should be carried out. A very important aspect of the soil problems in El Tina Plains is the impermeability of the lacustrian clay soils, which effectively prevents leaching of salts and makes it impractical to try to reclaim the land. One dimension of the detailed soil studies, therefore, would be to conduct laboratory tests on the leaching qualities of these soils, on a large enough scale that conclusive evidence is obtained. (See Project Summary No. 171.)

VI - CONCLUSIONS

- Despite the inherent limitations of water and soil in Sinai, opportunities exist for both enhancing productivity of the existing agriculture and initiating new, potentially productive activities.

- Olives dominate in the existing irrigated agriculture at El Arish; while olive production appears even now to be profitable, considerable potential exists for increasing productivity through time, at low cost.

- Date palms are well-adapted to large stretches along the coastal areas of Sinai; through systematic selection of superior varieties and with improved techniques of propagation and pollenization, substantial improvement in quality and increases in output, at low cost, will be possible.

- Much improvement is possible in the quantity and quality of fresh vegetables produced in the immediate vicinity of El Arish and other population centers in Sinai, virtually all of which are in deficit supply.

- The key to improvement in productivity of olives, dates, vegetables -- indeed, all of agriculture in Sinai -- is a strong system of agricultural experimentation, field testing and extension; much knowledge and varietal materials exist in other parts of the world which could be readily adapted to Sinai conditions with an efficient experimental system.

- The possibilities for improving productivity in the traditional livestock subsector, although severely limited by low annual precipitation, are attractive enough to warrant a determined effort.

- The key to improving productivity in the traditional livestock sector is the formation of livestock/grazing associations as institutions which would supervise the rotational use of grazing reserves, resulting in an improved forage base.

- If the feed base is improved through a rationalized grazing system, the payoff from improved breeding of goats, camels and sheep and improved animal health facilities will be significant.

- Sizable areas with reasonably favorable soil conditions exist in various parts of Sinai that could be effectively reclaimed if good quality water were available; the extent to which these may be reclaimed with well water can only be determined after more is known about groundwater potential.

- Unfortunately, the better soils in Sinai are in areas that are not feasibly accessible to irrigate with Nile water; the soils in the northwestern crescent of Sinai that are accessible with Nile water are generally of poor quality relative to other candidate plots for reclamation in Egypt.
- Of the candidate plots for reclamation in Sinai, using Nile water, the area east of Bitter Lakes, which is currently being reclaimed, is the most promising.
- The irrigation infrastructure from the Suez Canal through to farms in the area east of Bitter Lakes urgently needs rehabilitating.
- Except for the area east of Bitter Lakes, no further land reclamation with Nile water is recommended for Sinai, except possible up to 50,000 feddans, from extension of Salaam Canal under the Population Maximization strategy.
- Commercial poultry production appears to be feasible for El Arish and is recommended.
- The feasibility of dairy and beef enterprises at El Arish depends on the extent to which new sources of good quality water make it possible to reclaim additional land there on which forages might be grown, or on the extent to which forages might be grown in the strip between El Arish and Rafah to support these enterprises.
- Controlled environment agriculture as a means of producing quality vegetables is technically feasible; and while the economic feasibility appears to be marginal, such systems may have a place for special situations such as for the tourist trade, when it starts to mature, at coastal resort areas such as El Arish and St. Catherine's and for petroleum and mining communities which are remote from any agriculture.