

PREPARED FOR  
INTERNATIONAL COOPERATION ADMINISTRATION

# Sugar Production Potentials in the Republic of the Sudan

TUDOR ENGINEERING COMPANY, WASHINGTON, D. C.  
DECEMBER 1958

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International Cooperation Administration  
815 Connecticut Avenue, N. W.  
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December 29, 1958  
Reference: TEC-234

SUBJECT: SUGAR PRODUCTION POTENTIALS IN  
THE REPUBLIC OF THE SUDAN

Attention: Mr. Norman E. Thompson

Gentlemen:

On June 27, 1958, ICA issued Task Order No. 234 requesting that an investigation be made of the sugar production potentials in The Republic of The Sudan.

The Tudor Engineering Company engaged the services of Harold A. Wadsworth, Irrigation Specialist and team leader, Hector E. Gandia, Sugar Mill Design Engineer, Luis R. Marques, Consultant in Sugar Cane Culture, G. Donald Sherman, Consultant in Tropical Soils, assisted by Forest G. Warren of the U. S. Department of Commerce. The consultants left Washington, D. C. on October 3, 1958, and returned in the early part of December.

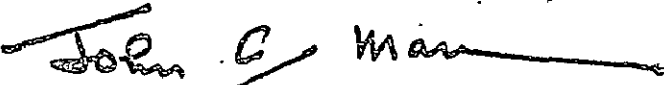
The accompanying report, prepared by the consultants after their return to Washington, is based on a review of all available reports and data, observations in the field, and their own studies, analyses and computations. The Tudor Engineering Company provided the essential backstopping in the preparation of this report. Certain parts of the report were drafted by individual consultants, but all have concurred in the final presentation.

Robert W. Kitchen, Jr., Director, USOM/Sudan, indicates in a foreword the importance of industrial development in The Sudan.

This report finds that it is feasible and economic to undertake the development of sugar cane and the production of sugar therefrom in The Sudan.

Very truly yours,

TUDOR ENGINEERING COMPANY

  
John G. Marr  
Project Manager

JGM:ebf



UNITS OF MEASURE AS USED IN

THE REPUBLIC OF THE SUDAN

AND THEIR EQUIVALENTS

1 feddan	=	1.038 acres
1 LS (Sudanese Pound)	=	\$2.87
1 LS	=	100 piastres
1 piastre (P)	=	2.87 cents
1 metric ton*	=	1.1 tons
1 gallon (Imperial)*	=	1.2 gallons ( U. S. )
100 cubic meters	=	0.97 acre inch
1 meter <sup>3</sup> /sec	=	35.32 ft <sup>3</sup> /sec
1 kilometer	=	0.621 miles
1 millimeter	=	0.03937 inch

\*Unless otherwise specified, the unit "tons" when used in this report refers to metric tons, and the term "gallons" refers to Imperial gallons.

First printing, December 1958.

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## TABLE OF CONTENTS

	<u>Page</u>
Letter of Transmittal.....	1
Frontispiece, Regional Map of The Sudan.....	2
Units of Measure as Used in The Republic of The Sudan and Their Equivalents.....	3
Introductory Comment by Mr. Robert W. Kitchen, Jr., USOM/Khartoum...	9
Summary of Findings and Recommendations.....	10
Chapter I - Foreword.....	12
Land Use Patterns.....	13
The Government's Interest in Land Use.....	15
Purpose of Study and Composition of the Team.....	16
Duration of Study and Methods Used.....	17
Basic Requirements.....	18
Chapter II - The National Economy.....	20
Foreign Trade of The Sudan.....	21
The Balance of Trade.....	21
The Shrinkage of Foreign Exchange.....	22
Efforts to Reduce the Outflow of Money.....	22
Government Versus Private Investment.....	23
Banking, Insurance Facilities and Interest Rates.....	24
Banking Facilities.....	24
Insurance Facilities.....	24
Interest Rates.....	24
Availability of Local Capital.....	24
Commercial Capital.....	24
Investment Capital.....	25
The Tax Pattern.....	25
Local Taxes.....	26
Direct Taxes.....	26
Business Profit Tax.....	28
Calculation of the Business Profits Tax.....	28
Population Distribution.....	29
Education.....	31
Cultural Backgrounds.....	32
Occupational Employment of Labor Population.....	32
Chapter III - The Environment and Agricultural Limitations in The Sudan.....	37
General Soil Groups.....	38
Climate in The Sudan.....	42
The Rainfall Pattern.....	42

# Table of Contents, Continued:

	<u>Page</u>
Temperatures.....	43
Water Supplies.....	43
The Nile and Its Tributaries.....	44
Underground Water Supplies.....	45
Chapter IV - Regulations Relating to Land and Water Use.....	48
Attitude of the Government Toward Land Use by Tenants.....	49
Water Licensing.....	49
The Pump Ordinance.....	50
International Agreements and Complications.....	51
Gravity Developments.....	51
Chapter V - Possibilities with Sugar Cane.....	53
Sugar Statistics, Imports and Consumption.....	53
Per Capita Imports.....	54
Imports by Type of Sugar.....	54
Imports by Country of Origin.....	54
Sugar Consumption Per Capita by Provinces.....	56
Local Trials with Sugar Cane.....	60
Trials at Mongalla, Equatoria Province.....	60
The North Khartoum Plantation.....	60
Trials at the Wad-Medani.....	61
Chewing Cane, Artesian or Panela Sugar.....	61
Potential Areas for Commercial Sugar Cane Planting.....	62
Criteria for Selection.....	62
Promising Areas for Sugar Cane Production.....	63
Kosti Area, White Nile (West Side).....	63
Sennar Area, Blue Nile (East Side).....	64
Wad en Nail and Abu Na' Ama Area, Blue Nile (West Side).....	66
Mongalla Area, White Nile (East Side).....	69
Areas of Great Future Potential.....	71
Jebel Moya.....	71
Limiting Conditions for Areas Not Recommended.....	73
On the Blue Nile - Bunzuga.....	74
On the Nile below Khartoum - Khartoum North.....	74
Bergeig.....	74
El Chaba.....	74
On the White Nile above Kosti - El Jebelain - Er Renk.....	74
Modern Sugar Production Practice.....	75
Field Operations.....	76
Land Clearing, Plowing, Furrowing.....	76
Seed Cane Production.....	78
Cane Planting.....	78
Irrigation.....	79
Harvesting.....	79
Irrigation Methods and Water Requirements.....	80
Irrigation Layouts.....	81
Possibilities in Overhead Sprinkling.....	82
Water Requirements.....	82

## Table of Contents, Continued:

	<u>Page</u>
Mill Operation and Design .....	83
The Values in Unified Field-Mill Management .....	88
The Cost of Sugar Production at Sennar .....	91
Capital Costs .....	92
Required Daily Workers for Effective Mill Operation .....	95
The Cost of Growing Cane .....	97
Profit and Loss Statements for Hypothetical Sugar Plantation .....	98
The Cost of Growing Sugar and the Possibility of Profits ....	103
Sugar Cane By-Products .....	104
Bagasse .....	104
Molasses .....	104
Training and Responsibilities of Supervisory Personnel .....	112
Field Supervisors .....	112
Responsibilities and Training of Mill Personnel .....	113
Chief Mill Engineer .....	113
Superintendent of Fabrication .....	113
Assistant Superintendent .....	113
Training of Sudanese Personnel .....	114
Sugar Cane Varieties .....	115
Sugar Cane Diseases and Their Control .....	118
The Need for Sugar Cane Research in The Sudan .....	119
Studies Leading to Improved Varieties .....	120
Necessary Work in Management .....	120
Mill Control and Improvement .....	120
Proposed Research Station .....	120
Need for Sudanese Journal of Agriculture .....	122
 Chapter VI - Possibilities with Sugar Beets .....	 124
Temperate Zone Origin of Sugar Beets .....	124
The Place of Beets in a Rotation .....	125
Sugar Beet Trials in The Sudan .....	125
The Diffusion Process in Sugar Extraction .....	127
Need for Abundant Clean Water .....	127
Sugar Beet Pulp as a Livestock Feed .....	128
Some Factors in Sugar Beet Culture .....	128
Harvesting by Machines .....	129
Requirements for an Adequate Beet Location .....	129
Acreage Requirements .....	129
Area .....	129
Transportation Requirements .....	130
Soil Requirements .....	132
Labor Requirements .....	132

# Table of Contents, Continued:

	<u>Page</u>
Potential Areas for Sugar Beet Production.....	133
Aliab-Mutmir Area, Northern Province.....	133
Seleim Area.....	134
Cost of Growing Sugar Beets, Cost of Refining Beet Sugar, Cost of Production in Cents (or Piastres) per Pound....	135
Recommendations with Respect to Sugar Beets.....	136

## APPENDICES

<u>No.</u>		<u>Page</u>
I	Tables Relating to the Economics of the Republic of The Sudan.....	138
II	Details of Capital Requirements for Field Operations Building Requirements Other than Factory for Effective Mill Operation Unit Operation Costs in Sugar Cane Production, Sennar Area Mill Manning during Grinding Season Mill Manning during Dead Season.....	144
III	"Government Policy Towards the Encouragement of Local and Foreign Capital in the Field of Industry and Its Attitude Towards Foreign Capital in General".....	151
IV	Acknowledgements.....	161
V	References.....	164
VI	Task Order No. 234.....	166

# LIST OF TABLES

<u>No.</u>		<u>Page</u>
1	Comparative Climatological Data for Several Locations of Agricultural Interest.....	14
2	Population Density by Province.....	30
3	Percentage of Population Receiving No Schooling in The Sudan by Province.....	31
4	Occupation and Distribution of Male Population Over Age of Puberty.....	33
5	Census of Male Labor Population over Puberty by Occupational Groups, 1955-56.....	35
6	Contributions to Main Nile Flow.....	45
7	License Fees for Nile Pumps in Sudanese Pounds per Year.....	50
8	Quantity and Value of Sugar Imports by Type, 1951-1957.....	55
9	Sugar Imports for the Period 1951 through 1957; Percentage Distribution by Country of Origin.....	57
10	Quantity and Value of Crystal Sugar Imports, 1951-1957.....	58
11	Sugar Consumption per Capita for Each Province, for the Year 1956.....	59
12	Climatic Conditions at Kosti.....	65
13	Climatic Conditions at Sennar.....	67
14	Climatic Conditions at Singa.....	70
15	Climatic Conditions at Juba.....	72
16	Capital Requirements for Essential Sugar Cane Plantation Operations.....	93
17	Required Personnel and Necessary Salaries for Field and Mill Operations.....	94
18	Costs of Unit Field Operations, Sennar Area.....	97
19	Profit and Loss Statement for a Hypothetical Sugar Plantation at Sennar.....	98
	Part One - First Year.....	98
	Part Two - Second Year.....	99
	Part Three - Third Year.....	100
	Part Four - Fourth Year.....	101
20	Capital Costs for Industrial Alcohol Distillery.....	109
21	Factors Determining Cost of One Gallon of 190° Proof Industrial Alcohol.....	110
22	Possible First Trial Sugar Cane Varieties Ecologically Appropriate for The Sudan.....	117
23	Geographical Pattern of Trade, 1953-1957, Appendix I.....	139
24	Balance of Trade, 1948-1957, Appendix I.....	140
25	Value of Exports by Major Commodity Group and Principal Commodities, 1954-1957, Appendix I.....	141
26	Value of Imports by Major Commodity Group and Principal Commodities, 1954-1957, Appendix I.....	142
27	Banking Statistics, Appendix I.....	143
28	Details of Capital Requirements for Field Operations, Appendix II.....	145
29	Building Requirements Other than Factory for Effective Mill Operation, Appendix II.....	147
30	Unit Operation Costs in Sugar Cane Production, Sennar Area, Appendix II.....	148
31	Mill Manning during Grinding Season.....	149
32	Mill Manning during Dead Season.....	150



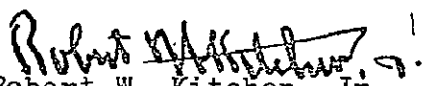
## UNITED STATES OPERATIONS MISSION TO SUDAN

Khartoum, Sudan

The Republic of Sudan has focused upon the question of accelerating its economic development soon after the achievement of independence. In that connection, considerable interest has been manifest in both the feasibility and suitability of private investment as an adjunct to Government of Sudan capabilities and external assistance projected from various international and bilateral agencies.

From the first contact with The Sudan, the International Cooperation Administration has felt that considerable advantage, not only in the form of capital flows but in obtaining additive administrative, managerial, and technical talent, would accrue from exhaustive and successful efforts to enlist the support of the private sector. It is further felt that a substantial part of the USOM/Sudan program should properly be that of serving as a catalytic agent in bringing together responsible, competent potential investors and appropriate agencies of Government and private business within The Sudan.

The work of the Sugar Survey Team which is now presented represents the first in what we hope will be a continuing series of feasibility studies which will at once assist the Government in developing policy decisions with reference to industrial effort and provide banking, industrial and governmental circles with a thorough pre-project evaluation. If these efforts can be conducted with competence and imagination, it is our continuing conviction that the results issuing from cooperation between private and public sectors will in all probability provide a greater enhancement of the future of The Sudan than would either sector functioning independently.

  
Robert W. Kitchen, Jr.  
Director  
United States Operations  
Mission to Sudan

November 22, 1958

## SUMMARY OF FINDINGS AND RECOMMENDATIONS

The Republic of The Sudan offers great possibilities for the economic production of cane sugar. The climate in many parts of the country is ideal, except for rainfall deficiencies, which can be offset by irrigation. In general, the soils are heavier and more difficult to work than would be desired. In some areas internal drainage is poor. In view of the extremely flat surface, some difficulties with surface drainage might be expected. But it is felt that these disadvantages can be offset by a careful selection of the location for the enterprise and by careful agricultural management.

An area south of Kosti and on the west side of the White Nile is recommended for first consideration. Its advantages are listed in the report. Other areas worthy of serious consideration are at Sennar and Abu Na 'Ama on the Blue Nile, at Mongalla in Equatoria Province, and Jebel Moya on the Sennar Junction-Kosti rail line.

A sugar plantation of sufficient size to carry 9000 feddans of sugar cane and a sugar mill capable of providing 34,000 metric tons of sugar per year offers the possibility of a return of about 7 per cent on the capital invested. Estimates made in The Sudan in the Fall of 1958 indicate that an investment of about LS 4,150,000 (\$11,900,000) would be required for such an enterprise.

A profit and loss statement has been prepared for a hypothetical sugar cane plantation at Sennar. This study indicated that an investment in excess of LS 4,000,000 would be required for the necessary field equipment, in purchase and erection of the sugar factory and the providing of essential auxiliary facilities. When this investment is made and working capital for salaries and supplies are provided, a profitable enterprise seems assured. The cost figures

used are conservative, since no means of evaluating tax concession that might be made by the government, under the authority of its policy to encourage new enterprise, particularly those financed by foreign capital, were available. A Business Profit Tax of 40 per cent has been included as an item in the cost schedule.

No immediate use is evident for the molasses which is an inevitable by-product of a sugar cane processing plant. The usual outlet, as a cattle feed, does not exist at this time. Fermentation into industrial alcohol is feasible but costly. The market for such a product is dubious. Molasses, as a fuel, is a possibility.

Sugar beets do not present as encouraging a picture. A long series of trials would be required to demonstrate that an adequate yield of recoverable sugar might be secured. A yield of 20 tons of beets per feddan and an average sugar content of 16 per cent, at the factory, should be assured before a sugar beet enterprise is established.

It is recommended that serious, immediate consideration be given to the establishing of a sugar cane plantation and sugar factory at Kosti or at Sennar. The cost and profit figures given in the body of the report should be inviting to foreign capital.

As is indicated in Chapter V of the report, the total sugar imports into The Republic of The Sudan in 1957 amounted to 106,800 tons. A single enterprise of the size recommended as an efficient economic unit might be expected to produce 34,000 tons per year. It is evident that several units of this size would be required before the entire demand could be satisfied by local production.

## CHAPTER I

### FOREWORD

The Sudan in North Central Africa is an ancient land. The Republic of The Sudan is a recent addition to the family of nations. The early history of the area, including as it does the accounts of waves of conquest as they swept across the ancient land of Kush from Egypt and from the Red Sea and the stories of the slave-raiders of more recent times, is not important for the present purpose, but those stories provide interesting reading.

The modern period, beginning with the reconquest of The Sudan by combined English and Egyptian forces during the last years of the nineteenth century, is significant. For, after the battle of Omdurman, there has been a continuing introduction of European cultures and institutions into the area. The final result was the establishment of a government of foreign domination under the authority of a Condominium Agreement between Britain and Egypt.

Although this foreign control resulted in marked advances in the governmental processes and physical prosperity of the area, it was unacceptable to the proud people of The Sudan. By 1951, an agreement was reached, after peaceful negotiations, by which a three-year period of self-government was established as a trial of local competence. Elections to a self-governing Parliament were held in 1953. The Republic of The Sudan assumed full independence on January 1, 1956.

As might be expected, the long influence of both British and Egyptian interests has left a pattern which is important in the present study. Governmental concepts and economic processes are in large measure patterned after

those in Britain. But, the ties with Egypt are strong, partly because of geographical location, and partly because of the large number of people who, due to ancestry or political inclination, find an interest in Egypt and its policies. The political situation in the Near East at present makes these considerations of great importance.

#### Land Use Patterns

Few countries present such a wide diversity of land usages as those found in The Republic of The Sudan. Nomadic tribes traverse the deserts and near-deserts with their herds of camels, goats and cattle as they did a thousand years ago. In the Gezira area, between the Blue and the White Nile, where the Sennar Dam adds the benefits of irrigation water, the agricultural practices are as modern and as productive as any intensively farmed area in the world. Between these two extremes lies a wide range of agricultural practices. These practices have been described by Tothill<sup>(5)\*</sup> to which the reader is referred.

The turning point is water. Where the Nile can be drawn upon, either by modern diesel-driven pumping plants, or by ancient water wheels, intensive production can be expected and is to be found. In the absence of this resource, rainfall in some areas makes the production of dura, the great grain crop, possible, although sometimes precarious. In drier areas, grazing is possible if the animals are moved with the natural grass that follows the pattern of the rains.

The Sudan is a land of great contrast. In the northern desert, near the ancient village of Dongola, an annual rainfall of 23 millimeters (less than 1 inch) per year may be expected. South of the great swamp between Malakal and Juba, an average annual rainfall of 970 millimeters (38 inches) is reported,

\*All references to published material shown thus ( ) refer to "References" cited in Appendix V.

with such a uniform distribution with respect to time that most of the crops of the tropics can be grown without benefit of irrigation, although even here irrigation facilities add security.

Similar contrasts can be found in the daily temperatures over the wide expanses of the country. Table 1 presents temperature, rainfall and relative humidity data from several typical areas of agricultural interest. The figures are from the excellent records of the Sudan Meteorological Service. More detailed data with respect to some of these areas will be found in subsequent sections.

TABLE 1  
COMPARATIVE CLIMATOLOGICAL DATA FOR SEVERAL  
LOCATIONS OF AGRICULTURAL INTEREST

Station	Latitude	Temperatures °C			Period of Records, Years	Annual Rainfall (Milli- meters)	Average Relative Humidity %
		Average Daily		Avg. Range			
		Max.	Min.				
Dongola	19.2 N	36.9	18.5	18.4	6	23	32
Shendi	16.7 N	37.2	21.9	15.3	9	136	35
Wad-Medani	14.4 N	37.0	19.8	17.2	10	381	43
Kosti	13.2 N	35.9	21.4	14.5	8	427	46
Roseires	11.8 N	36.2	19.9	16.3	26	802	56
Juba	4.9 N	33.6	20.9	12.7	24	970	73

Source: Sudan Meteorological Service

It is to be noted that all the stations listed above are on or near the Nile or one of its great tributaries. Except for a few relatively small areas, where local sources of water have been found, the agricultural economy of The Republic of The Sudan is dependent upon the wise and conservative use of the waters of this Great River system.

### The Government's Interest in Land Use

The Sudanese authorities have been active and constructive in establishing procedures by which the water of the great river and the land it serves may be used, but not unfairly. Any new activity such as a sugar enterprise will, in all probability, be governed by these procedures, although certain modifications or exceptions, particularly in the case of sugar cane, may be hoped for.

Most of the intensively irrigated land in the Nile Valley is primarily devoted to cotton growing. Due to British influence, a rigid system of rotation is established and adhered to. The pattern of the rotation may vary somewhat, but the planting of cotton is limited to one year in three, or one year in four. During other years, the land is devoted to the production of dura, lubia, a popular legume, or allowed to remain fallow. It must be admitted that this practice has been successful. Yields are maintained with a minimum use of costly imported fertilizers. Moreover, pest and disease problems are more readily controlled.

But the basic concept of rotation does not lend itself well to the production of sugar cane. When this crop is grown, it is anticipated that the planting will remain in place for four or five years, and that three or four crops will be harvested without benefit of replanting. Such a practice is in common use in all sugar cane producing areas. For experience has shown that the savings in such infrequent plantings, with the high costs of land preparation associated with such plantings, are more than enough to pay for the additional fertilizer necessary to maintain acceptable yields. In Cuba, Puerto Rico and Hawaii, areas have been in sugar cane continuously for seventy years. During this period, yields have continuously increased. It should be said, however, that agricultural management has been good and mineral fertilizers have been generously applied.

## Purpose of Study and Composition of the Team

A firm determination for economic independence by a new and relatively undeveloped area, particularly an area of no long history of industrial and agricultural diversification, demands an exhaustive search for possibilities for increased products which may be exported to the markets of the world or for products which will satisfy local demands and so save the expenditure of precious foreign exchange. This search is now underway by the Sudanese Government. The brewery which is now in operation in North Khartoum and the cotton textile mill which has been authorized are examples of successful efforts to reduce imports and to conserve foreign exchange. The possibility of producing sugar for local consumption deserves attention.

In an effort to explore this possibility, the International Cooperation Administration (ICA), under a contractual arrangement with the Tudor Engineering Company (TEC) of Washington, D. C., sent a team of five specialists to The Republic of The Sudan in October 1958. This team consisted of:

H. A. Wadsworth, Irrigation Specialist and Team Leader

G. Donald Sherman, Consultant in Tropical Soils

Luis R. Marques, Consultant in Sugar Cane Culture

Hector E. Gandia, Sugar Mill Design Engineer

Forest G. Warren, Chief, Middle East Section, U. S.

Department of Commerce

The party remained in the field until the end of November 1958. This team was instructed to investigate and to report upon the factors involved in the possible success or failure of a sugar cane or sugar beet industry in The Republic of The Sudan. The team was specifically instructed to report upon:

1. The possibilities of growing either or both sugar crops on the many soils and climate zones in The Republic;

2. The agricultural practices best suited for the areas studied;

3. The availability of labor and suitable methods for the local or foreign training of supervisory personnel;

4. The mill design best suited to each possible location, together with an estimate of the cost of producing and milling a unit of commercial sugar;

5. The economic climate for such a venture, including legal limitations, the tax structure and their effects upon such an enterprise;

6. The available markets for sugar and the by-products from a cane or beet enterprise; and

7. The possible effects of insects and diseases upon the crops.

The findings of this team make up the body of this report.

#### Duration of Study and Methods Used

In preparation for its field work, the team exhausted the possibilities of source materials in the offices of governmental agencies in Khartoum. Officers of the Ministry of Finance and Economics, Ministry of Commerce, Industry and Supply, Ministry of Communications, Ministry of Mineral Resources and the Faculty of Agriculture at Shambat, North Khartoum, were consulted and their advice used in the formulation of a program of field trips. As a result of many conferences, three field trips were undertaken. One of these was up the Blue Nile as far as Bunzuga; the second was north from Khartoum to Kerma; and the third was south to Juba, across the great swamp-like area of The Sudd, and to the area between Mongalla and Genmeiza. The expeditions were arranged to provide for an investigation of the several apparently most

promising sites for sugar enterprises. The tentative identification of these areas resulted from the many conferences in Khartoum. Sayed A. M. Hamadto, Commissioner for Development, Ministry of Finance and Economics, Sayed Hassam Mutwakil and Sayed Yogoub el Hilu of the Ministry of Agriculture were of great help in the identification of areas of evident potential and in arranging for these field trips.

#### Basic Requirements

Cane and beet sugar crops, like all others, present a series of requirements for satisfactory and economic production.

1. The soil should be permeable to both air and water. It should be of such a character that it can be worked easily by modern tools. It should be relatively free from excessive accumulation of saline or toxic materials. Natural fertility is a great attribute, but modern technology permits the continuing use of non-fertile soils. It should be said, however, that the skill of the operator must increase rapidly as the soils under consideration lose their natural fertility.

2. Water should be readily and economically available during a large part of the year, particularly with sugar cane. If irrigation is resorted to, controls with respect to frequency of application and the equivalent surface depth of water applied at each irrigation are essential.

3. Sugar cane is essentially a crop of the tropics. High temperatures can be tolerated and seem to be essential. Not much is known about the necessary length of day for maximum economic production. Day length is important in the formation of the flowering inflorescence which results in the loss of stored sugar in the flowering stalk.

4. Cane sugar can be produced in many areas of the world. The most favored areas, from a standpoint of over-all economy if other things are equal, are those favored with a market close to the point of production and in equal measure, areas that enjoy low base prices and minimum freight costs on the supplies that must be purchased.

5. The sugar beet, on the other hand, is generally considered as a crop of the temperate zone. It was first used as a source of refined sucrose in Europe immediately after the Napoleonic Wars.

Since that time, intensive breeding trials in temperate zone experimental stations have expanded its usefulness. There is no record of a commercial sugar beet plantation for sucrose recovery in the tropics. (4) The crop seems to mature best when there is promise of frost and when the days begin to shorten. The elaborate breeding studies leading to new varieties have tended to expand the beet areas in the Continental United States to the north rather than to the south. This is not to say that sugar beets should not be tried in The Sudan, but such a trial should be considered as exploratory. Several years spent in experimentation might elapse before economic feasibility of this crop on a commercial scale could be proven.

The Republic of The Sudan covers a wide area. It extends from the southern boundary of Egypt on the north in a latitude of about  $22^{\circ}\text{N}$  to the northern boundary of Uganda and the Belgian Congo on the south to a latitude of  $4^{\circ}\text{N}$  (see Frontispiece). In the other direction, it reaches from the deserts of French Equatorial Africa on the west to the mountains of Ethiopia and the Red Sea on the east.

Such a wide expanse, which is larger than all of the United States lying east of the Mississippi, must and does cover a wide variety of soil types, water supplies and other ecological situations.

## CHAPTER II

### THE NATIONAL ECONOMY

The economy of The Sudan is almost entirely an agricultural economy. The population census shows that 85 per cent of the gainfully employed males over the age of puberty are engaged in farming or caring for herds of cattle, goats, or other animals. Those who are engaged in farming are largely on a subsistence basis. They cultivate irrigated, as well as rain-grown, crops. Principal agricultural crops are cotton, lubia, dura, millet, sesame, corn and some wheat.

Livestock, amounting to 21,000,000 head of cattle, sheep, goats and camels, with an estimated value of LS 183,000,000, constitute a great wealth in The Sudan. (12) However, nearly 60 per cent of the value of livestock is in cattle and should not presently be considered as a major source of income because of the local habits and customs of the people. In some areas, cattle are considered as tokens of personal prestige and are infrequently sold. However, the government recently established a separate Ministry of Animal Resources "due to the growing importance of animal products, both as essential factors in raising the standard of living of the people and as exports of increasing value." (12)

The main product of irrigation-farming is cotton. This crop is grown on from 60 to 70 per cent of the land under irrigation each year. Other irrigated land is planted to dura and lubia. Cotton is thus the life blood of agricultural production and, since The Republic of The Sudan is dependent on

its agricultural economy, it is the life blood of the national economy of the country. Here rests the basic reason for the great need for diversification in agriculture.

At the present time, The Sudan has little industrial activity outside of the railway system centered in Atbara, and the cement plant, also at Atbara. In addition, there are several small plants in Khartoum, including a soap factory; a brewery, a shoe factory, and a black syrup factory. In Wad-Medani there is a new cigarette factory. In the south there is a small textile factory and a small cigarette factory. However, these and several other small plants provide employment for less than 200,000, or less than seven per cent of the total gainfully employed males over puberty in The Sudan.

#### Foreign Trade of The Sudan

The Sudan being a producer of agricultural products is compelled to trade largely with those countries that have a demand for more raw agricultural materials than can be produced. For this reason, the United Kingdom, India, and Egypt have historically been the major markets for Sudan exports. These three countries provided the market for 50 per cent of Sudan's exports in 1957, and were the source of 46 per cent of her imports (Appendix I, Table 23). The United States purchased only £S 1.2 million in The Sudan, or 2.7 per cent of Sudan's total exports. The United States was the source of Sudan imports in the amount of £S 2.1 million, or 3.3 per cent of her total imports. Sudan's primary export to the United States is gum arabic.

#### The Balance of Trade

Since 1948, the total foreign trade of The Sudan, i.e., exports plus imports, has increased from £S 46,000,000 to £S 112,000,000 in 1956 and £S 111,000,000 in 1957. (Appendix I, Table 24.) This healthy increase is

partly due to increased prices and partly to an increased volume of trade. The Sudanese government is to be commended on its continuous efforts to increase its domestic production to secure the foreign exchange needed to pay for the goods which it must import.

#### The Shrinkage of Foreign Exchange

The reliance upon cotton as the major foreign exchange earner has created a situation which makes the foreign exchange availability constantly vulnerable. For example, in 1956 cotton constituted nearly two-thirds by value of the total exports. In 1955, cotton accounted for approximately 60 per cent of the foreign exchange received from exports. A schedule showing the values of exported products by years is given in Appendix I, Table 25. These cotton returns have resulted in a favorable foreign exchange situation for The Sudan over the past years, but the vulnerability of a one-crop economy became not only apparent but serious in 1957 when the value of the cotton exports fell nearly 50 per cent below the 1956 level with a resulting unfavorable trade balance of LS 14,854,000. This unfavorable balance has continued into 1958 with an unfavorable balance of LS 10,611,000 for the first eight months.

#### Efforts to Reduce the Outflow of Money

The Sudan government is well aware of the current situation in regard to the unfavorable balance of trade. Several significant steps have been taken to improve the situation and to remedy the basic cause. As an emergency measure, the export price of cotton was adjusted to make Sudanese cotton more competitive on the world market, and the bank credit restrictions, which initially were imposed in September 1957 in an effort to reduce imports, were further tightened in September 1958. In addition, import permits have been issued only for essential items.

More basic than the emergency measures taken to conserve foreign exchange and to close the gap in the unfavorable trade balance are the actions taken by the government to diversify its agriculture, to increase domestic industry and so reduce the drain on foreign exchange. Research projects are being carried out to find improved varieties of dura and millet to increase yields. New crops are also being tested in an effort to add diversity to the agricultural program. Tests have been conducted for several years on growing sugar cane. Sugar beets have also been grown. Several test plots of castor beans have been established. Consideration is also being given to the soybean.

In the industrial field, the government has recently issued a license for the establishment of a \$24,000,000 textile plant. The government is also interested in the establishing of a new cement plant. The possibilities of a sugar industry are the subject of this current study.

The 1957 imports of cotton piece goods alone amounted to over LS 6 million and sugar to just under LS 6 million. As indicated in Appendix I, these account for 20 per cent of the total 1957 imports (Appendix I, Table 26).

#### Government Versus Private Investment

Apart from railways, public utilities, and ordnance works, The Sudan government is actively encouraging private investment in industrial fields. However, in all undeveloped countries, the governments play an important role in new industries. The Sudan government, if it feels it appropriate, might enter into an industrial scheme as a state enterprise. This, however, is not to be interpreted as meaning that the government desires to nationalize any given industry. Government officials have clearly stated that The Republic of The Sudan desires participation of private capital to the fullest extent possible in its development programs. Because of the importance of this statement, it is reproduced in full in Appendix III, together with the implementing legislation.

## Banking, Insurance Facilities and Interest Rates

Banking Facilities. Complete banking facilities are available in The Sudan. The following seven banks, located in Khartoum, have been authorized by the Sudan government to deal in foreign exchange:

Arab Bank Limited  
Banque Misr S.A.E.  
Barclays Bank (D.C.O.)  
Credit Lyonnais  
National Bank of Egypt  
Ottoman Bank  
State Bank of Ethiopia

Many of these banks have branches throughout The Sudan. For example, Barclays Bank has ten branches throughout the country from Juba in the south to Atbara in the north, and from El Obeid in the west to Port Sudan and Kassala in the east.

Dealings by banks in The Sudan in foreign currency are carried out through the National Bank of Egypt, Khartoum, for sterling and by the Barclays Bank D.C.O., Khartoum, for U. S. dollars.

Insurance Facilities. The commonly written types of life and property insurance are available through local representatives of 27 British, Italian and Egyptian insurance companies. The leading type of insurance from the standpoint of premiums is automobile insurance. Workmen's compensation legislation is in effect and provides that the government may declare insurance to be compulsory for employers in particular industries.

Interest Rates. The commercial interest rate for working capital is 6 per cent for cotton production and  $6\frac{1}{2}$  per cent for other commercial loans.

### Availability of Local Capital

Commercial Capital. Due to the limited industrial development and the recent poor cotton crop, the availability of local commercial capital is currently

very limited for any new major undertaking. This is reflected not only in the shrinkage of available foreign exchange, but also in the level of domestic loans and advances and the relationship of such loans and advances to total bank deposits.

As of December 31, 1955, the loans and advances by banks amounted to 71 per cent of the total bank deposits. The percentage increased to 87 per cent by the end of 1957 and to 99 per cent by June 30, 1958. The June 30, 1958 percentage of 99 per cent compares with 93 per cent for a year earlier and 68 per cent for June 30, 1956. The actual loans and advances increased from LS 22,289,000 on December 31, 1955, to LS 26,331,000 on December 31, 1957, and to LS 27,986,000 by June 30, 1958. (Appendix I, Table 27.)

Investment Capital. There are no data on available savings by individuals in The Sudan since most of the savings are invested in animals, real estate, gold ornaments, and grains. The savings which are made available in form of cash are limited. Actual savings by the majority of the people are limited due to the relatively low incomes which prevail and to the tendency to spend slightly in excess of income. An unofficial estimate placed the average indebtedness of the Sudanese worker at three times his monthly income. Indications are that it would be impossible to raise sufficient local Sudanese capital for any major industrial development scheme of the magnitude envisioned in the sugar production program.

#### The Tax Pattern

The specific taxes which a new enterprise is required to pay in The Sudan are determined by the official policy of the government toward new enterprises and foreign capital. If an enterprise qualifies under the special law for encouragement of capital investment in the field of industry and thus

becomes an "approved or pioneer enterprise", tax concessions are made by the government according to the "particular requirements of the industry".

(Appendix III.)

The regular taxes which an industrial activity is subject to in The Sudan, not taking into consideration any special tax concessions which an approved enterprise may be granted, are of three general types: (1) local taxes, (2) direct taxes by the central government, and (3) business profits tax. There is no regular income tax.

Local Taxes. (a) General tax. This tax is a local tax which is assessed against the owner of occupied property and is based on the actual rental value. (b) Latrine tax. This tax is assessed on each latrine to provide sanitary service. (c) Special tax. This tax is assessed according to need to provide for public services such as street lighting, and paving.

The local taxes vary from community to community. It is, therefore, impossible to give specific rates. In the Sennar area, these rates are:

- (a) General rate \_\_\_\_\_ 11% of assessed rental value
- (b) Latrine rate \_\_\_\_\_ negligible
- (c) Special rate \_\_\_\_\_  $3\frac{1}{2}\%$  of assessed rental value

Direct Taxes. The direct taxes are those which are assessed directly by the central government and are as follows:

(a) Custom duties: The general rate of import duty is 25 per cent ad valorem. Alcoholic beverages carry specific duties and foodstuffs and clothing are assessed at 20 per cent ad valorem, machinery and equipment are assessed at 10 per cent ad valorem, self-propelled road passenger vehicles, omnibuses of 9 seats and over and ambulances and bodies and chassis thereof

are assessed 60 per cent on £S 500 or less, and 100 per cent over £S 500; all other vehicles for operation on roads, including tractors, fork trucks, farm wagons and the like are assessed at 25 per cent; and office business machines are assessed 50 per cent.

The government policy toward the encouragement of local and foreign capital states that approved or pioneer enterprises may be given assistance by a reduction of import duties on raw materials. (Appendix III.) No reference is made to other import duties; however, the listings in the appendix are only illustrative of the type of assistance which may be given.

(b) Quay dues: In addition to the import duties, quay duties are assessed at Port Sudan on all imported goods at the rate of 1.2 per cent ad valorem.

(c) Land tax: The land tax, which is collected by the local governors, is an annual tax in the Blue Nile (Gezira and Managil) Kassala, Khartoum, Kordofan, and Northern Province on all cultivable land except land subject to ushur. The tax is calculated by either of the following procedures: (1) a maximum rate of £S 1.50 per feddan or (2) a maximum of 12.5 per cent of the value of the crop (except dates) or less if it is with consent of the Minister for Local Government.

(d) Ushur: Ushur is an annual tax on all rainlands which pay no land tax or rent. This is in lieu of the land tax and is leviable in amounts up to 15 per cent of the crop value.

(e) House tax: The house tax is assessed at 1/12 of the annual value of an assessed rent on all dwelling houses, hotels, stores, shops, factories or other buildings.

(f) Animal tax: All animals (camels, cattle, donkeys, goats, horses, mules, and sheep) are taxed at the rate of 5 per cent of the local market value.

(g) Date tax: In the Northern Province, each male date tree which has reached the flowering stage and each female tree which has begun to bear fruit is taxed at LS .06 per year. This amounts to 15 to 18 per cent of the crop value.

Business Profits Tax. The business profits tax is assessed as follows:

<u>Profits</u>	<u>Per Cent</u>
On first LS 500	12
On next LS 500	15
On next LS 4,000	20
On next LS 5,000	25
On next LS 10,000	30
On next LS 10,000	35
On the remainder	40

Calculation of the Business Profits Tax. Import duties, quay taxes, and local taxes are treated as business expenses in determining profits of an industry. The business profits tax is calculated using the rates indicated. From the tax thus calculated is deducted all of the various direct taxes which have been paid to arrive at the net business profits tax which is payable.

An exact evaluation of the tax liabilities of the hypothetical plantation is impossible until the concessions offered under the government's policy toward new enterprises and foreign capital can be determined. Some taxes will undoubtedly be payable.

A tax liability of 40 per cent of business profits has been used in the profit and loss statement. This arbitrary allowance for taxes is probably more than will be required after negotiation.

## Population Distribution

The potential market for the products from a local sugar enterprise must be measured by the current and expected population in The Sudan, for there is no thought, at present, that the product will enter the highly competitive world market. Moreover, any sugar enterprise requires a labor force of considerable size with a wide variety of skills and experience. Since this labor force should come in large measure from the population of The Sudan, the census figures as distributed by residence, schooling and occupation are important considerations in the evaluation of economic feasibility.

As a result of a government census made during the year between July 1955 and July 1956, the population of The Republic of The Sudan was given as 10,262,536. This population consists of two basic groups.

One of these groups includes the residents of the provinces of Kassala, Darfur, Kordofan, Khartoum, the Blue Nile and the Northern Province. They are, in general, Arabic-speaking Moslems. The other group includes the residents of the southern provinces, Bahr El Ghazal, Upper Nile and Equatoria. They are largely Pagan.

The populations of these provinces and the population densities are given in Table 2.

The Sudan as a whole is very sparsely populated, but the overall figures for population density may be deceiving. The population is largely concentrated along the Nile rivers, particularly in the Blue Nile and Khartoum provinces. These two provinces, which include the three towns of Khartoum, Khartoum North and Omdurman and the Gezira area, account for only 6.5 per cent of the total area, but include 25.1 per cent of the population (Table 2).

TABLE 2

POPULATION DENSITY BY PROVINCE (9)

<u>Province</u>	<u>Population</u> (number)	<u>Area</u> (sq. miles)	<u>Population</u> <u>Per Sq. Mile</u> (number)
Northern Provinces:			
Northern	873,059	184,151	4.7
Kassala	941,039	131,493	7.2
Darfur	1,328,765	191,598	6.9
Kordofan	1,761,968	146,891	12.0
Khartoum	504,923	8,095	62.4
Blue Nile	2,069,646	54,865	37.7
TOTAL	7,479,400	717,093	10.43
Southern Provinces:			
Bahr El Ghazal	991,022	82,508	12.0
Equatoria	903,503	76,475	11.8
Upper Nile	888,611	91,165	9.8
TOTAL	2,783,136	250,148	11.1
TOTAL (ALL PROVINCES)	10,262,536	967,241	10.6

The majority of the people of The Sudan live in villages and towns. The largest concentration of population is in the Khartoum-Khartoum North-Omdurman area with a total population of 245,736. Omdurman is the largest city of the three in this district with a population of 113,551. Khartoum has 93,103 and Khartoum North 39,082. Population of the remaining principal cities is as follows:

El Obeid (205 miles south of Khartoum and approximately 190 miles west)	52,372
Wad-Medani (in the Gezira area 110 miles from Khartoum)	47,677
Port Sudan (on the Red Sea)	47,562
Kassala (due east of Khartoum approximately 270 miles)	40,612
Atbara (212 miles north of Khartoum)	36,298
El Fasher (370 miles west of El Obedi)	26,161
Kosti (205 miles south of Khartoum)	22,688

The 10 principal cities have a population of 519,106, or 5 per cent of the total population. An additional 335,000, or 3 per cent, live in 58 other major towns.

## Education

The 1955-56 census revealed that 80.9 per cent of the children in The Sudan between the age of 5 years and under puberty had received no schooling. Seventy-two per cent of males had received no schooling, as compared with 92 per cent of the women. (9) In the Blue Nile and Khartoum Provinces, which include 25 per cent of the population, only 64 per cent of the men in the Blue Nile had received no education and only 39 per cent of the men in Khartoum had received no education.

The trend in the field of education in The Sudan is revealed by a comparison of the percentage of people over puberty who have received no education, with those in the age group of 5 years and under puberty. For the country as a whole, 88.1 per cent of the population over puberty have received no schooling, compared with 80.9 per cent of the population falling within the age bracket of 5 years to under puberty. Although the census figures indicate that an increased percentage of the population is receiving schooling, the trend is most pronounced in the northern provinces, particularly in Blue Nile, Northern and Khartoum Provinces (Table 3).

TABLE 3

PERCENTAGE OF POPULATION WITHOUT  
SCHOOLING IN THE SUDAN BY PROVINCE (9)

<u>Province</u>	<u>5 years of age and over</u> <u>to under puberty</u>			<u>Over Puberty</u>		
	<u>Both</u>			<u>Both</u>		
	<u>Sexes</u>	<u>Male</u>	<u>Female</u>	<u>Sexes</u>	<u>Male</u>	<u>Female</u>
Bahr El Ghazal	95.2	92.7	98.3	97.9	96.5	99.4
Blue Nile	75.3	64.2	89.8	83.6	70.9	96.2
Darfur	87.1	78.0	97.5	83.7	65.0	98.7
Equatoria	83.7	76.4	92.7	90.3	84.6	95.4
Kassala	79.4	71.2	91.2	85.9	77.0	95.8
Khartoum	50.6	38.9	65.9	66.8	49.6	87.0
Kordofan	89.1	82.9	96.9	93.7	88.0	99.1
Northern	63.1	44.2	87.8	83.4	65.5	97.5
Upper Nile	97.7	96.4	99.1	98.7	97.7	99.7
Sudan as a whole	80.9	71.8	92.4	88.1	78.4	97.3

## Cultural Backgrounds

Culturally, as well as geographically, The Sudan shares in both African and Middle Eastern civilizations. The population of the northern provinces are culturally part of the Islamic world. For centuries, nomadic tribes, in the scant rainfall area of the north, have been content to follow the seasonal rains north with their camel herds and to return yearly. Large numbers have settled along the Nile. The people of the central province of Kordofan, just south of the northern desert area, are now well settled, although the 8 to 9 month drought limits their agricultural activities. (8)

The southern tribes speak central African languages in contrast to the Arabic speaking northerners. In general, the southern population is less developed, culturally, than the northern. It seems clear, however, that all the people, regardless of their origin and places of residence, can be trained for agricultural work. This is evident in the labor force now employed in the private pumping schemes along the Nile, the Gezira scheme, the limited industry in Khartoum, the beginning of mechanized farming in the Blue Nile Province and the developments now taking place in Equatoria which require trained laborers.

## Occupational Employment of Labor Population

The 1955-56 census showed that there were a total of 2,752,166 male laborers, over age of puberty, in The Sudan. (Table 4.) However, of this number, only 3 per cent are craftsmen, 1.6 skilled workers, and 2.6 per cent laborers other than farm laborers. This means that any new industry coming to The Sudan would have to recruit its labor force largely from the 68 per cent of the labor force classified as farmers, hunters and fishermen, as

well as from the 5 per cent classified as animal owners and 10 per cent as shepherds. These three classifications make up 83 per cent of the male labor population.

TABLE 4  
OCCUPATION AND DISTRIBUTION OF MALE POPULATION  
OVER AGE OF PUBERTY (3)

<u>Occupation</u>	<u>Number Employed</u>	<u>Per Cent</u>
Professional-Non-Technical	2,621	.1
Professional-Technical	1,108	a/
Managerial Commerce and Industry	1,486	a/
Farm Owners and Farm Managers	196	a/
Semi-Professional-Non-Technical	38,148	1.4
Semi-Professional-Technical	6,765	.2
Shops and Workshop Owners	65,765	2.4
Clerical Workers, Senior	3,669	.1
Clerical Workers, Junior	20,026	.7
Craftsmen - Mechanics	79,518	2.9
Skilled Workers	43,051	1.6
Farmers, Hunters, Fishermen	1,868,316	67.8
Animal Owners	150,025	5.4
Machine Operators	32,663	1.2
Personal Services	36,781	1.3
Laborers, Except Farm Laborers	72,275	2.6
Farm Laborers, Forestry Workers	35,680	1.3
Shepherds	277,214	10.0
Protective Services	16,859	1.0
Total Gainfully Employed	2,752,166	100.0
Students, Unemployed, Beggars, Unknown	98,843	
Total	2,851,009	
Percentage of Gainfully Employed Total		96.5
a/ less than 0.1 per cent		

The population in the northern area from which a new industry of the magnitude under consideration would have to draw its labor supply would be the settled population along the Nile from Wadi-Halfa on the Egyptian frontier

down through Dongola, Kareima and on to Atbara, but particularly in the area between Wadi-Halfa and Kareima. There is currently surplus population in this irrigated area from which much of the labor for the Khartoum area is drawn. In addition, large numbers migrate to Egypt to seek work.

The caliber of the labor force in the northern Nile region is perhaps the best in The Sudan. Local government officials report that a labor force of from four to five thousand would be readily available. The census shows over 29,000 laborers, including craftsmen, machine operators, and non-farm laborers, currently in the Northern Province (Table 5). A large portion of these laborers are employed in cotton schemes and by The Sudan Railways at Atbara. These sources of employment are not adequate to prevent the migration of labor from the area.

As one moves south from the northern Nile area to Khartoum, the Gezira Scheme\* and Southern Kassala labor is less readily available due to the demands in Khartoum and in the Gezira area because of the increased agricultural activity. In addition to the local labor, this area relies on migratory labor and seasonal employment. Any new industry would have to pay sufficiently high wages to attract local farmers from the relatively low paying rain-crop farming for part time employment or to interest outside surplus labor on a permanent basis. The most evident source of such labor is in the north.

The number of craftsmen and mechanics in the Khartoum-Gezira-Southern Kassala area equals half of those in The Sudan, and the farm labor force equals 86 per cent of the total. Nevertheless, there is currently a shortage of labor. It seems apparent that to attract an adequate force from other occupations, additional inducements in one form or another will have to be made.

\*Scheme used interchangeably with word Project.

TABLE 5

## CENSUS OF MALE LABOR POPULATION OVER PUBERTY BY OCCUPATIONAL GROUPS

1955-1956

Occupational Group	P R O V I N C E									Total
	Northern	Kassala	Darfur	Kordofan	Khartoum	Blue Nile	Bahr El Ghazal	Equatoria	Upper Nile	
Craftsmen, Mechanics	10,462	6,661	6,270	6,762	22,307	18,428	2,289	5,298	1,041	79,518
Farmers, Hunters, Fishermen	114,225	142,453	232,456	375,162	33,701	388,446*	196,346	191,612	193,915	1,868,316
Animal Owners	3,682	3,688	42,509	38,167	3,883	9,624	17,382	27	31,063	150,025
Machinery Operators	4,441	4,007	1,109	3,139	8,309	9,449	455	1,180	414	32,663
Laborers, except Farm Laborers	14,187	9,867	1,024	3,318	12,555	22,178	903	7,255	988	72,275
Farm Laborers and Forestry Laborers	880	1,236	538	739	1,465	29,348	449	718	307	35,680
Shepherds	13,117	87,254	31,433	29,004	4,947	21,799	44,053	25,449	20,158	277,214
Others	28,812	28,591	21,464	27,218	57,951	44,585	7,959	12,668	7,227	236,475
Total Employed	189,806	283,837	336,803	483,509	145,198	543,857	269,836	244,207	255,113	2,752,166
Students, Unemployed, Beggars and Unknown	10,678	9,062	10,636	10,487	12,382	16,583	11,002	11,501	6,507	98,843
Total	200,484	292,899	347,439	493,996	157,580	560,445	280,838	255,708	261,620	2,851,009

Source: Compiled from data in "First Population Census of Sudan 1955/56 Last (9th) Interim Report", The Republic of The Sudan, Ministry of Social Affairs, Population Census Office, (Khartoum, May 1958).

In the Equatorial regions, a new industry would be faced with not only a current shortage of available labor for field work, as well as mill laborers, but also with local customs which are not inductive to an expenditure of energy beyond the amount necessary to satisfy the most immediate personal needs. Such needs are not many. The warm climate and the availability of native fruits decreases the need for outside income to provide the minimum essentials of life.

The proposed sugar industry would require from 4,000 to 5,000 laborers. In Equatoria Province, there are currently only 14,000 craftsmen, machine operators and laborers, including farm laborers. They comprise only 6 per cent of the total gainfully employed male population. This compares with 79,000 or 15 per cent of the 544,000 gainfully employed in the Blue Nile Province. A new industry in the area would have to rely either upon importing labor from the north, which is not likely in view of the differences in the habits, customs and racial origin, or upon training additional local farmers and shepherds. It would probably be possible to secure the 4,000 to 5,000 laborers required, but it would be a greater problem in Equatoria than in any other region of The Sudan. It seems evident, too, that the cost per unit of labor would be greater.

### CHAPTER III

#### THE ENVIRONMENTAL AND AGRICULTURAL LIMITATIONS IN THE SUDAN

The area within the boundaries of The Republic of The Sudan embraces a wide range of agricultural practices and possibilities. In some districts, such as the deserts in the north, the land, without irrigation, is of little agricultural value. When water from the Nile is available, dates, citrus fruits and grain are produced. But the land used for these purposes in the north is a narrow non-continuous fringe along the great river.

Farther south, where the annual rains are greater, although highly seasonal, some natural vegetative cover occurs. Here during short seasons there is a limited possibility in livestock production, provided the animals are moved to follow the rains and so take full advantage of the short-lived grasses that occur. In some favored locations, quick-maturing grain crops can be grown by careful conservation of the rainfalls. Such possibilities increase rapidly as the annual rainfall increases toward the south. In Equatoria Province, annual rainfalls are sufficient for the production of many crops without benefit of irrigation.

These broad belts of agricultural practices run from east to west in general, and across them, from south to north, runs the great Nile River. Diversion from this source of irrigation water provides for the intensive production of cotton which has been described. There are undoubtedly opportunities, too, for other crops as well.

## General Soil Groups

The soils of The Sudan have developed under the effects of a hot and usually a dry climate. Although the area extends from a latitude of about  $4^{\circ}$  N in the south to  $22^{\circ}$  N on the Egyptian frontier and enjoys a rainfall varying from 40 inches a year in the south to essentially no rain in the north, there are relatively few general soil groups in the area. Soil forming processes have been retarded in the north by low rainfall and in the south by the effects of impeded internal drainage and surface flooding.

The soils fall into three broad systems:

1. Soils developed on sands under dry or semi-arid, but tropical conditions;
2. Cracking clays developed generally on transported materials; and
3. Ferruginous ironstones - red, iron-rich, soils developed on old geological materials.

As in other areas, the nature of the parent material, the climate, drainage and age are the major factors responsible for the genesis of Sudanese soils.

Another grouping gives a view of the natural soil association. This classification, which includes groups that are much broader than those used in the American system, gives seven groups which, together, include all the soils in The Sudan. These broad groupings are as follows:

1. Deserts - bare sands almost barren of vegetation.

A. Fixed deserts: These soils have a stable surface which may be due to the removal of fine material by winds or to the stabilization of the sands which may be brought about by the cementing action of dehydrated iron oxide.

B. Abraded deserts: These are shifting soils. They are characterized by the occurrence of sand dunes.

2. Desert Soils - these soils present a weakly developed A horizon but present little evidence of a B horizon of any kind.

A. Red deserts: In the formation of the soil, ferruginous sandstone aggregates have protected the weathering soil from desert winds. Such soils are usually reddish in color.

B. Desert alluvial soils: These soils are located along the drainage systems of the intermittent desert streams. Such soils usually carry enough silt to permit their classification as sandy loams. Remains of vegetation have darkened the surface. The soils are developed from seasonal deposits by the action of streams and wind.

C. Desert clays: Desert clays are found in depressions in the desert which may hold sufficient water, after floods, to permit a significant deposition of silt and clay. The clay content is usually sufficient to cause the soils to crack upon drying, but they contain much more silt than those discussed later as "clays".

3. River Delta Complexes - these occur in desert alluvial fans such as those in the deltas of the intermittent rivers in Kassala Province. These streams carry heavy loads of sands, silt and clays during their short periods of freshet flow. These are deposited on the level plains; little of the water reaches a surface drainage channel. The changing courses of the river result in mixed deposits of sediments. There is no profile development. Salinity is a problem in some of the lower deltas.

4. Riverain (Riparian) Soils - frequent, possibly annual, floodings of the lands adjacent to the Nile and its tributaries, as well as lesser streams, have resulted in silt and clay deposits on the flat lands adjacent to the river. Such soils are high in their silt content; they would be classified as silty clay loams. One explanation for the great width of these plains of deposition is to assume that the Nile was at a much higher elevation in the geological past than at present. Soils have developed on these recent and ancient silt deposits. The young soils show no profile development due to the intermittent flooding and the constant addition of fresh silt. The oldest sediments lie beyond the currently cultivated areas. They have developed into saline, cracking clays with weak profile developments.

5. Semi-Desert Soil Complexes - these soils occur in the Nuba Mountains and on the slopes of Jebel Marra in the Kordofan and Darfur Provinces. In the region of the Nuba Mountains,

large areas of soils, classified as fine gravels or sandy loams, have been formed through the residual weathering of the rock. They were terraced and intensively cultivated in the past. In the Jebel Marra area, at the lower elevations, there are alluvial deposits along the channels of the intermittent streams.

6. Cracking Clays - these soils occur over a large area in The Sudan. Their greatest development is to be found between the Blue and the White Nile and from Khartoum to The Sudd on the White Nile. They are to be found as well east of the Blue Nile from Khartoum to Kassala and the Ethiopian border.

These soils may be classified in four groups upon the basis of their salt contents, their exchangeable sodium contents, the presence or absence of calcium carbonate and the degree of internal drainage that may exist.

In general, soils in all these sub-groups have developed on similar parent material. This material is the transported clay, laid down during the flood stages of the rivers and probably dried out during the dry seasons. All of these clays are montmorillonite clays. These develop great cracks during the dry seasons. They were undoubtedly deposited under conditions of higher rainfall than exist today. Most of these clays lie directly over the basal complex. But at Sennar, and around The Sudd, they are in direct contact with lateritic materials. This fact, too, indicates a significant change in climatic conditions.

The four main groups of cracking clays are:

a. Saline - alkali cracking clays. The soils of this group carry a salt content sufficiently high to affect the growth of plants, and an exchangeable sodium content which is capable of producing a dispersed condition in the soil with concomitant difficulties. Such soils are found in the lower and central portion of the Gezira, (2) the area bordering the White Nile north of Kosti and the residual clay accumulations in the scattered depressions in the semi-arid sands.

b. Alkali Cracking Clays. These soils along the Blue Nile carry a moderate salt content, but they do not ordinarily have the high sodium content that produces a

poor physical condition in the soil. There are no gypsum aggregates in the profile. These soils along the Blue Nile are more permeable to water than are the saline-alkali cracking clays and are better suited to irrigation farming. Alkali cracking clays along the White Nile, on the other hand, have a higher content of sodium in the third foot than those along the Blue Nile. A soil reaction of pH 10.0 is quite common.

c. Alkaline Cracking Clays. These soils, as distinguished from the alkali cracking clays, are characterized by their high clay content, their non-salinity, and their lack of exchangeable sodium. These soils represent some of the best agricultural areas in The Sudan. Unfortunately, their full utilization must wait for the completion of the proposed dam at Roseires on the Blue Nile. This dam will deliver gravity water at such elevations that the largest area of these soils lying between the Blue and the White Nile may be served. Other areas with soil of this type are to be found in southern Kassala Province. The calcareous clays west of the White Nile, the ironstone impregnated clays on the lower slopes southwest of The Sudd and areas adjacent to the White Nile in the Mongalla area are other examples of alkaline cracking clays. Typical profiles of these soils show the following hydrogen ion concentrations:

1st foot - pH 8.3 to 8.9  
2nd foot - pH 8.7 to 8.9  
3rd foot - pH 8.7 to 9.1

d. Hydromorphic Clays. The most important of these clays are those of the "Toich" areas along the White Nile. These areas are flooded seasonally for a period sufficient to prevent tree growth. These clays are water logged for long periods. They are used mainly for grazing.

7. Ironstone Soils - these soils are to be found only in the three southern provinces where they practically blanket the lands at higher elevations. Ironstone soils fall into two general classifications. One of these includes the laterites which will indurate on exposure; the other is a ferruginous ironstone which will not harden under the same exposure. The laterites occur on the slopes of the hills. Their value depends entirely upon the depth of the friable loamy surface that covers them. If this depth is 18 inches or more, profitable agricultural production can be expected. If the surface accumulation is less than this, the greatest value lies in forest cover. The red ferruginous clays cover the top of the plateau beginning near Yambio and extending westward. This soil carries red, friable kaolin in varying depths over an ironstone subsoil. It represents the most promising agricultural soil in the southern provinces.

## Climate in The Sudan

Despite the fact that The Republic of The Sudan fronts on the Red Sea for a small part of its eastern border, the climate is typically continental in character. As has been previously suggested, the country consists of one great plain, and this plain to the north and west extends far beyond the frontiers.

The Rainfall Pattern. The general pattern of wind flow is easily defined in general terms although local or temporary abnormalities may occur. There are two main lines of flow in the atmosphere. Since the pattern of rainfall is associated with these winds, they are important.

The northerlies, which originate in Arabia or in the Sahara are dry winds, and dominate the magnitude and distribution of rainfall in The Sudan. During the summer, moisture-laden southerly winds from high pressure areas in the Indian Ocean and South Atlantic tend to replace those from the north and by doing so bring rains. The Sudan is an area of summer rain and winter droughts. Such a statement is probably an over-simplification. The Sudd is essentially an inland sea which provides atmospheric moisture in an unmeasured amount, while the Nuba Mountains in the west undoubtedly distort the flow of winds that has been described.

In the northern latitudes, the dry northerlies prevail and the area is dry almost to the point of being rain free. Farther south, the effects of the south winds become more and more apparent as the summer advances. The seasonal distribution of rainfall follows the migration of the boundary between the dry northern winds and the moisture-land winds from the south. This boundary moves to the north during the summer and back again in the fall. The rainy season is shortest in the north and longest in the south.

Despite the inevitable year-to-year variations, the annual precipitation at a specific location shows less deviation from normal than is usually encountered with a continental climate.

Temperatures. The Republic of The Sudan lies entirely within the tropics. The temperatures are within the range normally associated with such a location, but the area does lie near the center of a large land mass. Low temperatures are sometimes encountered. The lowest temperature ever reported in The Sudan was  $-2.0^{\circ}\text{C}$ . This occurred at Wadi-Halfa in December, 1917. Other below freezing temperatures have been reported at El Obied. The highest temperature ever recorded in The Sudan was  $52.5^{\circ}\text{C}$ . This was reported in April, 1903, again at Wadi-Halfa.

Despite these occasional extremes, the mean daily temperatures for all the reporting stations are surprisingly similar. This figure, computed as the average of the mean daily maxima and mean daily minima shows a long time average temperature of  $29.6^{\circ}\text{C}$  for Khartoum and  $24.7^{\circ}\text{C}$  for Yambio. Other stations fall between these limits. (5)

Such generalities as those given with respect to rainfall and temperatures may give basic information, but they are inadequate for the identification of a suitable location for a sugar cane plantation. Additional and more specific information concerning the four sites offered for critical consideration is offered under the heading "Potential Areas for Sugar Cane Production" in Chapter V.

#### Water Supplies

Without the Nile River, there would be little life and activity in The Sudan, and the government with great wisdom has been alert to the necessity of

conserving this great resource. Sayed Mirghani Hamza, Minister of Irrigation and Hydro-Electric Power, discussed the importance of the great river in his introduction to "Sudan Irrigation". (7) Here he writes:

"But the country as a whole is a dry and thirsty one. Only in less than one-fifth of its area can the farmers rely on a rainfall of 30 inches in three years out of four. In the northern third, the rainfall averages less than 6 inches and only by artificial irrigation is agriculture possible at all. Even in the central zone, the rains are so variable and unreliable that at least supplementary irrigation is necessary to mature most types of crops. Much the most important source of supply of water for irrigation must always be the River Nile as it flows through the country. But all sources must be used to the utmost."

In most parts of The Republic of The Sudan, the Nile is two rivers rather than one. These two Niles, the Blue and the White, join at Khartoum and continue northward through the virtual deserts of the Northern Province to the Egyptian frontier, and then on to the Mediterranean.

The Nile and Its Tributaries. The two main tributaries to the lower Nile differ greatly in character. The White Nile is a stream of relatively constant flow. The Blue Nile is a stream of widely varying discharges from month to month; it is a stream of little character. The White Nile is navigable for many miles above Khartoum. The Blue Nile is rarely used for this purpose. In general, the Blue Nile contributes most of the heavy silt load carried by the Main Nile to the flood plains of Egypt.

This wide difference results from the sources of the two streams and the character of their channels. The White Nile finds its source in Lake Victoria, which, in itself, acts as a regulating reservoir. Shortly after the river crosses the southern boundary of The Republic of The Sudan, it enters a papyrus swamp (The Sudd) which, although it may permit the loss of large amounts of water by evaporation, provides still another control to the

river as the water drains away from the area and starts its long journey to Khartoum and the sea. The Blue Nile finds its origin in Lake Tana in Ethiopia and the western plains of that country. Here a multitude of tributaries drain an area of high but intermittent rainfall. The seasonal character of such rains and the lack of natural settling reservoirs contribute to the erratic character of the stream flow and its high silt load.

Another tributary of minor significance in irrigation planning is the Atbara River which rises in the northern part of the Ethiopian plateau and joins the Nile north of Khartoum. The Atbara is more erratic than the Blue Nile and is often dry during parts of the year.

The table below illustrates the discharge characteristics of these streams during the year.

TABLE 6  
CONTRIBUTIONS TO MAIN NILE FLOW (10)

	<u>High Flood %</u>	<u>Low River %</u>
From the Blue Nile	68	17
From the White Nile	10	83
From the River Atbara	22	0

These streams, together with some possibilities of underground water in the Nubian sandstones in the Northern Province and in the Seleim Basin, provide the irrigation resources of the country. Recent stream flow records are superior. Records, with ever increasing precision, cover the period from the earliest times to the present.

#### Underground Water Supplies

The evident possibility of supplementing the water resources of The Sudan by tapping underground supplies has received continuous attention for many years. A few twelve-inch wells have been driven to a depth of 500 feet

in the Nubian sandstones near El Fasher in the Darfur Province. Yields have been small, approximating 2,000 gallons per hour, and the salt content is generally high. Some have been too saline for human consumption.

Gibb (1) makes no mention of the possibility of underground water as an irrigation resource. Nor is there mention in Hamza's "Sudan Irrigation". (7) Apparently, if adequate underground water from deep sources exists, they have not, as yet, been discovered.

Occasionally, however, shallow wells, which increase in depth as the site moves away from the river, are to be found. Here the source is undoubtedly seepage from the Nile. In general, such seepage is slow because of the heavy soil through which the great river runs for most of its length. Some possibilities of irrigation wells exist, in favored locations near the river. A few are in successful operation.

A recent development in the Seleim Basin, opposite Dongola in the Northern Province, will add interest to the possibilities in underground water. A series of six wells to an average depth of 300 feet have been drilled at some distance from the river. Each is equipped with an eight-inch deep well turbine pump. Power for each is supplied by a gasoline engine. The pumping lift is about 100 feet.

A typical discharge is reported to be 45,000 gallons per hour, or about 750 gallons per minute. Although the cost of each installation is great, the development of this resource makes the intensive development of the Seleim Basin a real possibility.

The Geological Survey Department seems convinced that the water is the result of seepage from the Nile and not the result of precipitation on remote

areas and the conveyance of that water through porous rock, far below the surface.

So far, the resources under the Seleim Basin should be classified as unproven.

#### CHAPTER IV

##### REGULATIONS RELATING TO LAND AND WATER USE

Many of the attributes of the pattern of land holdings which prevail in The Republic of The Sudan stem from the ancient occupation of the riparian lands of the Nile and the intermittent and temporary use of the land beyond the influence of the river by nomadic herdsmen.

In general, but not universally, lands fronting on the rivers are privately owned. Subdivision of an original holding among several heirs for many generations has created the common problem of small ownerships. Such holdings, small as they may be, are jealously held. "Land in towns, in the Gezira area, along the main Nile north of Khartoum and in certain other areas has been officially settled (i.e., ownership legally decided) and registered under the Land Settlement and Registration Ordinance." (10)

In other areas, title is still undetermined. In some cases, land use is regulated by local or tribal customs. Waste and unoccupied lands are deemed to be government property. The burden of proof to the contrary lies on the shoulders of the claimant who protests the overriding title in the government.

Consequently, the titles to an area large enough to be considered for a sugar cane enterprise might be confused. It should be said, however, that the government has a long and powerful arm when, in its opinion, private titles and title claims run counter to public policy.

## The Attitude of the Government Toward Land Use by Tenants

There is much evidence of the government's sympathetic interest in the rights and opportunities of the small farm operator. It is usually impractical to provide fee simple ownership to a large number, but a good substitute is found in the tenant agreements that run from the pump scheme operator to the tenant who undertakes the day-by-day operation of a small acreage irrigated by the facilities of the pump scheme, or from the great Gezira gravity diversion.

When this plan is followed, the tenant, usually without capital, is granted the right to farm a restricted area. Expenses for operating may be provided by the scheme operator. A share of the returns goes to the tenant, with deductions for advances that have been made. There are many variants to this general plan; they do not need attention here.

It should be said that this consideration by government for the well being of the small farmer has been highly successful. It will undoubtedly be a firm feature of future policy toward land use.

But it is not applicable to sugar cane agriculture. Here an overall administration of the farmed area is essential. The policy would be perfectly appropriate for sugar beet culture.

## Water Licensing

As might be expected, the Government of The Republic of The Sudan exerts a jealous and complete jurisdiction over the waters of the country. Diversions by river pumps may be permitted upon proper application and the payment of specified fees to the Nile Pump Control Board. License fees for the use of water, when the petition to pump is granted, vary with the diameter of the suction side of the pump.

The Pump Ordinance. (6) The fee for a license to pump varies with the character of the license. There are three categories:

1. A perennial license provides permission to pump water throughout the entire year;

2. A flood license provides permission to pump water from July 16 to December 31;

3. A restricted license provides permission to pump from July 16 to November 30.

The Nile Pump Control Ordinance stipulates the following fees for some pump sizes:

TABLE 7

LICENSE FEES FOR NILE PUMPS

in Sudanese Pounds per Year

<u>Size of Pump Suction Diameter</u>	<u>Perennial License</u>	<u>Flood License</u>	<u>Restricted License</u>
4"	1.50	1.00	.50
24"	57.50	34.50	23.00
40"	160.00	96.00	64.00
48"	230.50	138.00	92.00

Costs for licenses for other sizes are listed in the Ordinance.

Perennial licenses for the operation of pumps larger than ten inches are valid for fifteen years, calculated from May 1 next following the issuance of the license. Such licenses may be renewed by the Board for a period of an equal length, when they expire, after appropriate application to the Nile Pump Control Board.

It should be noted that the Nile Pump Control Ordinance specifies that the applicant for a license must satisfy the District Commissioner "that he owns or can obtain rights of cultivation over or can enter into water renting or cultivation agreements with the persons owning or having such rights over the land....." (6)

In view of the wide expanse of governmental land holdings and the frequently expressed interest in the sugar proposal by officials, it seems probable that land would be made available for the hypothetical sugar venture.

The water licensing program has been most effective. Conservative control of the waters of the Nile is maintained in the hands of government officials. Pumping projects have increased rapidly in number. Two hundred and forty-four projects, or schemes, had been authorized by 1939. By 1957, this number had increased to 2,229. The area irrigated under the authority of such pumping licenses in 1956 was 695,000 feddans. (10)

#### International Agreements and Complications

Like other streams draining and serving more than one sovereign government, the waters of the Nile have been subject to international study and agreement. The Nile Water Agreement between Great Britain and Egypt, based upon a recommendation of the Nile Water Commission of 1925, provided that the Anglo-Egyptian Sudan might not, without the consent of Egypt, construct works which would affect the arrival of Nile water in Egypt. Egypt, on the other hand, might not undertake construction work on the river without adequate measures to safeguard interests in The Sudan.

Officials of The Republic of The Sudan suggest that the new Republic might not feel itself bound by the conditions of this early agreement, but no statement of policy has been issued.

#### Gravity Developments

The outstanding gravity diversion is from the Sennar reservoir on the Blue Nile about 200 miles upstream from Khartoum. Water from this great reservoir is carried by gravity canals to the Gezira Irrigation Scheme. Here cotton is grown, in rotation with other crops, through a complex but highly

effective cooperative agreement between tenant farmers, the Sudan Gezira Board and the Government. Plans are underway for the extension of the area irrigated from the Sennar dam.

Additional acreage will be served if the six proposed dams are constructed on the Blue Nile. Each of these dams would be a major engineering undertaking. If international agreement can be reached and financing provided, the agricultural resources of The Republic of The Sudan would be greatly increased through such works.

These possibilities are mentioned here, in some detail, since sugar-growing potentials would be correspondingly increased. The current study is limited to areas in which irrigation water is readily available through the use of pumps operating on the Nile or by gravity diversions which are either in use or under construction.

## CHAPTER V

### POSSIBILITIES WITH SUGAR CANE

Except for the wide expanse of deserts to the west of The Republic of The Sudan, adjacent countries have recently embarked upon programs for sugar production to satisfy the needs for local consumption or, as in the case of Egypt, to increase the possibilities in sugar export.

The long history of successful sugar cane production in Egypt is well known, but it should be said that present plans call for a significant increase in this activity.

Ethiopia to the east expects a production of more than 32,000 tons during the 1957-1958 season.

The Belgian Congo reported a production of 15,650 tons in 1955.

A sugar factory for cane processing was erected in Kenya in 1957.

Uganda and Tanganyika are just beginning to produce cane sugar for their own needs.

Judging by experiences in countries nearby, it would appear that The Republic of The Sudan could confidently look forward to a successful sugar cane enterprise.

#### Sugar Statistics, Imports and Consumption

In 1957, the total sugar imports of Sudan of LS 5.8 million constituted 9.2 per cent of the total imports of LS 63.0 million (Appendix I, Table 26) into The Sudan. In 1956, the import value of them was LS 4.6 million and constituted 10.2 per cent of all imports. Upon the basis of value, the imports

of sugar were exceeded in 1957 only by cotton piece goods amounting to LS 6.1 million and machinery amounting to LS 11.1 million. In 1956, the value of sugar imports was exceeded only by cotton piece goods and machinery. Sugar, cotton piece goods and machinery thus constitute the heaviest drain on the available foreign exchange.

Per Capita Imports. In 1956, The Sudan imported 115.0 thousand metric tons of sugar of all sorts or 11.1 kilograms per capita. The average yearly imports for the period from 1952 through 1957 have been 101.5 metric tons or 9.9 kilograms per capita (Table 8). Due to the variation in consumption habits by regions, this per capita import figure does not represent a realistic per capita consumption figure over the country as a whole. This is discussed fully in the sugar consumption section in this chapter.

Imports by Type of Sugar. The Sudan imports crystal sugar almost entirely. Out of 106,800 metric tons imported in 1957, all was crystal sugar except for less than 600 tons. Since 1951, there has never been more than 3,000 tons of non-crystal sugar imported in any year. Crystal sugar is not the white refined sugar commonly referred to as table sugar in Europe and America. Crystal sugar is not as white as refined sugar and it has a coarser grain. It possesses the same qualities in regard to sweetness, but has not gone through the final-refining process to give it the fine grain and white color.

Imports by Country of Origin. In view of the relative insignificance of the non-crystal sugar in The Sudan's imports, the crystal sugar imports only will be discussed by source. The Sudan buys sugar on the open market on a bid basis. Therefore, there is no assurance that any one country will be a continuing source. However, during the seven-year period 1950 through 1957, 37.9 per

TABLE 8

## QUANTITY AND VALUE OF SUGAR IMPORTS BY TYPE

1951-1957

Year	Types of Sugar			Total
	Crystal	Confectioner's	Other	
Quantity (Thousands M Tons)				
1951	59.7	1.8	a/	61.5
1952	99.9	2.7	0.1	102.7
1953	96.9	1.9	0.1	98.9
1954	100.4	1.9	0.7	103.0
1955	80.3	2.2	0.2	82.7
1956	114.3	0.3	0.4	115.0
1957	106.2	0.6	b/	106.8
Value (Thousands Sudanese Pounds)				
1951	3,731.3	313.3	0.3	4,044.9
1952	6,154.1	407.7	3.5	6,655.3
1953	3,880.7	345.2	3.7	4,227.6
1954	3,654.2	316.9	3.6	3,974.7
1955	3,200.3	340.4	8.3	3,549.0
1956	4,637.7	39.6	19.2	4,696.5
1957	5,779.0	122.1	b/	5,901.1
Value (Thousands U. S. Dollars)				
1951	10,714.6	899.7	0.8	11,615.1
1952	17,671.9	1,429.2	10.1	19,111.2
1953	11,143.7	985.5	10.6	12,139.8
1954	10,493.2	910.0	10.3	11,413.5
1955	9,189.9	977.5	23.8	10,191.2
1956	13,317.4	113.7	55.1	14,486.2
1957	16,594.7	350.6	b/	16,945.3

a/ 1951, 3.2 M Tons.

b/ Not separately classified.

cent of the crystal sugar has come from the United Kingdom and 16.4 per cent from Taiwan (Table 9). These two major supplying countries provided The Sudan with 54.3 per cent of her sugar imports and were major sources of supply six out of the seven years (Table 10). Poland, Netherlands and France have been sources of supply only three years out of the seven. Other countries which have supplied sugar irregularly include Czechoslovakia, Argentina, Egypt, both East and West Germany, Spain, India and Italy.

Of the total 106.2 thousand tons of crystal sugar imported in 1957, 41.5 thousand tons were imported from the United Kingdom, 36.8 thousand from Taiwan, 14.8 thousand from India, 9.8 thousand from Italy and 3.3 thousand from France. India and Italy, which supplied 24.6 thousand tons or 23.2 per cent of the total 1957 imports, had not previously been a source of supply during the seven-year period from 1950 through 1957 (Table 10).

Even though a major portion of the imports of sugar into The Sudan are from the sterling area, the release of foreign exchange required for sugar imports, amounting to a yearly average of £S 4,433,900 for the period 1951 through 1957 (Table 10), would ease pressure on available foreign exchange and would also release exchange for other needed imports.

Sugar Consumption Per Capita by Provinces. As might be expected, the per capita consumption of such a product as sugar varies widely among the Provinces in The Sudan. A national average of 11.14 kg per capita is reported for the year 1956. During this year, 114,349 metric tons were imported.

The per capita consumption for 1956, for individual provinces, varies from 26.081 kg per capita for the Province of Khartoum to 0.76 kg per capita in Equatoria. The details for these provinces and others are shown in Table 11.

TABLE 9

SUGAR IMPORTS FOR THE PERIOD 1951 THROUGH 1957

PERCENTAGE DISTRIBUTION BY COUNTRY OF ORIGIN

<u>Country of Origin</u>	<u>Frequency of Source Number of Years</u>	<u>Per Cent</u>
United Kingdom	6	37.9
Taiwan	6	16.4
Poland	3	8.6
Czechoslovakia	2	6.6
Netherlands	3	5.1
Argentina	1	5.0
Egypt	2	4.5
France	3	4.2
Germany, Eastern Zone	2	3.4
Spain	1	3.4
India	1	2.2
Italy	1	1.5
Federal Republic of Germany	1	1.2
Other	1	*
Total		100.0

\* Less than 0.1 of one per cent.

Source: Calculated from Trade Statistics in Table 10 .

**TABLE 10**  
**QUANTITY AND VALUE OF CRYSTAL SUGAR IMPORTS**  
**1951-1957**

Year	Argentina	Czechoslovakia	Egypt	France	Germany, Eastern Zone	Germany, Federal Republic	India	Italy	Netherlands	Poland	Spain	Taiwan	United Kingdom	Other Countries	TOTAL
<b>Quantity (Thousands Metric Tons)</b>															
1951	--	--	--	--	--	--	--	--	3.8	--	--	9.2	46.7	--	59.7
1952	--	--	--	--	6.4	--	--	--	24.4	--	--	12.5	56.6	b/	99.9
1953	--	--	--	--	--	7.7	--	--	5.1	--	22.5	30.1	31.5	--	96.9
1954	--	16.2	--	--	16.2	--	--	--	--	42.5	--	1.5	24.0	a/	100.4
1955	32.8	--	22.5	17.0	--	--	--	--	--	8.0	--	--	--	a/	80.3
1956	--	27.0	7.0	7.4	--	--	--	--	--	6.0	--	17.7	49.2	--	114.3
1957	--	--	--	3.3	--	--	14.8	9.8	--	--	--	36.8	41.5	--	106.2
<b>Value (Thousands Sudanese Pounds)</b>															
1951	--	--	--	--	--	--	--	--	264.7	--	--	609.2	2,857.3	--	3,731.2
1952	--	--	--	--	392.6	--	--	--	1,670.0	--	--	702.8	3,308.7	b/	6,154.1
1953	--	--	--	--	--	320.3	--	--	218.2	--	876.2	1,105.9	1,360.0	--	3,880.7
1954	--	585.9	--	--	576.3	--	--	--	--	1,551.0	--	48.3	852.6	b/	3,654.2
1955	1,277.1	--	964.0	669.0	--	--	--	--	--	209.5	--	--	--	b/	3,200.4
1956	--	1,020.1	262.5	284.2	--	--	--	--	--	228.6	--	660.6	2,181.7	--	4,637.7
1957	--	--	--	202.5	--	--	819.2	450.6	--	--	--	1,662.7	2,644.0	--	5,779.0
<b>Value (Thousands U. S. Dollars)</b>															
1951	--	--	--	--	--	--	--	--	760.2	--	--	1,749.3	8,205.0	--	10,714.5
1952	--	--	--	--	1,127.3	--	--	--	4,795.4	--	--	2,018.2	9,730.9	c/	17,671.9
1953	--	--	--	--	--	919.9	--	--	626.6	--	2,516.1	3,175.7	3,905.1	--	11,143.7
1954	--	1,602.5	--	--	1,654.9	--	--	--	--	4,453.9	--	138.6	2,563.4	c/	10,493.3
1955	3,667.2	--	2,768.1	1,923.3	--	--	--	--	--	831.2	--	--	--	c/	9,189.8
1956	--	2,929.3	753.8	816.1	--	--	--	--	--	656.5	--	1,896.9	6,264.9	--	13,317.5
1957	--	--	--	501.4	--	--	2,352.5	1,294.0	--	--	--	4,774.5	7,592.4	--	16,594.8

a/ Less than 500 M Tons; b/ Less than LS 500; c/ Less than \$500.

Source: 1951 through 1955 "Annual Foreign Trade Report 1955", Ministry for Social Affairs, Department of Statistics, The Republic of The Sudan.  
1956 and 1957 "Foreign Trade and Internal Statistics", Ministry for Social Affairs, Department of Statistics, The Republic of The Sudan, January 1958.

TABLE 11

SUGAR CONSUMPTION PER CAPITA FOR EACH PROVINCE

FOR THE YEAR 1956\*

<u>Province</u>	<u>Population</u>	<u>Total Consumption Metric Tons</u>	<u>Consumption Per Capita Kilograms</u>
Bahrel Ghazal	991,022	5,463	5.512
Blue Nile	2,069,614	40,479	19.56
Darfour	1,328,559	7,089	5.34
Equatoria	903,718	686	.76
Kassala	941,379	10,863	11.5
Khartoum	505,157	13,175	26.081
Kordofan	1,762,760	18,870	10.7
Northern	870,765	15,666	17.99
Upper Nile	889,700	2,058	2.31
Totals	10,262,674	114,349	11.14

\* Estimates of consumption by provinces, based upon estimated yearly shipments to government warehouses in different parts of the country, as per information given by the Sudanese Customs Department.

## Local Trials with Sugar Cane

Although sugar cane has been produced in neighboring countries for some time, interest in this crop in The Republic of The Sudan is recent. It is probably true that the availability of cane sugar from Egypt during the effective life of the ~~Condominium~~ Agreement suppressed exploratory work with this crop; whether this was the sole reason is immaterial. The fact remains that nearby neighboring countries are now operating sugar cane enterprises. Those in Egypt, Ethiopia, and Tanganyika, Kenya and Uganda are examples of sugar cane developments in the same geographical and ecological area.

Trials at Mongalla, Equatoria Province. Recently, since the beginning of the negotiations which led to the creation of The Republic of The Sudan, exploratory work and the beginnings of commercial developments have been rapid. By 1951, the Boxall Company, Ltd. had begun extensive sugar cane trials on the east bank of the White Nile, between Mongalla and Genmeiza. These trials were continued for about six years and resulted in a vast amount of information concerning the proper management of cane and the probable cost of sugar production in Equatoria Province.

The North Khartoum Plantation. More recently, a commercial sugar enterprise was begun by the Middle East Agricultural Company on the east bank of the Nile about 25 miles north of Khartoum. Sugar cane, mostly of Indian varieties, is growing under conditions which require irrigation during its entire life, except for the ripening period. Fertilization is a vital part of the operation.

Yields of about 50 tons of cane per feddan for the plant crop are reported with some evidence of reduced yields in the ratoons that follow.

No refined sugar is produced. The extracted juice is boiled in open kettles, to a specified concentration, and sold as sugar syrup.

The Agricultural Research Stations have recently become active in sugar cane investigation. Small cane plantings have been made, mostly with seed pieces from the North Khartoum enterprise on the lands of the Faculty of Agriculture at Shambat. The Agricultural Department of the Blue Nile Province made plantings of both sugar cane and sugar beets for about three years in Wad-Medani. Work with these crops has not been active recently.

Trials at the Wad-Medani. At about the same time, the Experimental Department of the Sudan Gezira Board began work with both sugar cane and sugar beets, near the Barakat Headquarters in Wad-Medani. These experiments are continuing with growing enthusiasm by Mr. A. M. Toms, an Agriculturist for the Board. Mr. Tom's results with sugar beets will be referred to in subsequent sections.

Chewing Cane, Artesian or Panela Sugar. In addition to these formal records of agricultural research with the sugar crops, there are many accounts of small plantings, mostly to supply chewing cane, in diverse areas. Most of these are in regions of abundant rainfall or on stream beds, where the small plantings secure water from the rivers, without benefit of formal irrigation works.

Apparently, the most extensive of these is in the Yambio district near the Belgian Congo border in Equatoria Province. Here juice has been boiled to crystalization and cast into molds. This crude sugar manufacture is a common forerunner to more refined methods in underdeveloped countries. It is the artesian sugar, reported in the English literature, and panela in Spanish reports.

Such diverse experiences over such a geographic range suggest that sugar cane can be grown through a wide area in The Republic of The Sudan. The case for sugar beets is not so well documented; but in the regions tried, they seem promising.

#### Potential Areas for Commercial Sugar Cane Plantings

Criteria for Selection. It is evident that a sugar cane plantation will prosper if it is located in an area in which all the factors contributing to its operation are ideal. Such a combination rarely or never exists.

The factors which contribute most directly to a successful operation are:

1. An adequate area. The area must be adequate in size to provide the cane necessary for successful and economic mill operation. Moreover, additional area should be available to permit the orderly expansion of the planting in the future to the economic limit of the milling facilities.

In addition, land should be available for other activities associated with the operation of a cane sugar enterprise. These include land for the mill and the mill yard, railroad facilities and roads, housing facilities in the mill area and space for labor villages in more remote areas. A modern sugar enterprise normally is a self-contained community. This involves space for parks, playing fields, schools, churches and markets.

The proposal is that an original planting of about 9000 feddans would be required. With the expected increase in mill capacity, an additional 4000 feddans of cane would be necessary. This future demand, together with community needs, suggest that an area of 20,000 feddans should be available for the enterprise.

2. A suitable soil. An ideal soil for sugar cane was not encountered in The Sudan. Such a soil would be relatively light in texture, deep and free from impervious subsoil strata, and free from excessive salt accumulation. The surface would be relatively smooth, but would carry a slope of from 20 to 30 centimeters per 100 meters to facilitate irrigation.

3. An adequate water supply. Some sugar cane, in an enterprise of the size considered, would require irrigation every month of the year unless timely rains made it unnecessary. Irrigation facilities are essential.

4. Transportation facilities. A productive sugar enterprise requires flexible transportation facilities to a major center for distribution. The need for a constant flow of products to market and materials and personnel to the area must not be underestimated.

5. Availability of field labor. A sugar cane operation requires many hands. A location in which there is a supply of resident labor nearby is ideal. If this is not possible, living facilities must be provided for labor recruited from a distance.

6. Living conditions for skilled personnel. A rural activity runs most smoothly if the morale of the operating personnel is high. This can best be secured if the enterprise is close enough to a major center of population to provide the personnel with frequent contacts with others of similar background and training.

#### Promising Areas for Sugar Cane Production

A close inspection of many areas, which were suggested by officials in the Ministry of Finance and the Ministry of Agriculture, indicated that four of the general locations were suitable for economic sugar cane enterprises. These four, described below, are given in the order of their apparent priorities.

Kosti Area, White Nile (West Side). This site, on the west side of the White Nile and south of Kosti, is recommended for first consideration. Here an adequate area is apparently available. Gibb (1) cites an area south of the Umm Hani Pump Scheme which seems appropriate. The area has been surveyed for the projected Zuleit Irrigation Scheme.

The soils of this area are silty clay loams and have an excellent physical structure. They have developed on an old, extremely level alluvial flood plain. The subsoil shows little horizon differentiation. An absence of clay layers in the subsoil will permit excellent root penetration.

The soils contain a moderate salt content in the subsoil. The physical condition is maintained by the dominance of calcium in the exchange complex.

Infiltration is slow due to the high content of swelling clays. However, the rate of water penetration is greater than that experienced in the Gezeira area.

An adequate water supply can be assured if a Perennial Pumping License can be secured. It is probable that the results of a detailed engineering study, if this area is used, will specify that a canal from the river deliver water to a forebay from which heavy-duty pumps will deliver the water to canals which carry it to the points of use.

Transportation facilities are excellent. The proposed site is on the railroad line from Khartoum to El Obeid. Kosti is currently the northern terminal for barge transportation on the Nile.

It is reported that field labor is available, but there may be some competition for that labor from the existing cotton schemes in the area.

Living conditions for skilled personnel would be better than are normally found in rural areas. The nearness of Kosti, with its markets, is a decided advantage. Social and scientific contacts with the research personnel at Wad-Medani give an added advantage.

Climatic conditions at Kosti are summarized in Table 12.

Sennar Area, Blue Nile (East Side). The area proposed for second consideration is on the east bank of the Blue Nile at the Sennar Dam. Adjacent or nearby land in the vicinity is used for a productive cotton scheme. Information received on the site indicates that adequate government land is available for the sugar project.

The soils of the area are the most promising of those inspected. Although they are characterized by the presence of "cracking clays", the presence of calcium carbonate close to the surface provides and maintains an excellent tilth.

TABLE 12

Climatic Conditions at Kosti

Month	Temperature(C <sup>o</sup> )		Rainfall (mms)			Relative Humidity (%)		
	Average Maximum	Average Minimum	Total	Max. for One Day	Date of Maximum	6 A	Noon	6 P
January	32.5	16.8	0	0	--	36	24	40
February	33.7	17.2	0	0	--	28	17	33
March	37.5	19.5	1	5.0	15-1949	23	13	23
April	40.3	22.6	3	2.5	11-1950	21	12	23
May	39.9	24.6	23	33.2	30-1948	39	21	31
June	37.8	25.0	53	36.4	9-1948	56	31	42
July	35.0	23.4	116	75.0	18-1944	71	43	58
August	33.0	22.6	145	80.5	9-1948	79	51	70
September	34.4	22.6	57	43.5	5-1950	73	45	65
October	37.2	23.3	28	91.3	14-1946	57	30	50
November	36.2	21.0	1	5.6	8-1945	36	21	31
December	33.5	17.9	0	0	--	37	22	42
Total or Average	35.9	21.4	427	--	--	46	27	43

The soils have dark, grayish-brown, silty clay surface horizons. These are underlain by very calcareous, gray subsoils of the same texture. These subsoils contain numerous aggregates of calcium carbonate. This high concentration of calcium near the surface reduces the effect of the sodium present and provides improved infiltration and internal drainage.

These soils carry a lower total salt content than others which were studied.

The water for irrigation would be secured from the Blue Nile after a Perennial Pumping License had been secured. In view of the character of the river, the pumping lift at some seasons would be relatively high, but other advantages seem to offset this objection.

The position of Sennar, at the junction of the railroad lines to Port Sudan, to Khartoum and to Kosti, promises excellent facilities for the distribution of the product of the mill and for the expedient delivery of incoming supplies.

Labor is available in the vicinity as is evidenced by the cotton scheme. A sugar enterprise might encounter some competition for field help, but it is believed that this situation would be rectified by immigration of seasonal labor.

Technical help, particularly that imported from foreign lands, would be reasonably close to the desired scientific contacts to be found at Wad-Medani.

Climatic conditions at Sennar are summarized in Table 13.

Wad en Nail and Abu Na' Ama Area, Blue Nile (West Side). An adequate area might be secured north of Wad en Nail, if several of the closely defined areas in the Gibb (1) report were combined. It seems reasonable to suppose that a single area of adequate size might be located with a small addition to the pumping lift.

TABLE 13

Climatic Conditions at Sennar

Month	Temperature (C°)		Rainfall (mms)			Relative Humidity*		
	Average Maximum	Average Minimum	Total	Maximum for One Day	Date of Maximum	6 A	Noon	6 P
January	34.9	15.1	0	0	--	43	---	--
February	36.3	15.7	0	0	--	36	--	--
March	39.4	18.3	0	0.8	21-1944	30	--	--
April	41.5	21.6	4	43.8	29-1944	29	--	--
May	40.9	23.5	30	66.5	19-1937	41	--	--
June	39.0	23.4	55	77.0	27-1940	56	--	--
July	34.9	21.7	135	91.0	12-1937	74	--	--
August	33.1	21.1	160	105.0	4-1942	80	--	--
September	35.0	21.0	65	64.3	7-1927	74	--	--
October	38.2	21.3	20	47.5	17-1941	59	--	--
November	37.6	18.9	1	5.5	1-1933	43	---	--
December	35.5	16.0	0	--	--	45	--	--
Total or Average	37.2	19.8	470	--	--	51	--	--

\*Relative humidity readings are not reported for noon and 6 pm at the Sennar Station.

As with other areas, an adequate supply of water will be available when the necessary pumping license is secured and the necessary pumps installed.

The soils of the Wad en Nail area occur on a flat, clay plain which still carries its native vegetation. This is typically an acacia-tall grass savannah. The clay content is greater than that at Sennar and is more completely dispersed. The plain is extremely flat, except for areas near the Blue Nile, where the development of surface drainage channels has resulted in some undulations. These channels provide outlets for drainage ditches which might be necessary in some areas remote from the river.

The soils of this clay plain are complex. Many areas are characterized by cracking clays, but they vary widely with respect to internal drainage. The best soils are those with a dark, grayish-brown surface horizon. Such soils are to be found in areas favored with better surface and internal drainage. They occupy approximately 80 per cent of the area under consideration. The poorest soils are those with gray surface horizons. They occur in the poorly drained depressions. Such areas can be readily identified by the presence of the white barked *Acacia fistula* which grows upon them. Such poor soils occupy about 10 per cent of the area. The remainder of the area carries intermediate soils which grow excellent crops of dura, cotton and corn at the Tozi Rainland Station in the neighborhood.

Reasonable transportation by rail would be provided on the new line that runs from Sennar to Roseires, but Wad en Nail is far from Khartoum, which would be the natural distribution center for the product of the mill.

This same distance might add difficulties as far as the contacts of the skilled, scientific employees are concerned. It should be said that the

scientists at the agricultural research station at Tozi would reduce the isolation of the personnel at a sugar enterprise at Wad en Nail.

Table 14 gives a summary of the climatic factors at Singa. This station is about 32 miles northeast of Abu Na' Ama.

Mongalla Area, White Nile (East Side). The area between Mongalla and Genmeiza presents a great expanse of land which could readily be made available to a competent sugar enterprise. It lies along the east bank of the White Nile.

An adequate water supply would be available from the river after appropriate licenses had been secured. The pumping lift is relatively small and would remain fairly constant throughout the year.

The soils of the Mongalla area are coarse, sandy clay loams in general. The surface carries slight undulations. The sandy clay loams occur on the higher elevations. Heavy cracking clays are to be found in the depressions or in poorly drained areas. Even the sandy clay loam soils show some evidence of poor internal drainage.

The profile description of the soils on the higher elevations is as follows:

0-14", black, coarse sandy clay loam. This soil is quite porous.

14-30", light, yellowish, coarse sandy clay. Dark rust colored and gray mottling increases with depth. This characteristic is associated with restricted drainage.

The soil is underlain by laterite which probably presents an impervious layer to percolating water and so contributes to impeded internal drainage.

This sandy clay loam soil on the slight elevations are acid in reaction. The heavy clays in the depressions are very alkaline.

Soils of this sort can be developed for sugar cane production, provided certain special attention is given to drainage and fertilizer practice.

TABLE 14

Climatic Conditions at Singa  
(For Use in Abu Na'Ama Analysis)

Month	Temperature (C°)		Rainfall (mms)			Relative Humidity (%)		
	Average Maximum	Average Minimum	Total	Max. for One Day	Date of Maximum	6 A	Noon	6 P
January	35.2	16.5	0	0	--	42	23	41
February	36.5	17.3	0	0	--	36	20	34
March	39.7	19.8	0	4.0	20-1928	31	17	24
April	41.4	22.8	5	30.0	29-1944	33	17	27
May	40.1	24.2	31	65.0	27-1924	43	24	32
June	37.6	23.3	69	63.3	29-1923	59	34	47
July	33.9	22.0	167	100.0	13-1941	72	47	63
August	32.1	21.4	199	130.0	16-1950	79	56	76
September	33.9	21.4	92	91.2	8-1944	75	51	70
October	37.5	21.3	26	44.3	6-1933	62	34	58
November	37.9	19.5	1	4.4	7-1925	43	22	39
December	35.8	17.5	0	0	--	45	23	35
Total or Average	36.8	20.6	590	--	--	52	31	45

The outstanding difficulty with the district is its remoteness from a distributing center for the sugar and from the markets from which supplies must come. Transportation of bulky materials is only available by river boat and the distances are great. Air transport is available to and from Khartoum.

A relatively large population is to be found in the neighborhood, but most of the residents have had little need to work and no experience in the day-by-day activities required by a sugar enterprise. It is doubtful if Moslems from the north would be interested in emigrating to Equatoria Province.

Another disadvantage of the site is its remoteness from the scientific contacts which trained scientific personnel seem to require for continued productivity.

Climatic factors at Juba are presented in Table 15. Juba is about 30 miles south of Mongalla.

#### Areas of Great Future Potential

Jebel Moya. The most promising soil type encountered was found near the station, Jebel Moya, on the Sennar Junction-Kosti rail line. Here the soil, although somewhat heavier than sandy loam, would give fewer problems in the cultivation and in internal drainage than most of the soils studied. Moreover, the surface, although smooth, carries a significant gradient that would be of great value in the distribution of irrigation water.

The area is of adequate size for a sugar enterprise such as is proposed. It is on a main line of The Sudan Railway and so is linked with distributing centers for sugar and for supplies. Kosti, the downstream terminal of White Nile navigation, is not far away.

The great limitation is irrigation water. Two future sources are possible. One of these is the proposed Roseires Reservoir; the other involves major engineering construction.

TABLE 15

Climatic Conditions at Juba  
(For Use With Mongalla Analysis)

Month	Temperature (C°)		Rainfall			Relative Humidity (%)		
	Average Maximum	Average Minimum	Total	Maximum for One Day	Date of Maximum	6 A	Noon	6 P
January	36.1	20.1	4	33.1	28-1940	52	24	43
February	36.6	21.4	11	50.0	9-1936	53	25	42
March	36.3	22.3	39	55.0	19-1944	61	31	50
April	34.7	22.6	110	110.8	7-1939	72	44	62
May	32.9	21.9	151	109.5	19-1945	80	55	75
June	31.6	21.1	137	89.2	26-1934	83	57	78
July	30.1	20.4	140	86.1	27-1945	88	62	83
August	30.4	20.2	130	91.9	24-1950	87	60	83
September	31.7	20.3	107	95.5	14-1939	83	54	79
October	33.3	20.5	95	76.2	27-1924	79	47	77
November	34.5	20.7	33	55.4	9-1941	73	38	65
December	35.1	19.4	13	50.0	21-1936	61	31	54
Total or Average	33.6	20.9	970	--	--	73	44	66

The location studied is about 20 miles northeast of Kosti and, reputedly, about 40 meters above the river at that point. An exhaustive cost study involving the analysis of many proposals for location of ditches and pumping plants would be necessary before the economic feasibility of the area could be determined, but, from a crop production aspect, it seems ideal.

Area to Be Served by the Managil Extension. The Managil Extension of the distribution facilities of the Sennar dam will provide gravity water to a large area of land similar to that now farmed in the Gezira Scheme. Although this land is heavier than would be ideal for sugar cane culture, it would be productive. The soils have a moderate salt content in the subsoil. This, however, will not be detrimental to sugar cane, as has been shown by Gezira Board's experiments near Wad-Medani.

The great advantages are that a large area is available and that the high costs of pump installation and operation would be avoided. It should be said, however, that sugar cane requires irrigation facilities throughout the year, although during some rainy months, those facilities might not be used. The current regulations with respect to the timing of withdrawals from the Sennar Reservoir do not make this possible.

#### Limiting Conditions for Areas Not Recommended

The areas recommended for further study by officials of the Government or by interested individuals were selected after visits to many possible locations. Each had distinct advantages and disadvantages. The areas recommended carried values great enough to override the limitations.

The other areas visited are listed below, with a brief comment upon the reasons for their exclusion from the list of immediate importance.

On the Blue Nile: Bunzuga. This area is too remote from a major distribution center to deserve serious consideration at this time. It seems probable, too, that field labor would be secured with greater difficulty than in other areas. It is clear that skilled personnel would be held with difficulty.

On the Nile below Khartoum: Khartoum North. The plantation of the Middle East Agricultural Company indicates what good management can do in sugar cane culture in this area. The soil is sandy to sandy loam in the first foot, but tends to carry more clay in the subsoil. There is evidence of salt accumulation on and near the surface. The outstanding disadvantages are the high irrigation costs and the scarcity of labor. This labor problem is probably aggravated by the nearness of the plantation to Khartoum.

Bergeig. The soil, a silty clay loam, in this area far north of Khartoum would lend itself well to sugar production, but transportation difficulties eliminate it as an immediate possibility.

El Ghaba. This area is too small to permit the establishment of an enterprise of the proposed magnitude.

On the White Nile above Kosti: El Jebelein-Er Renk. This great area is ruled out of primary consideration because of the heavy soil found in the region, the evidence of salt, the extremely alkaline reaction and the descriptions of the soil given by Gibb (1). Moreover, transportation difficulties are great and labor difficulties might be expected. It is anticipated that skilled, technical labor would not be permanent.

Melut. Here again, the area was temporarily discarded because of an extremely heavy clay soil. Drainage difficulties, both internal and superficial, might be anticipated. The difficulties with labor and transportation, mentioned for El Jebelein and Er Renk, apply to the Melut area.

The discussion of the areas under the caption "Limiting Conditions in Areas Not Recommended" is not to be considered as a sweeping indictment against the locations included. They undoubtedly have high agricultural potentials. The Sugar Investigating Team searched for a few localities in which the possibilities for the success of a sugar cane industry would be greatest under the current conditions.

#### Modern Sugar Production Practice

A well integrated cane sugar plantation is a complex organization. It involves the intensive cultivation of a large area and, in addition, it must operate a complex factory which transforms the raw materials from the field into a product of high value. The managerial skill required and the basic competence of the supervision should not be minimized.

The problems are complicated by the fact that the product from the field is a perishable commodity. It should be processed at once after harvest. To keep the mill operating continuously during an operating period or campaign of about 150 days each year, the fields must be started at such times and cultivated in such ways that areas of appropriate size, carrying sugar cane at maximum sugar content, are available for harvest every day during the campaign.

A redeeming feature is that the sugar cane plant will produce for several years after it is once well established. When cut at ground level, new shoots appear and, after a year or so, can be cut again. In general, from three to six such crops can be harvested before reduced yields indicate that the sugar cane should be plowed out and replanted. In the current study, it is assumed that four crops will be taken before the field is started afresh.

Such a practice provides some flexibility in the ripening of fields for harvest, but it also requires expert care of the fields. For the loss of one

field or a part of it through bad management would result either in the stopping of the mill or the complete disruption of the harvesting schedule.

It is evident that this essential practice of growing and harvesting makes the concept of crop rotation inapplicable. Experience with this crop indicates that good management and judicious fertilization can substitute for the values of crop rotation with other crops.

### Field Operations

Many of the operations involved in sugar cane production are similar to those used for other crops. The principal differences are that the areas involved are usually larger and the power tools are heavier and perhaps more numerous.

Due to the lack of experience in the planting, culture and harvesting of sugar cane in The Sudan, the management of a new plantation will be confronted with difficulties due to the scarcity of trained personnel and experienced labor. For this reason, experienced personnel will have to be brought from nearby foreign or overseas countries.

It would appear that the various operations required in sugar cane culture should be mechanized from the outset. Such mechanization will ultimately be required. With appropriate mechanization and proper cultural methods, high yields and low costs may be obtained.

Land Clearing, Plowing and Furrowing. The first operation, if the proposed site carries a significant stand of trees, is deforesting. In land carrying about one hundred acacia trees per feddan, as at Sennar, a power bulldozer, such as a Caterpillar D-8 with wide tracks, and proper attachments for uprooting trees, should be able to clear from 25 to 30 feddans during a working day of from 14 to 16 hours. For this operation, an extra crew of one truck

driver and from 9 to 12 laborers is needed to cut away branches and take out small trees which may stand alone. This accumulated material can then be burned.

As deforesting should be started during the dry season, the burning of grass and small shrubs should precede actual clearing. When this is done, the tractor operator can work with more ease and efficiency.

Deforesting should be started a year before work on the erection of the sugar mill begins. Using three crews and two shifts, the total area cleared during the first year should be about 3,500 feddans. Such an area would allow 10 per cent of the area for canals, roads and railroads, and 3,150 feddans would remain for planting.

Since the dry season may be expected to begin in early November, 136 working days are available before mid-April. If 30 feddans are cleared during 14 working hours, using one bulldozer, 4,080 feddans could be cleared during the season.

During the same period, another bulldozer, equipped with a root cutter (V-knives with a coulter), should be removing roots from the deforested land to a depth of 10 inches. The cutting action of the V-knives loosens up the soil and leaves a better surface for subsequent operations. If the root cutting crew works two shifts per day, the output will be around 30-40 feddans daily.

This operation is followed by plowing, using the same tractor and a Rome 10, 36 inches diameter, disc plow. Total manpower used will be four tractor drivers. The total area plowed will be about 3,360 feddans in 96 working days.

Furrowing is started after the small or secondary canals are located by an engineer. This furrowing is done by wheeled tractors. One operator may easily finish 8 feddans per day. If two shifts and two crews are employed for 96 days in the work, an area of 3,072 feddans is covered. Furrows should be 5 ft apart.

Seed Cane Production. As has been stated, deforesting should be started one year before the erection of the sugar mill begins. One of the reasons for this is that sugar cane seedlings must be available when planting on a large scale begins and they must be grown.

A seedling area of about 100 feddans should be started as soon as the area is chosen. The yield of seed will be around 25 tons per feddan and 2,500 tons should be available. If 5 tons of cane seed per feddan is used, enough seed would be on hand for the planting of 500 feddans. If this seed is multiplied as quickly as possible, there will be a seed supply, after 15 months, sufficient for the planting of 3,000 additional feddans. The procedures necessary for the production of seed cane are discussed in some detail, since a large supply of well grown seed is essential if a reasonable planting schedule is to be maintained. It cannot be purchased. It must be grown on, or near, the site of the commercial planting.

Plans for the continuous production of seed cane must be a vital part of the long time planning, for relatively large areas must be replanted every year.

Cane Planting. One crew of 7 workmen and one tractor operator should be able to plant 5 feddans daily. Employing two shifts and five crews, fifty feddans can be planted daily. By planting sugar cane at this rate, a total of 4,600 feddans should be available when grinding operations start. A total of 6,600 planted feddans should be available for the second year of mill grinding operations, and 9,000 feddans for the third year.

The cane seed is brought from nearby seedling areas on rubber-tired steel carts, each pulled by a wheeled tractor. A man on each cart throws cane seed into the prepared furrows. In this way, the seed is distributed rapidly

and economically. An additional crew aligns and cuts the cane seed into pieces about 12 inches long, as it lies along the bottoms of the furrows. Fertilizer is applied mechanically. The cane seed and fertilizer then are covered by a tractor with cultivating discs. It is then irrigated. Fertilizer is applied again 60-70 days after sowing.

Irrigation. During the first stages of sugar cane growth, water has to be applied frequently in order to achieve maximum growth. The interval can only be determined by observation. High tonnage and high sucrose yields are to be expected if irrigation is carried out properly during the entire period of growth. As the cane grows, and its root system develops, less frequent applications may be possible. The interval must be carefully determined by observations and experimentations. Irrigations are discontinued from two to three months before harvesting.

Harvesting. Cane cutting in The Sudan should be done by hand. One man should be able to cut at least one ton of cane every eight hours. As time goes on and the cutters gain experience, the output of cut cane per day may increase. The cane cutters should place the cut cane across the tops of the ridges to facilitate the operation of the loading machine.

Loading may be done with a Thompson loading machine, or one similar to it. The rated output of a Thompson loading machine is 300 tons per day, if operated by an experienced man. In The Sudan, we might expect an output of about 200-250 tons at the start of operations. After the operators are more experienced, an output of 250-275 tons daily should be expected.

Such cane loaders work in conjunction with a train of five rubbered-tired steel cane carts which are pulled by a Caterpillar D-4 tractor. As the loader

picks up cane and moves forward, so will the cane carts. The loader keeps on loading the carts until all five are loaded. The train is then taken to the transfer station, where the cane from each cart is transferred to the railroad wagons, and then taken to the sugar mill..

The cane is delivered to the mill carrier or stored for night grinding.

It is evident that cutting and loading operations near the sugar mill do not need a transfer station. In such cases, the train of carts is taken directly to the sugar mill.

Three tractor drivers and a crew of five men should remain in the field to collect cane during the mechanized loading. This gleaning operation saves a considerable amount of cane. In addition, it is a first step in preparing the field for its next crop.

As the tonnage of cane per feddan is expected to drop considerably after three or four cuttings, provision should be made to clear extra land. This would permit planting of an additional acreage to replace that plowed out because of falling yields.

This end would be attained by planting 2,250 feddans during the third and fourth year of mill operations.

#### Irrigation Methods and Water Requirements

The flat lands of the agricultural areas visited make the usual methods of irrigating sugar cane of questionable value in The Sudan. In general, the land slopes slightly in the direction of the river's flow and toward the river. But the flatness of the plain and the small rate of slope are seldom found in other sugar producing areas. As an example, the grade of the main Gezira Canal which taps the Blue Nile at the Sennar Dam and carries water through the lands of the project is built on a slope of 7 cms per kilometer. Such topography

makes ditch design relatively simple, although construction costs may be high per unit of volume carried. But that same topography may create difficulties in the actual distribution of water to plants that are not ordinarily irrigated by flooding.

The same problem, however, confronts the cotton grower. Here the crop is planted in straight rows running down the greatest slope available. With lines of economic length, some flooding between adjacent rows seems to be inevitable. Acceptable cotton yields have been secured and sugar cane which is as well, or better, adapted to temporary flooding will probably prosper under such intermittent flooding. The method is most unusual with sugar cane.

Irrigation Layouts. The general irrigation layout is simple to plan and to construct. In most cases, no surface leveling would be necessary. The cane lines would be straight and parallel and run down whatever grade is available from a supply ditch along the higher edge of the field. Water should be admitted to permanent furrows between adjacent cane lines.

In such an arrangement, only two variables remain in the hands of the irrigator. One of these is the length of the lines which is the distance between supply ditches. The other is the rate at which water is admitted to each furrow. From experience in other areas, it may be assumed that the tendency to flood, that is, to have water escape from the furrow, would increase as the lines become longer and as the amount of water introduced into the furrows increased.

What the proper length of line might be to assure acceptable distribution can only be determined by trial. Some evidence is already at hand from experience at the Gezira area. Variations in the amount of water introduced into each furrow can best be regulated by a tube or light wooden box through the bank

of the supply ditch. A cut with a shovel is not permanent and does not permit close adjustment.

Possibilities in Overhead Sprinkling. Overhead sprinkling, which is always mentioned when irrigation methods are discussed; does not seem to be currently suitable for sugar irrigation in The Sudan. This method finds its greatest usefulness in areas of high land and water costs and with costly labor. It should be said, too, that even moderate winds distort the pattern of coverage to such an extent that adequate distribution cannot be secured. The flat lands and heavy soils to be found south of Khartoum would tend to minimize this difficulty.

It may be said, however, that the added costs for sprinkler equipment and the power requirements for its operation would be unjustified at the present time. When a sugar enterprise has been in successful operation for a few years, and specific cost figures for conventional irrigation are at hand, the case for overhead sprinkling may well be reviewed.

Water Requirements. Few local data are available with respect to the water requirements for irrigated sugar cane in The Sudan. One study relates to a small plantation operating on relatively pervious soil a few miles north of Khartoum.

Here a 14-inch centrifugal pump provides water for 150 feddans of cane. This pump is said to deliver 3,500 (Imperial) gpm or 9.3 cubic feet per second. In this example, 1 cfs (for eight hours per day) supplies water for 16 feddans of sugar cane. If this ratio is expressed in the units of the country, the reported duty of water is 1 cubic meter per second for 570 feddans.

As usual in reports of water requirements, the units used vary widely. For example, one worker in Equatoria reports that 460 cubic meters of water

are required per feddan. This must refer to a single application. If so, the application is at the rate of 11 feddan cms per feddan.

Gibb (1) in his comprehensive analysis of the irrigable lands in The Sudan uses an empirical device for the determination of water requirements. Through the use of weather records and empirical constants, he concludes that the basic annual water requirement for a single crop at five locations from Mala-kla, on the south, to Wad-Medani in the north, vary from 1900 feddan-millimeters per feddan in the south to 2600 feddan-millimeters per feddan in the north.

In the present study, it is assumed that the crop will be irrigated for 10 months and that the planting on the level, relatively impervious soil of the Gezira area will require a gross application of 75 millimeters at 10-day intervals. About 2250 feddan-millimeters per feddan should be provided during the life of a single crop.

It is recognized that this is only a rough approximation. No allowance is made for rainfall. Future studies may indicate that no adequate distribution can be secured with an application as small as has been mentioned. However, even these rough approximations bring the gross duty of water reasonably close to those made by the empirical approach.

#### Mill Operation and Design

A sugar mill should be so designed and so operated in close coordination with field operation that when once started it will operate continuously day and night, until the campaign is finished, five or six months later. In order to accomplish this, the mill must be well serviced before the beginning of operations and experienced and resourceful men must be in constant attendance. The idle time between campaigns is spent in mill inspection, cleaning and replacement.

Despite such off-season inspections, occasions may arise during which the mill must be shut down. The skill of the mill engineer and his crew is measured by the amount of continuous running time, after operations begin.

Due to the lack of any former experience in sugar cane growing and sugar manufacture in The Sudan, no large scale processing units should be contemplated at the start of such an industry. Economic and successful milling operations require that there be a constant daily supply of sugar cane at the factory site during the grinding season, as the cost of the equipment and the fixed costs of factory operation are high. It is advisable that for any single area to be devoted to sugar cane growing in The Sudan, the sugar factory should be designed to have a normal daily grinding capacity of 2000 tons. The relationship between this minimum requirement and the area to be planted to sugar cane is important.

The original designs should be so planned that the grinding capacity could be increased at least 50 per cent with a minimum of new equipment. If the original operation is successful, such flexibility will be of great value.

The latest milling and sugar processing practices should be incorporated in the design of the sugar factory. The absence of any trained labor, and of sugar technicians for mill operation, makes it advisable that, where possible, automatic or semi-automatic devices be installed to control the many operations and processes in the factory. This will save manpower, and consequently lower the cost of processing each ton of sugar produced.

The design of the sugar factory for any site should incorporate the following general modern practices:

1. Automatic Sugar Cane Weighing Scales with Printomatic Devices. This type of scale will give an accurate weight and make a record of it. It is very important for sugar house control work that reliable records of the exact weights of the cane entering the mill be available every day.

2. Cane Handling Equipment. A tilting table, operated either hydraulically or electrically, is required for the efficient unloading of railroad cane cars. Such cars must be designed for this type of unloading. It is the most economical way of feeding the cane to the cane carrier.

One hammer-head, self-supported, revolving-type crane with at least 10-ton capacity, and a 65 foot working radius and a clear lift of 45 feet, should be installed to unload rubber-tired wheel cane cars or lorries. The cane can be stored by this crane for grinding when required, or it can be fed directly to a cane table which feeds it to the carrier.

3. Preparation of the Cane. Two sets of cane knives, electrically driven, and installed in the cane carrier, are required to prepare the cane properly before it enters the mill. This will ensure better feeding of the cane to the mill, better sucrose extraction, less sucrose lost in bagasse and consequently high milling efficiency.

4. The Mill Tandem. The mill tandem must have at least five three-roller mills. Each mill should be driven independently by its own steam turbine. The mill tandem must grind 2000 tons of cane per day at a normal circumferential speed of the rollers of 45 ft per minute. But it must be designed so that, when required, the turbines have power sufficient to increase the circumferential speed of the rollers to 60 ft per minute. The mill must be of all steel construction, with the gears having cut teeth and running totally enclosed in a bath of lubricant. An automatic system of lubrication similar to the Farval pressure system is required to lubricate the journals of the rollers. For applying hydraulic pressure independently to each one of the two journals of each top roller, a system similar to the Edwards system is required.

Provision should be made in the general design of the factory so that in the future a sixth mill can be installed. This, coupled to the flexibility in circumferential speed mentioned above, will make it possible to increase the grinding capacity in the future to over 3000 metric tons daily. The expense required to obtain this future increase in grinding capacity of the mill tandem will be small compared to the initial cost of the original mill installation.

5. The Boiler Plant. The boiler plant should, preferably, consist of three identical steam generating units, each designed for a least 250 pounds per square inch and 100° superheat. Any two of these should be able to supply the total steam demands of the factory when grinding 2000 tons of cane daily and using bagasse only as fuel. The third unit would be a stand-by unit. This arrangement will supply enough steam generating capacity for future expansions in grinding capacity, to 3000 tons of cane daily.

Each boiler must have an appropriate, modern bagasse furnace, steam superheater, air pre-heater, and a forced draft fan for supplying the air required in the furnace. In addition, an induced draft fan for exhausting the gasses of

of combustion through the boiler proper and the air-preheater, and discharging them to the atmosphere through the stack should be provided. Each boiler must be supplied with fuel oil burning equipment as a stand-by for emergencies.

Automatic control instruments, with provision for auxiliary manual control, should be provided for the operation of each boiler.

6. Sulfitation and Defecation of the Juice. A continuous process for the liming, sulfitation and defecation and clarification of the juice should be used. Several sulphur burning units should be provided to ensure a continuous supply of sulphur dioxide when any of the burners in use is being cleaned or repaired.

7. Juice Heaters. The juice heaters should be designed to use vapors at from 3 to 6 pounds per square inch, from the evaporator for heating the juice. Provision should be made for the use of exhaust steam when required. One spare heater should be provided to allow for the cleaning of any one of the heaters that might get fouled with scale while grinding.

8. Evaporator. A multiple effect evaporator consisting preferably of five separate bodies or effects, connected in series, should be used to concentrate the clear defecated juice into syrup. Steam economy will be obtained by withdrawing vapors from the first and second bodies and using these vapors in the vacuum pans and juice heaters. The design of the multiple effect evaporator, if based on these principles and on a carefully calculated heat balance for the factory, will result in overall fuel economy.

Automatic control for the liquid level in all the bodies and for the admission of live steam to supplement the exhaust steam when so required should be provided for the efficient operation of the evaporator.

In designing the evaporator, careful consideration should be given to an expected increase in daily grinding capacity to 3000 tons in the future. If this is done, the addition of one or two more bodies to increase capacity can be obtained with a minimum of cost.

9. Vacuum Pans. The vacuum pans should be of the calandria type, designed to use vapors from the evaporator at from 3 to 6 pounds per square inch, with provision for the use of exhaust steam when necessary. It is general practice in designing vacuum pans, that use vapors, to allow at least  $2\frac{1}{4}$  square feet of heating surface for every cubic foot of pan capacity. Provision should be made in the pan floor for installation of additional pan capacity for any future expansion in grinding capacity up to 3000 tons of cane daily.

10. Condensers. The evaporator and vacuum pans should have jet condensers, so that no vacuum pump will be required.

11. Crystallizers. The crystallizers should be water cooled by means of rotating coils in which the cooling surfaces are part of the stirring mechanism. Each crystallizer should be large enough to take one whole strike of the vacuum

pans. Provision should be made on the crystallizer floor for installation of additional capacity in the future to handle an increase in grinding capacity up to 3000 tons of cane daily.

12. Centrifugals. The centrifugals for "A" and "B" sugars (the finished product ready for drying and packing) should be of the latest type with 30" high by 48" diameter baskets, turning at 1200 rpm. Each machine should be driven by its own vertical motor. All phases of the centrifugal cycle should be automatically controlled by a combination electric-air control. They can be either fully automatic, including charging of the basket for continuous operation, or the charging can be done by a manually operated air valve which actuates air pistons attached to the charging gate. All other operations should be automatic once the machine is started by appropriate operations in the control box. The battery of centrifugals for "A" and "B" sugars must have its own mingler. This mingler must have a rotating coil which also serves as a stirring mechanism. By this device, hot water can be circulated to keep the massecuite at the proper temperature for purging. The temperature of the circulating water must be automatically controlled.

The centrifugals for "C" sugars (low-grade massecuites) should also be of the latest type with 30" high by 40" diameter baskets, turning at 1800 rpm. Each machine should be driven by its own vertical motor. All phases of the centrifugal cycle are to be automatically controlled by a combination electric-air control. The charging of the centrifugal basket should be by an air operated gate valve manually controlled, and the discharging by an air operated discharger, also manually controlled. Once the centrifugal is started, all other phases of the time cycle will be automatically controlled. As in the "A" and "B" machines above, the mingler in the "C" sugar centrifugal must be provided with a rotating coil through which hot water is circulated to keep the massecuite at the proper temperature for purging. The temperature of the circulating water will be automatically controlled.

Additional space should be provided for each battery of centrifugals for the installation of additional machines to handle future increase in grinding capacity up to 3000 tons of cane daily.

13. Power Plant. The power plant should have two steam turbo-generators, either of which must be capable of supplying the total electrical power demands of the factory. Space should be left in the power plant building for the installation of an identical third unit to take care of future increase in grinding capacity up to 3000 tons of cane daily.

The generators should be designed for 4600 volts AC, 3 phase, 60 cycles. All the motors in the factory should be 440 volts AC, 3 phase, 60 cycles. Transformer stations, 4600/440 volts AC should be installed at convenient places in the factory to supply power to adjacent motors. All lighting circuits should be 230/115 volts AC, single phase, 60 cycles. An auxiliary diesel generator of approximately 250 kw capacity, 480 volts AC, 3 phase, 60 cycles, should be installed. This generator will supply all lighting and power requirements during erection of the factory, and can be used to supply all power and lighting demands during the dead season when the factory is not grinding.

14. Water Treatment Plant. A water treatment plant should be provided for make-up water for the boilers, for cooling purposes in the factory, and for human consumption. Provision should be made to reclaim the cooling water used in the factory and return it to the system.

15. Cooling Pond. A cooling pond using water spray nozzles and natural air cooling and aeration should be used for cooling the water used in the jet condensers of the evaporator and the vacuum pans. Two sets of pumps will be used for this system. One set will pump the cool water from the cooling pond to the condensers; the other set will pump the hot water discharged by the leg pipes of the condensers through the spray nozzles into the cooling pond.

This system will require a minimum amount of fresh water to replace the water lost by evaporation and that carried away by the wind from the spray of the nozzles. The saving of water in The Sudan, where fresh water is at a premium, should be given careful consideration in the design and installation of any industrial enterprise.

16. Pumps. A spare pumping unit should be installed for each and every one of the pumping units in the factory.

17. Motors. One spare motor should be supplied for each one of the sizes and speeds up to 25 hp. Spare coils should be supplied for all motors larger than 25 hp.

#### The Values in Unified Field-Mill Management

Sugar cane enterprises the world over have developed along two lines. In one type of enterprise, the sugar company concerns itself only with the milling of cane brought to it by independent growers who operate under contractual agreements with the sugar company.

In the other type, a single company operates the mill and grows the cane. It is generally recognized that the close control over planting and harvesting dates, which is provided by this organization, makes the flow of ripe cane to the mill more secure and so results in more productive operation.

In general, the great sugar mills in Cuba buy cane, as a result of contracts, from a multitude of relatively small growers. Sugar beet factories in the continental United States operate on the same principle. In Hawaii, on the other hand, the field operations and the milling are under unified management.

That management has complete control of every operation from the preparation of the fields to the selling of the sugar.

It is the firm belief among modern operators that a program of unified management makes for most economical production. This practice is recommended for the proposed sugar cane industry in The Sudan. The case for this type of management with sugar beets is not so clear in view of the need for rotation to secure continuing yields of acceptable magnitude.

This discussion of the values in unified management applies only to sugar cane.

The successful operation of a sugar mill calls for the daily delivery of fresh, newly-cut cane. The sucrose built into the sugar stick through careful field management is subjected to loss through the process of inversion as soon as the stick is cut. The products of this inversion, although some of them chemically are still sugars, cannot be sold. Moreover, they hinder the commercial recovery of the valuable sucrose.

For this reason, harvesting operations should be so scheduled that cane reaching the mill during the eight or ten hours available for field work can be ground and processed during a twenty-four hour period. Any surplus results in loss through deterioration; any deficiency results in an idle mill, or a shut-down mill, if the shortage is serious enough.

These scheduling problems are compounded by the fact that the proposed date for harvesting a cane field should be determined three or four months in advance. If the schedule established for the ripening of a field is broken, more losses occur.

It is apparent that the problems involved in ripening the cane on a 9000 feddan plantation in such a sequence that 2000 tons of ripe cane will be

delivered to the mill every day are great. Unplanned-for shut-downs at the mill due to accident or mechanical failure may not be frequent, but they do happen. When this occurs, the harvesting schedule must be quickly modified to hold the inevitable losses of sugar to a minimum. Experience indicates that this can best be done with a unified management of mill and field operations. When such a system is used, a general manager has complete and immediate control of all operations.

The sugar investigating team strongly recommends that tenancy be avoided as far as sugar cane production is concerned. Experience indicates that the establishment of a program of unified management in an area where a previous program of tenancy had existed is extremely difficult.

It should be said that this argument, like the previous one, relates only to sugar cane operations. Sugar beet operations are usually based upon the purchase of beets grown by contractual growers who, except for the fact that they usually are independent operators, would have a status similar to that of tenants in the local scene.

Sugar beets suffer the same losses after harvesting as does sugar cane, but the administrative difficulties in unified management over the great area which is required because of needed rotation, which is essential with sugar beets, makes it impractical to strive for the advantages of unified management with this crop.

#### The Cost of Sugar Production at Sennar

Sugar cane growing and processing are costly activities, but under favorable circumstances they may be highly profitable. An analysis of the cost figures for a hypothetical plantation at Sennar, Blue Nile Province, is given below.

It is recognized that somewhat different figures would result if another area were used. For example, freight charges and labor costs would vary between possible areas, but these differences would be relatively small. It is believed that the Sennar district is indicative of what might be expected.

Like other large enterprises, a large capital investment is required before income is significant in a sugar cane enterprise. The capital investments required for the efficient operation of such a plantation are listed under two headings. One of these includes the capital costs which are necessary to establish and to operate the fields economically; the other deals with the capital necessary for the erection of the sugar mill and its adherent facilities.

Other sections of this chapter deal with the cost of operation, and the labor, both technical and manual, that is required.

A possible profit and loss statement for the hypothetical plantation during the first four years of the mill's operation is included. It should be said that these profit and loss statements make no allowance for savings in production costs that may result from the qualification of the plantation as an "approved" or "pioneer" enterprise under the terms of the policy of the government to encourage new industries and to encourage the advent of foreign capital. A complete statement of the policy and a copy of the Approved Enterprise (Concession) Act of 1956 is enclosed as Appendix III.

In this regard, it should be said that specific concessions can only be secured through negotiations with appropriate officers of The Republic of The Sudan. It would appear that such negotiations cannot begin until a formal proposal is made. The profit and loss statements made herein are conservative since the governmental concessions when secured would reduce costs in a measure that cannot now be determined.

Capital Costs. The cost figures are based upon the establishment and operation of a plantation of such a size that 9000 feddans of cane can be harvested each year. The mill is assumed to be of sufficient capacity to process 2000 tons of cane a day with facilities to increase this to 3000 tons per day without great expense. The necessary capital costs are listed in Table 16.

The salary requirements for field and mill operations are given in Table 17.

For the purpose of the following computations, no distinction was made between local and foreign expenditures, since this division is subject to adjustments, when and if foreign interest can be developed in the sugar project.

TABLE 16

CAPITAL REQUIREMENTS FOR ESSENTIAL

SUGAR CANE PLANTATION OPERATIONS

To Establish the Fields 1/

Buildings	LS 346,000.00
Field Equipment	238,930.00
Railroad Equipment	198,580.00
Roads and Telephone Lines	20,000.00
Irrigation Pumps	144,000.00
Main Irrigation Canal	16,800.00
Deforestation and Clearing	31,500.00
Contingencies, 15% of LS 995,810	<u>149,371.00</u>
	LS 1,145,181.00

(Use LS 1,150,000 as capital requirement for field development.)

To Construct the Mill (2,000 ton factory)

Complete Factory <u>2/</u>	LS 1,830,000.00
Transportation to Port Sudan <u>3/</u>	164,700.00
Transportation to Sennar Site <u>4/</u>	66,500.00
Erection <u>5/</u>	660,000.00
Buildings other than Factory <u>6/</u>	105,525.00
Railroad Yard, Cane Yard, Roads	26,000.00
Contingencies, 5% of 2,852,725 <u>7/</u>	<u>142,636.00</u>
	LS 2,995,361.00

(Use LS 3,000,000 as capital requirement for mill operation.)

- 1/ For details of capital requirements for Field Operation, see Appendix II, Table 28.
- 2/ Based upon the price of a similar completed factory installed in 1956 at Barquisimeto, Venezuela.
- 3/ Transportation cost based on data furnished by importers of heavy machinery from England.
- 4/ Transportation cost per ton, by rail from Port Sudan to Sennar (1045 km), furnished by importers of the diesel-driven pumps installed at Sennar.
- 5/ Based on erection costs for factory cited in 2/ above, but adjusted to the site in The Sudan.
- 6/ Building requirements other than factory are shown in detail in Appendix II, Table 29.
- 7/ If tests of the soil at the proposed site show that piles are required to carry the load of the mills and the stack, the estimate should be increased by LS 70,000.

TABLE 17

REQUIRED PERSONNEL AND NECESSARY  
SALARIES FOR FIELD AND MILL OPERATIONS

For Field Operation

<u>Job Title</u>	<u>Annual Salaries</u>
1 Chief Supervisor	LS 2,100
2 Assistants to Supervisor	3,360
1 Agricultural Engineer	1,560
1 Irrigation Engineer	1,680
2 Pump Attendants	1,320
1 Soil Chemist	1,920
25 Chief Farmers (foremen)	1,560
2 Clerks	1,440
2 Mechanics in Shop	720
4 Mechanics in Shop	1,200
4 Shop Helpers	720
Total Fixed Salaries	LS 17,580 per year

For Mill Operation

<u>Job Title</u>	<u>Monthly Salaries</u>
<u>Administrative Personnel</u>	LS
1 General Manager	300
1 Assistant General Manager	175
1 Chief Accountant	150
6 Bookkeepers	420
2 Correspondence Clerks	120
1 Sugar Warehouse Storekeeper	60
1 Factory Materials Warehouse Storekeeper	60
1 Assistant Factory Materials Warehouse Storekeeper	40
1 General Stores Storekeeper	60
2 Telephone Operators	40
	1,425
<u>Fabrication Personnel</u>	
1 Superintendent of Fabrication	250
1 Assistant Superintendent of Fabrication	175
3 Shift Assistants to Superintendent of Fabrication	300
3 Foremen for Sulpho-Defecation and Heating	150
3 Foremen for Evaporators	150
6 Sugar Pan Boilers	450
3 Foremen for Centrifugals	150
3 Foremen for Dryers, Weighing Scales and General Handling of the Sugar	120
	1,745

Table 17 Continued:

<u>Job Title</u>	<u>Monthly Salaries</u>
<u>Engineering and Factory Operating and Maintenance Personnel</u>	
1 Chief Engineer	LS 250
1 Assistant Chief Engineer	175
3 Shift Assistants to Chief Engineer	300
1 Draftsman	75
1 Chief Electrician	175
3 Shift Electricians	150
3 Mill Tandem Foremen	150
3 Boiler Foremen	150
3 Centrifugal Foremen	150
3 Overall Mechanics (one for each shift)	120
1 Machine Shop Foreman	75
2 Welders	60
2 Machine Tool Operators (for lathes, milling machine, planer, etc.)	60
	<u>1,890</u>
<u>Laboratory Personnel</u>	
1 Chief Chemist	<u>125</u>
Total Monthly Salaries	LS 5,185
Yearly Salaries (LS 5,185 x 12)	LS 62,220
Traveling Expenses, Welfare, etc., 25%	LS <u>15,555</u>
	LS 77,775
	Say LS 78,000

Required Daily Workers for Effective Mill Operation. The non-salaried workers required for the effective operation of the mill are divided into two classes. Some of these are hired for the grinding season only; others are employed during the dead season. They are necessary to repair the mill and to get it ready for the next campaign. Manning tables are shown in Tables 31 and 32 of Appendix II.

### The Costs of Growing Cane

In an analysis of the factors making up the costs of growing cane, the several operations, such as plowing and planting, fertilizing and others are considered in turn. In each case, the equipment and labor requirements are listed, together with a statement of the area that might be covered in one day with such facilities. The final cost for each operation per feddan is given in Table 18. The derivation of these costs is given in Appendix II, Table 30.

For convenience in the preparation of the profit and loss statement, another general operation, involving several of those listed in Table 18, has been added. This operation may be called "growing cane". It embraces the several field activities which are necessary every year to keep the cane growing vigorously.

These operations are:

<u>Operation</u>	<u>Cost per Feddan per Year</u>
Fertilizing the Crop	LS 16.532
Insect Control	.850
Hoeing	.915
Irrigation	<u>2.480</u>
	LS 20.777

### Profit and Loss Statements for Hypothetical Sugar Plantation

Table 19, consisting of four parts, contains profit and loss statements for a hypothetical sugar plantation at Sennar. Part One applies to the period extending from the beginning of field work to the end of the first year's operation of the mill. Parts Two, Three and Four apply to the second, third and fourth years of operation respectively.

TABLE 18

COSTS OF UNIT FIELD OPERATIONS

SENNAR AREA

<u>Operation</u>	<u>Cost LS per Feddan</u>	<u>Total Cost LS per Feddan</u>				
<u>Deforestation and Clearing</u>						
Tractor Operation	0.947					
Clearing Operations	1.000					
Clearing Field of Roots	<u>0.813</u>	2.760				
<u>Planting Operations</u>						
Plowing	0.813					
Furrowing Out	0.334					
Making Canals	0.323					
Planting of Cane	0.939					
Covering Cane	<u>0.305</u>	2.714				
<u>Fertilizing the Crop</u>						
Fertilizer Purchased	16.120					
Labor, 1st Application	0.206					
Labor, 2nd Application	<u>0.206</u>	16.532				
<u>Insect Control</u>	<u>0.850</u>	0.850				
<u>Irrigation</u>						
Labor	1.500					
Fuel for Pumps	<u>0.980</u>	2.480				
<u>Hoeing</u>	<u>0.915</u>	0.915				
<u>Harvesting Costs</u>						
	<u>1st Yr.</u>	<u>2nd Yr.</u>	<u>3rd Yr.</u>	<u>1st Yr.</u>	<u>2nd Yr.</u>	<u>3d Yr.</u>
Cutting Cane	9.500	7.880	7.000			
Cane Loading	2.123	2.059	2.059			
Transportation	7.125	5.910	5.250	18.748	15.849	14.309

The data given above, and others related to them, are assembled in Profit and loss statements in Table 19. In the preparation of these statements, it was assumed that the marketable sugar for the first year would be 23,890 tons, for the second year, 28,600 tons, and for the third and fourth years, 34,650. An average price for the product was assumed to be LS 46.85. This is the average price for the last seven years.

TABLE 19

PART ONE

PROFIT AND LOSS STATEMENT FOR A HYPOTHETICAL SUGAR PLANTATION  
AT SENNAR FROM THE BEGINNING OF FIELD WORK TO THE END OF  
THE FIRST YEAR'S OPERATION OF THE MILL

Income

23,890 tons of sugar at £S 46.85                      £S 1,119,246.00

Field Costs

Planting, growing and harvesting		
7,000 feddans planted @ 2.714	18,998	
5,980 feddans harvested @		
18.748	112,113	
8150 feddan-years grown (1) @		
£S 20.777	<u>169,332</u>	300,443.00
Maintenance (2)		38,891.00
Fixed Salaries (3)		17,580.00
Depreciation (4)		118,644.00
Interest (5)		57,500.00
Pump Licenses, 4 @ £ 160. (6)		<u>640.00</u>
Total Field Costs		533,698.00

Mill Costs

Chemicals and Materials (7)	12,000.00
Bags for Sugar (8)	26,400.00
Maintenance Materials (9)	15,000.00
Workmen's Wages	
During Campaign (125 days)	17,600.00
During Dead Season (120 days)	5,496.00
Annual Salaries (3)	78,000.00
General Administrative Overhead	12,000.00
Depreciation (4)	300,000.00
Interest (5)	<u>150,000.00</u>
Total Mill Costs, 1st year	£S 616,496.00

Summary

Income		£S 1,119,246.00
Costs		
Field	533,698.00	
Mill	<u>616,496.00</u>	
	Total Cost	<u>1,150,194.00</u>

First Year Loss                      £S 30,948.00

## PART TWO

## Income

## Field Costs

### Mill Costs

## Summary

-99-

TABLE 19

PART THREE

PROFIT AND LOSS STATEMENT FOR A HYPOTHETICAL  
SUGAR PLANTATION AT SENNAR, THIRD YEAR

Income

34,650 tons of sugar at LS 46.85                      LS . 1,623,352.00

Field Costs

Planting, growing and harvesting (10)		
2,250 feddans planted @ 2.714	6,106	
9,450 feddans harvested @ 14.309	135,220	
9,000 feddans grown @ 20.777	<u>186,993</u>	328,319.00
Maintenance		38,891.00
Fixed Salaries		17,580.00
Depreciation		<u>118,644.00</u>
Interest		53,928.00
Pump Licenses		<u>640.00</u>
Total Field Costs		588,002.00

Mill Costs

Chemicals and Materials	15,000.00
Bags for Sugar	31,460.00
Maintenance Materials	17,500.00
Workmen's Wages (11)	
During Campaign (180 days)	25,344.00
During Dead Season (150 days)	6,870.00
Annual Salaries	78,000.00
General Administrative Overhead	12,000.00
Depreciation	300,000.00
Interest	<u>140,701.00</u>
Total Mill Costs, 3rd Year	626,875.00

Summary

Income		1,623,352.00
Costs		
Field	588,002	
Mill	<u>626,875</u>	
Total Costs		<u>1,184,877.00</u>
Profit before Taxes		438,475.00
For Business Profits Tax (40%)		<u>175,390.00</u>
Third Year Profit after Taxes		LS 263,085.00

TABLE 19

PART FOUR

PROFIT AND LOSS STATEMENT FOR A HYPOTHETICAL  
SUGAR PLANTATION AT SENNAR, FOURTH YEAR

Income

34,650 tons of sugar at £S 46.85                      £S 1,623,352.00

Field Costs

Planting, growing and harvesting		
2,250 feddans planted @ 2.714	6,106	
9,000 feddans harvested @ 14.309	128,781	
9,000 feddans grown @ 20.777	<u>186,993</u>	321,880.00
Maintenance		38,891.00
Fixed Salaries		17,580.00
Depreciation		<u>118,644.00</u>
Interest		52,007.00
Pump License		<u>640.00</u>
Total Field Costs		549,642.00

Mill Costs

Chemicals and Materials	15,000.00
Bags for Sugar	31,460.00
Maintenance Materials	17,500.00
Workmen's Wages	
During Campaign (180 days)	25,344.00
During Dead Season (150 days)	6,870.00
Annual Salaries	78,000.00
General Administrative Overhead	12,000.00
Depreciation	300,000.00
Interest	<u>135,700.00</u>
Total Mill Expense, 4th year	621,874.00

Summary

Income		1,623,352.00
Costs		
Field	549,642	
Mill	<u>621,874</u>	
Total Cost		<u>1,171,516.00</u>
Profit before Taxes		451,836.00
For Business Profits Tax (40%)		<u>180,734.00</u>

Fourth Year Profit after Taxes                      £S 271,102.00

Footnotes for Table 19, Parts One, Two, Three, and Four

(1) It is anticipated that the first seed-cane will be planted at least two years before the mill starts its first grinding season. This is required by the fact that sugar cane seed is heavy and cannot be imported in the amount necessary for the anticipated area. It must be grown; this is a time-consuming operation.

The figures used in the profit and loss statements are for the first year based upon the following schedule of plantings:

<u>Time before First Mill Operation in Years</u>	<u>Feddans Planted</u>	<u>Feddan Growth Years</u>
2½	100	250
2	500	1000
1½	3000	4500
1	1400	1400
½	2000	1000
Total		8150

Feddan growth years as listed for the second, third and fourth years in the profit and loss statements were established in a similar manner.

(2) Maintenance charges are computed as follows:

1. Main canal, £S 16,800 @ 5%	840
2. Buildings, 346,000 @ 3%	10,380
3. Roadways, telephone lines, railways, 218,580 @ 5%	10,929
4. Irrigation Pumps, 144,000 @ 3.33%	4,795
5. Agricultural Equipment, 238,930 @ 5%	11,947
Total annual maintenance charge	38,891

(3) For details of necessary personnel and annual salary account, see Appendix II, Table 17.

(4) Depreciation.

For Field Operations

1. Agricultural equipment, £S 238,930 @ .20%	47,786
2. Buildings, 346,000 @ 10%	34,600
3. Railroads, telephone lines, etc., 218,580 @ 10%	21,858
4. Irrigation pumps, 144,000 @ 10%	14,400
Annual depreciation charge	118,644

For Mill Operation

Total investment of £S 3,000,000 @ 10%	300,000
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(5) Interest. Interest charges were computed upon the basis of a 20-year period of amortization with interest on unpaid balances at 5%. The sum of interest and principal payments is constant.

(6) Pump licenses were computed upon the basis of charges given in The Laws of The Sudan, Volume 5, page 147.

(7) This item includes the necessary materials for processing, such as sulphur, lime, lubricating oil and grease. The estimate is based on experience elsewhere and local prices.

(8) The cash requirements for jute sugar bags was based on a CIF Port Sudan price of £S 100 per ton. One ton carries approximately 1,000 jute bags.

(9) Spare parts and materials for general repairs and upkeep are included. Annual cost based upon experience and observations of local prices.

(10) Details of planting costs are shown in Table 30, Appendix II.

(11) Workmen's wages were computed by applying current wage rates to the Manning Tables, Tables 31 and 32 in Appendix II.

#### The Cost of Growing Sugar and the Possibilities of Profits

The cost figures presented in the following summary are in terms of pounds (Sudanese) per ton of sugar and in cents (U.S.) per pound. Such figures are necessary for comparison with other producing areas.

#### Summary of Yields and Costs per Unit of Production on the Hypothetical Sugar Plantation

Year of Mill Operation	Sugar Cane Tons Yield Per Feddan	Assumed Sugar Yield %	Expected Yield of Sugar (Tons)	Cost of Produc- tion (£S)	Cost of Production	
					£S per Ton	Cents per Lb.
1st	47.5	11	23,890	1,150,194	48.15	6.27
2nd	39.4	11	28,600	1,120,050	39.16	5.10
3rd	35.0	11	34,650	1,184,877	34.20	4.45
4th	35.0	11	34,650	1,171,516	33.81	4.40

## Sugar Cane By-Products

All sugar cane mills produce two major by-products which, because of their great volumes and low values, may present disposal problems. One of these, bagasse, the dried fiber of the cane stick, is usually used for fuel for the factory. The other, molasses, presents a more serious problem.

Although molasses may vary in composition from mill to mill and even from month to month in the same mill, it consists mainly of sucrose, which has escaped crystallization in the operation, glucose and other simple sugars, and inorganic salts which the sugar cane plants had absorbed from the soil. There is also an appreciable amount of organic matter. Molasses as it appears after the last step in sugar separation in the mill should not be considered as a human food.

Possible uses for these sugar mill by-products are discussed below.

Bagasse. It is assumed that the bagasse resulting from a sugar mill in The Sudan will be used for fuel in the boiler room. If this is not done, imported fuel oil would be required with an expenditure of foreign exchange. In favored marketing areas, some bagasse is made into fiberboard. In Peru, a fair quality of paper, for general use, is manufactured from this material. In such cases, the value of the fiber product is sufficient to permit the use of oil as a fuel. Such a condition does not seem to exist in The Sudan. The evident use is as a fuel.

Molasses. The problem of molasses disposal is more serious. The sugar mill described in this report will produce approximately 12,000 gallons of molasses per day. Unless some economic use can be found for this material, and it can be changed economically into a useful and saleable product, the mill would soon be confronted with a disposal problem of considerable magnitude.

Conventional uses of molasses from cane sugar processing plants include the following:

1. Cattle Feeding. The mills in Hawaii and some of those in Cuba and elsewhere dispose of their molasses through livestock feeding enterprises. The heavy concentration of easily digested carbohydrates in the molasses makes that material a valuable component of livestock feeds designed primarily for the fattening and finishing of beef cattle. When used in this manner, the molasses is in competition with low priced feed grains. Moreover, the daily intake of molasses is strictly limited. In moderate amounts, however, the molasses is a valuable constituent of a beef cattle ration. Although most of the molasses used in livestock feed is used by beef cattle finishers, it does find use in dairy feeds and in chicken rations in limited degree. It is not used as a commercial hog feed.

This material is rarely used on the ranges. Some attempts to keep molasses available to cattle and dairy cows in open troughs at strategic locations have not been overly successful. The rate of acceptance by the animals has been low; it is difficult to keep the troughs clean; in some cases, fermentation quickly makes the material unacceptable. But, when used as a constituent of a carefully devised ration, in which other materials are used, the feeding values of molasses can be, and in many cases are, fully realized. Such a program requires carefully penned animals. Barn feeding is common with dairy cows and fattening pen practices are used where molasses is incorporated in the feed for beef animals.

The livestock industry in The Sudan presents unusual problems if this method of using the large supply of molasses is contemplated. Cattle

are not pen-fed at present, and the development of a program by which migrating cattle would be assembled at an appropriate age for that operation would be difficult. Despite its evident value in increased rates of gain and improvement in meat quality, the program is contrary to age-old practices.

If necessary, the hypothetical cane sugar company could establish its own beef production enterprise. If this were done, yearling animals would be bought, if possible, from the owners of migrating herds and established in well designed feed lots where molasses in combination with other local feeds, such as locally produced cotton seed meal, dura, chopped lubia, and possibly alfalfa, would be fed.

As has been indicated, it seems doubtful if yearling animals, in sufficient numbers, could be purchased from cattle owners for this purpose. The possibility of expanding the operation of the molasses feeding enterprise to include a breeding herd still remains. This would increase the scope and cost of the activity, but perhaps, due to quality control in the feeders, would be much more profitable. It is evident that a marketing outlet for a large supply of well finished beef would be essential for financial success. The possibility of exporting chilled sides of beef to southern Europe immediately suggests itself.

It should be said at once that the establishing of a beef feeding subsidiary to the hypothetical sugar cane enterprise would be a costly venture. It would also demand competence and experience in the management. It is, however, a logical way of disposing of a large supply of a by-product which, upon accumulation, would prove to be a decided liability. In other areas, such activities have been most profitable.

An exhaustive analysis of such a proposal would be necessary before animal feeding should be considered as a solution to the molasses problem. But the proposal does offer a possible solution.

2. Molasses Fermentation. In Puerto Rico and in the Philippines, large amounts of molasses are profitably used by fermenting them into beverage alcohol. The rum of Puerto Rico is famous. This fermentation process has turned what might be an embarrassing surplus of molasses into a valuable product which enjoys worldwide distribution. Because of the cultural background of the people of The Sudan, the common practice of fermenting molasses into a beverage seems a remote and impractical possibility.

Industrial alcohol, another product of molasses fermentation, is another possibility. The efficient fermentation of the daily yield of molasses from the sugar factory would yield 6650 gallons of 100° proof industrial alcohol. This product has a wide range of uses. In continental United States, it is abundantly and economically obtained from the processing of natural gas.

There may be some opportunity for the exportation of industrial alcohol secured by fermentation of molasses in The Sudan, but its most apparent use in The Sudan is in the form of a fuel additive. A minor adjustment of the carburetor on a motor vehicle permits the addition of significant quantities of industrial alcohol to the gasoline which is used as a fuel. Promising as this use might appear, in view of the necessity of importing gasoline into The Sudan and the consequent outgo of foreign exchange, the alcohol has only 58 per cent of the fuel value of an equal volume of gasoline. Moreover, the production of industrial alcohol, assuming that molasses were available at no cost, would cost £ 0.184 per gallon. Gasoline at Khartoum sold for £ 0.190 per gallon in 1958. There seems to be no economic reason for the

production of industrial alcohol as a fuel additive unless the government feels that the saving in foreign exchange, resulting from curtailed gasoline imports, justifies a subsidy, in some form or other, to the fermentation plant.

The capital investment required for an alcohol distillery adequate to accommodate the molasses from the sugar mill, is given in Table 20. Factors determining the cost of a unit volume of industrial alcohol of 190° proof are given in Table 21.

3. Molasses as a Fuel. Although molasses has a relatively high value as a fuel, it has rarely, if ever, been used as a source of heat on sugar plantations. The abundance and more immediate availability of bagasse has probably contributed to this practice. Moreover, certain modifications of the conventional fire box are necessary, and specially designed burners are required.

But in areas in which significant demands for power outside the mill might be anticipated, the additional fuel value of the molasses should be considered. The hypothetical sugar plantation seems to be such a case.

Here four forty-inch centrifugal pumps are to be installed. It is initially proposed that each be equipped with a 400 horsepower diesel engine. The proposal is that three of them would operate for eight hours a day; the fourth would serve as a standby installation.

If it were possible to increase the generator capacity at the mill to such a degree that the pumps could be operated by electric power, the savings would be great. This possibility should be carefully explored by the mill engineer when the plant is designed. If the bagasse is supplemented with the fuel potential in the molasses, there should be no scarcity of fuel for the increased power requirement.

TABLE 20

CAPITAL COSTS FOR INDUSTRIAL ALCOHOL DISTILLERY

Daily Capacity 3500 Imperial Wine Gallons  
190° Proof Industrial Alcohol

Complete Distillery, including all apparatus, machinery, equipment and distillery buildings, FOB point of origin	£S. 315,000
Transportation to Port Sudan, including packing, freight and insurance	26,500
Transportation by rail to Sennar site	12,000
Erection, including foundations	140,000
Buildings, other than distillery	30,100
Distillery yard, roads, water system and lighting, other than distillery	<u>15,000</u>
Total	538,600
Contingencies, 5% of 538,600	<u>26,930</u>
Total	565,530
Spare parts and materials for maintenance	<u>15,000</u>
Total Capital Requirement	£S 580,530

TABLE 21

FACTORS DETERMINING THE COST OF ONE GALLON  
OF 190° PROOF INDUSTRIAL ALCOHOL  
(First Year of Operation)

Annual Fixed Expenses

Depreciation: 10% of cost of distillery plus contingencies	LS 56,553
Interest on total cost of distillery and spares for first year of operation 1/	<u>29,026</u>
Total fixed expenses for first year	85,579

Operating Expenses

Yearly salaries for personnel	23,925
General administrative overhead	4,000
Costs of materials: ammonium sulfate, ammonium superphosphate, sulphuric acid, lubricants, etc.	5,000
Fuel oil for use during periods in which the sugar mill is idle	7,302
Diesel oil, during periods in which the sugar mill is idle	1,200
Spare parts and maintenance materials	3,000
Workmen's wages (210 days operation)	5,040
Workmen's wages (70 days dead season)	<u>532</u>
Total operating expenses	<u>49,999</u>

TOTAL OPERATING COST LS 135,578

1/ Interest at 5%.

Annual production 190° proof industrial alcohol, 735,400 gallons

Unit Cost of Production LS 0.1844 per gallon

Such a device, if appropriate analysis indicates that molasses may act as an economic fuel supplement, would dispose of the molasses and, at the same time, contribute to the solution of one of the significant operating problems.

The possibility of disposing of the molasses by burning it in the mill furnace deserves serious consideration, whether or not the additional energy is required for pump operation.

## Training and Responsibilities of Supervisory Personnel

In well established sugar cane areas, a program of in-service training provides a steady flow of young men from beginning jobs to positions of responsibility and trust. The local training is often interrupted in the case of exceptional young men to provide intensive full time training in an experimental station devoted to sugar production, or in a laboratory mill. It is interesting to note that these programs have trained men for foreign service in the sugar business.

The proposed sugar industry in The Sudan must face a difficult situation as far as qualified men is concerned for a few years, at least. The most evident solution is to provide for the importation of competent technicians for service in the fields and in the mill. If this can be done, and it should be recognized that the inducements will have to be substantial, a program of internal training can be quickly established and the foreign technicians and supervisors ultimately replaced by local men.

If this scheme is followed, and there seems to be no alternative, supervisors for field operations should be at hand when the first cane is planted. Mill technicians should be on the job when mill erection starts.

### Field Supervisors

Field Superintendent. The occupant of this important position should be a college graduate with undergraduate training in agronomy or soil science or plant physiology. In addition, he must have had several years' experience in sugar cane production. At least five of the years should have been spent as manager or assistant manager of a progressive sugar plantation. It should be understood that such men could only be secured with much difficulty and with substantial inducement. But it may be true that the success of the venture would depend upon the competence of this key figure.

Assistant Field Supervisors. Two experienced assistants to the Field Superintendent should be provided at the beginning of the field operation. These men should have college training and some experience in sugar field operation, but their period of responsible management may be less than that required for the Supervisor. Like the Superintendent, they should be imported from a progressive sugar producing area.

Other imported technicians should include an agricultural engineer and an irrigation engineer.

### Responsibilities and Training of Mill Personnel

Chief Mill Engineer. This important officer must be responsible for the sugar manufacturing processes from the time the cane arrives at the mill until the finished product, sugar, is ready for bagging. He should be a man with a college degree in mechanical or electrical engineering. He must have wide and long experience in the milling of sugar cane and a complete knowledge of sugar house machinery. He should have occupied the position of Chief Engineer in a progressive sugar factory for from three to five years. Such experience will not only equip him with a knowledge of new techniques of sugar milling, but will also give him confidence in organizing, directing and controlling labor.

Superintendent of Fabrication. The Superintendent of Fabrication must be a college graduate with a degree in chemical engineering. In addition, he should have previous experience in sugar house work. This should include responsible work in a sugar mill control laboratory. Here he would become familiar with the application of principles to the methods and problems of sugar manufacture and become acquainted with the details of processes that contribute to the effective operation of the mill.

Assistant Superintendent. The first assistant to the Superintendent should have had experience as a chemist in a sugar mill laboratory. In his position as Assistant Superintendent, he would work an eight-hour shift, and carry all the responsibility of the sugar house.

The three positions described above must be filled with men of competence and experience, otherwise, the sugar house, no matter how modern, or how well designed, will not be successful.

The success or failure of any sugar factory can rest entirely in the hands of these three men.

As has been indicated, the eight positions, five in the field operations and three in the mill, should, at the outset, be filled by experienced men, selected upon the basis of their experience.

Such imported technicians occupy a difficult position in the community. They should be adaptable to the social scene, in addition to being technically competent. They should be able to lead an active life in the area. They should keep themselves informed on community problems and be able to associate with neighbors in a friendly and mutually helpful way.

Valuable as these important technicians may be, steps should be taken to replace them with Sudanese nationals as soon as this can be done without jeopardizing the program.

#### Training of Sudanese Personnel

It is urgently recommended that a number of young men with a reasonable educational background be sent abroad for appropriate training as soon as the sugar producing program has operated long enough to provide the necessary evaluation of the young men who might be candidates for such work.

Some of the young men might well be sent for training in modern, well managed sugar mills; others might serve in the field organizations of a large and productive sugar company. Still others with an adequate educational background might be sent to an American university for graduate or undergraduate work in sugar plantation operations. The University of Puerto Rico and the University of Hawaii would be appropriate for this purpose.

The United States Government, through its ICA program, offers facilities for such training to foreign nationals from selected countries. Such training programs may be either in an appropriate university or in industry.

Another effective device for the training of local personnel in the complicated processes of sugar growing and manufacture is illustrated by a recent undertaking in another Middle Eastern Area.

The Kingdom of Iran recently faced the problems that confront The Republic of The Sudan in its efforts to establish a sugar cane industry for local consumption. In the solution reached in Iran, a foreign, well-equipped sugar corporation was authorized, and will be paid, to establish and operate a plantation of appropriate size in Iran, using proven key personnel from its home area. This authorization is strictly limited with respect to time; when the authority expires, the foreign corporation must withdraw, and the plantation, as a going concern, is to be delivered to the Government of Iran for operation.

One of the strong arguments for such a scheme lies in the requirement that capable young men from Iran will be screened on the new Iranian plantation and the most promising will be trained in the theory and practices of modern sugar production on the modern, well run plantations of the foreign contractor.

When this plan is used, excellent training is provided for young men under ideal circumstances. It should be said, however, that this device for training young men would be a relatively expensive one, for it is a by-product of a costly contractual arrangement between the Iranian government and the foreign corporation.

#### Sugar Cane Varieties

Sugar cane is a broad botanical species. It embraces varieties developed, either naturally or by skilled plant breeders, for a wide array of tropical soil and climatic conditions. Some of these varieties are best suited for humid lowlands, others for hot dry areas where irrigation must be resorted to

and still others to wet mountain slopes where irrigation is unnecessary or unjustifiably expensive. In some cases, varieties have been developed primarily for resistance to disease and insect attack and in others for high sucrose content.

These varieties are carefully maintained in gardens throughout the world. They are carefully catalogued. The greatest American garden is at Canal Point, Florida. Much research in sugar cane genetics, aimed toward improving the varieties currently available, is being done by the U. S. Department of Agriculture at Beltsville, Maryland. Other research stations, both public and private, are engaged in the same work.

Varieties are named in such a way that the originating station, as well as the varietal-cross number given by that station, is evident. These variety numbers are recognized throughout the cane sugar world.

In general, varieties have become well known when, because of their genetical composition, they become important in particular ecological areas. It might be said in passing that only a small percentage of the varieties created by the sugar cane breeder become commercially important.

In a relatively untried area, such as The Republic of The Sudan, a start can best be made with proven varieties from neighboring areas or from areas of similar environment. Selection and local breeding can narrow the choice and provide new varieties better suited to the local situation than any now existing. But it should be said that such a breeding program is costly and time-consuming.

A catalog of appropriate varieties, based upon experiences elsewhere, is given in Table 22.

TABLE 22

POSSIBLE FIRST TRIAL SUGAR CANE VARIETIES

ECOLOGICALLY APPROPRIATE FOR THE SUDAN

<u>Variety</u>	<u>Area in which the Variety Is Commercially Important</u>
azul	Peru
B = Barbados	
B 3404	West Indies
B 37161	West Indies and British Guiana
B 37172	West Indies
B 4098	West Indies
B 41211	West Indies
B 41227	West Indies and British Guiana
B 4362	West Indies
B 4744	West Indies
Co. = Coimbatore, India	
Co. 290	India and Egypt
Co. 301	India
Co. 312	India
Co. 313	India
Co. 331	India
Co. 413	India and Egypt
Co. 419	India
Co. 421	India
Co. 453	India
Co. 513	India
Co. 527	India
CP = Canal Point	
CP 29-116	Louisiana, New South Wales, Philippines
E (Ebene) 1/37	Mauritius
F (Formosa) 180	Formosa
F 134	Formosa
M 134/32	Mauritius
Mayaguez 336	Puerto Rico
N. Co. 310 (N. Co. = Natal Coimbatore)	Natal, Formosa, Louisiana
Pindar	Queensland
POJ 2725	Various countries
POJ 2878	Many countries, including Egypt
POJ 2883	Philippines
POJ 3016	Java, Philippines
POJ 3067	Java
Q 50	Queensland
Trojan	Queensland

Seed cane, in small lots, for these varieties can be secured from the Canal Point variety station. In view of the untried environment in The Sudan, as far as sugar cane is concerned, it is suggested that a wide array of these varieties, and possibly others, be secured and planted in observation and multiplication plots at the location of the proposed plantation. Considerable time is required for seed multiplication. Such a variety garden should be begun as soon as possible after the decision as to location is made.

As has been said, the best local variety may be used as a start. Although a sugar cane planting is a relatively long time enterprise, the varieties can be gradually changed when experience indicates that improved varieties are at hand.

#### Sugar Cane Diseases and Their Control

Sugar cane is attacked by a wide array of pests and diseases, and the difficulties increase as the concentration of plants in a limited area increases. Some of these diseases are caused by bacteria which are dispersed from infected plants by the wind, rain-splash or insects. Others, such as Fiji disease, are caused by a virus. Cercospora rot is an example of a fungus disease. There are many other diseases in each of these categories.

The attention of skilled plant pathologists has been directed toward these diseases for many years. An easy cure for a diseased sugar cane field is rarely, if ever, found. In some cases, the use of fungicides have given some measure of relief; in others, dipping the seed pieces in hot water helps retard the spread of certain infestations. But, in general, the sugar cane industry has maintained itself through an energetic cane breeding program. As a result of this effort, resistant varieties are now available for most of

the serious diseases to which sugar cane is susceptible. There is no end in this attack, for disease organisms can apparently change with time and varieties which are resistant now may not be resistant to the organisms and viruses in the future.

Some of these diseases may be carried in the seed piece and seed imported into a clean area may start an infestation that can be eradicated only with difficulty. Consequently, progressive sugar cane areas insist upon an adequate quarantine for newly imported seed. The seedling areas used to receive such imports are geographically far removed from the commercial area in which the seed is to be planted. Imported seed is usually grown for two years in quarantine before it is released for field use. During this period, the plants are closely inspected by competent sugar cane pathologists. Plants showing disease symptoms are destroyed. When imported varieties are released from quarantine, they are taken to the commercial area and multiplied as rapidly as possible.

The great distributing center for sugar cane varieties at Canal Point, Florida, U. S. A., has excellent quarantine facilities. It may be assumed that varieties released for planting by this station are free from disease.

A sugar cane breeding program is an essential part of any progressive sugar cane growing enterprise. In most cases, the cure for a serious threat by disease has been met by the geneticist who has succeeded in developing a variety which is resistant to it. The pathologist and geneticist form a valuable team in any commercial sugar cane enterprise. The safety of the enterprise may depend upon them.

#### The Need for Sugar Cane Research in The Sudan

In order to maintain a progressive and successful sugar industry, a competent research program in the problems related to management and improvement of sugar production must be established. All industrial enterprises,

whether private or public, have come to realize that they can only maintain their position by establishing a comprehensive research program in the processes of production, manufacturing and distribution. A sugar industry in The Sudan will require the same aggressive, progressive and sound research program as is currently provided for cotton growing. For a maximum rate of development and security, the Sudan Government should immediately initiate a research program in the problems basic to the establishment and maintenance of a sugar industry. This research program should include the following fields of research.

Studies Leading to Improved Varieties. Work should be begun in the development of sugar cane and sugar beet varieties adapted to the environmental conditions in The Sudan. This program would include the introduction of varieties from other countries and the development of new varieties in the local scene by established breeding methods.

Necessary Work in Management. In view of the lack of local experience, research in the cultural management of sugar cane should be included in the program to develop the highest yields at the lowest costs of production. This would include studies in field management, methods of irrigation, the application of fertilizer, weed control, and in harvesting mechanization where feasible.

Mill Control and Improvement. Research should be conducted to improve the methods of milling the sugar cane and the recovery of sugar. This should include studies in quality control.

Proposed Research Station. In order to meet this need, the investigating team recommends the establishment of a research station with its essential laboratories, in the most promising sugar producing area. This station should

devote its entire effort in the investigation of problems of a growing sugar industry in The Sudan. In its beginning, funds for the establishment and operation of the research facility might well come from the Government of The Sudan. After the industry has become established, the research station might well be supported by an assessment on each ton of sugar produced. A general schedule of the projects which should be included in the program of a sugar research station are as follows:

1. Genetics: the breeding and selection of varieties suited to The Sudan, with special reference to necessary disease resistance;
2. Fertilizer Research: the investigation of fertilizer requirements with respect to kinds and amounts for sugar cane or sugar beets in various soil types;
3. Cultural Research: development of new methods of cultivation, planting, and harvesting;
4. Weed Control: investigation in the merits of chemical weed control;
5. Disease Control: development of essential disease control practices and the development of disease resistant varieties;
6. Insect Control: development and establishment of efficient pest and insect control practices;
7. Sugar Technology Research: research program involving the improvement of mill operation and sugar recovery; and
8. Irrigation: research to develop the most economical and efficient irrigation intervals and methods of water distribution.

The staff of this research station should consist of a Director who would be responsible for the coordination of the entire research program. He would also be responsible for the allocation of funds to support each research project. The other professional staff members should include an irrigation engineer, a soil scientist, a sugar crop agronomist, a plant physiologist, a geneticist, an agricultural engineer, an entomologist, a plant pathologist and a sugar technologist. For effective work, this staff must be supplemented with adequate

assistants to insure energetic prosecution and the completion of every approved research project. The senior staff members should be encouraged to participate in the International Sugar Society. The exchange of research findings from other experimental stations of the world is facilitated by this international organization.

The benefits derived by the establishment of a sugar research program are many. First, it is the surest method to secure and maintain a successful sugar industry. Secondly, it will provide a means of solving current problems occurring in the industry; thirdly, it will provide the solution of problems before they arise, such as a disease resistant variety before the disease appears in serious concentration; and, lastly, it will provide a basis for the orderly expansion of the sugar industry.

Need for Sudanese Journal of Agriculture. The development and continued progress of a well planned scientific research program should include facilities for the publication of the research findings. In order to provide for the publication of these scientific findings which should include not only sugar production research, but all fields of agricultural sciences, the Government of The Sudan might well establish a journal for agricultural science. Such a journal would publish articles presenting scientific facts and findings, established by the research programs, in all fields of agricultural science, including sugar crop production. The government might then ask for foreign subscriptions to this journal. In this way, findings of Sudanese scientists would be brought to the attention of scientists of comparable fields of interest throughout the world. This would facilitate the exchange of ideas and materials

which would facilitate and enhance the progress of any research program. The Government of The Sudan could also use the subscription to this journal in exchange for subscriptions for foreign scientific journals, thus providing the Sudanese scientists access to foreign published scientific findings from the entire world without loss of exchange currency.

It is apparent that the Sudan Government has full appreciation of the value of research in its own agricultural and industrial development. We feel that a greater contribution of the Sudanese scientists to world knowledge would enhance and stimulate the progress of agricultural and industrial development.

## CHAPTER VI

### POSSIBILITIES WITH SUGAR BEETS

The possibility of growing sugar beets for The Sudan Sugar Industry was given serious consideration. The reasons are as follows:

1. Sugar beets require a much shorter growing season and for this reason do not require as much irrigation water per feddan per year as sugar cane.
2. The growing of sugar beets would coincide more nearly with the months during which ample water is available on the pump schemes of the lower Nile than does the production of sugar cane.
3. There is similarity in the field operations for sugar beets and cotton.
4. Sugar beets must be rotated with other crops and, therefore, would fit into present rotation schemes. Sugar cane could not do so because of its longer growing season.
5. The by-product sugar beet pulp is an excellent cattle feed and would be available during the short-feed months of April and May.
6. Sugar beets would offer seasonal labor to workers in other agricultural crops without conflicting with them.

#### Temperate Zone Origin of Sugar Beets

Sugar beet culture has been limited to the more temperate climates of Northern and Central Europe and the Northern and Western states of the United States. The crop is grown in several countries, but always where the climate is quite temperate. However, sugar beets are grown in very hot areas of California under irrigation. The chief difference between the California area and The Sudan is the length of day in the two areas and the period of the year

in which the beets are grown. California has winter and spring rains and the beets are grown to fit this season, while in The Sudan, most of the rainfall comes during July and August.

#### The Place of Beets in a Rotation

Sugar beets would fit into present systems of rotation used in The Sudan. Unlike sugar cane, sugar beets cannot be grown successfully by continuous cropping. They can fit into a system of rotation, however, where they can be followed by dura, maize or wheat. They could also be used in a cotton-duralubia rotation. The cultural management of this crop would be similar to cotton in the early stages, since it would be planted, thinned, cultivated, fertilized and irrigated in a similar manner. The point being made is that established and well understood cultural practices will be adequate for sugar beets. The crop would require irrigation in practically the same schedule as that for cotton. Sugar beets are normally grown with frequent irrigation for 4 months. Irrigation is then stopped and the soil allowed to dry out. This practice forces the sugar beets into a ripening process.

#### Sugar Beet Trials in The Sudan

Sugar beets have been grown experimentally in the Barakat area in the Gezira by the Gezira Board. These trials have been largely exploratory to date. Certain facts, however, have been brought out by these preliminary experiments.

1. Yield: The experiments indicate that a fair yield can be obtained on the Gezira soils. These yields cannot be considered as completely satisfactory for commercial operation, but it would appear that they could be increased.

2. Sugar Content: The sugar contents of the beets were low. According to the conclusions of the experimenters, this was not due to inadequate ripening, to improper restriction of irrigation

water, to variety, or to moisture and nutrient deficiencies. The opinion expressed was that day-length was responsible for low sugar content.

It seems doubtful if the experimenters have adequately considered all of the possibilities. The great variation which the experiments suggested between the sugar content of several varieties of beets does not point to length of day as being the only physiological reason for the low sugar content. The extremely vigorous vegetation growth of the beets described in these experiments indicates that the high level of nitrogen in Gezira soils, coupled with high water retention in the sub-soils, might mitigate against the storage of sugar in the beets. Such factors retard the ripening process which is essential to maximum sugar storage in beets.

Another explanation for the low sugar yield in the beets lies in the high rate of inversion of the stored sucrose due to high temperature at the time of harvest. Often chemical process is stimulated by high temperatures and results in the loss of sucrose and the accumulation of non-marketable sugars. This possibility should be carefully explored. If such rapid inversion is involved, the beets should be processed immediately after harvest. The need for fast transport from field to factory is evident.

The Gezira Board has conducted field studies for two seasons on the suitability of sugar beets on the Gezira soils. The experiments established the following facts:

1. The yields of some varieties do approach 20 tons per feddan yields, but were quite variable. The reported range is from 4 to 19.5 tons. It is feasible to obtain the 20-ton yield minimum.
2. The sugar content of beets was very low, ranging from 8 to 14 per cent. There is some question as to possibility of meeting the minimum acceptable sugar content of 16 per cent.

3. Damping off, a fungus disease, limits the growing period. It is impossible to take full advantage of the rains due to presence of this disease. It is difficult, if not impossible, to control this disease in moist alkaline soils. Because of this disease, seeding must be delayed until surface soils are dry. The disease, when present, will always cause variability in yields, other things being equal. Experiments indicate that seeding should be delayed until approximately November 1, to afford protection from fungus attack. This would limit the growing season to 4 months, before beets would have to be thrown into a ripening program for harvest.

4. Sugar beets are hosts to insects and nematodes which could affect cotton, the major cash crop.

5. Even with the listed disadvantages, sugar beet culture could be economical, as the cost of production might be sufficiently low to provide a profitable enterprise. A yield of 2.8 tons of sugar per feddan appears to be feasible.

#### The Diffusion Process in Sugar Extraction

The process used in the recovery of sucrose from sugar beets differs markedly from that used in sugar cane. When cane is being processed, the stick is chopped and pressed between heavy rollers operating under great pressure. The juice carrying the sugar is forced out by mechanical means. The fibrous material, the bagasse, which remains, is a waste product and is normally used for fuel.

Such a treatment is impossible with beets. To prepare beets for processing, the roots are cut into small pieces and these pieces are packed into large diffusion cells. Water is forced back and forth through the beet chip. Sugar stored in the cells in the beet chips is extracted by the process of diffusion. The sugar-bearing water, when the process is completed, is treated to much the same processes that are used in the manufacture of sugar from crude cane juices.

#### Need for Abundant Clean Water

The diffusion process requires a supply of clean water for its successful operation. Well water, such as that found in the Seleim Basin, would be entirely

suitable. An attempt to use river water for this purpose would require the installation of a water cleaning plant.

#### Sugar Beet Pulp as a Livestock Feed

The material remaining in the diffusion cells is a valuable animal feed. It is removed, dried, and made available to livestock men who use it in their feed lot procedures. It normally contributes significantly to the profits of a sugar beet factory.

#### Some Factors in Sugar Beet Culture

As has been indicated, sugar beets are grown in a wide range of temperate zone locations, and varieties have been developed through varietal crosses to satisfy the immediate needs for each location. Which of these many varieties would be best suited to the appropriate areas in The Sudan cannot be determined without field trials.

Samples of beet seed, in an amount suitable for a plot of reasonable size, perhaps 10 meters wide by 50 meters long, should be secured from areas in which sugar beets are grown. It would appear that seed developed in low latitudes would offer the greatest possibilities of success.

It seems highly doubtful that any existing strain or variety would be ideal for The Sudan. Improvement can undoubtedly be made through a local breeding program.

As with sugar cane, a breeding program is a costly activity, but the time required for the making of each crossing and the testing of the progeny is much shorter with sugar beets than with sugar cane. The cost per variety created is consequently much less.

### Harvesting by Machines

Harvesting of the sugar beets should be done with one of the newly devised harvesting machines, designed to loosen the beets and lift them out of the soil. The beets might well be topped by hand in The Sudan, although machines are available. The portion of beet root above the soil has a low sugar content and a high mineral content and must be removed along with the leaves. After topping, the roots are transported as rapidly as possible to the factory for processing.

### Requirements for an Adequate Sugar Beet Location

In the selection of a site for sugar beet production, there are several contributing factors which must be considered. They are:

Acreage Requirements. A successful sugar beet industry in The Sudan would require that the minimum yield of beets would be 20 metric tons per feddan and that the sugar content would be in excess of 16 per cent. This would give a minimum yield of approximately 3 tons recoverable sugar per feddan.

A sugar beet mill with the capacity of handling 2,000 tons of washed beets per day would require 7,000 feddans for a 70-day mill operation, 8,000 feddans for 80-day mill operation, and 9,000 feddans for 90-day mill operation. Preliminary estimates indicate that there is little saving in building a sugar beet processing plant with a capacity of less than 2,000 tons per day. A mill with 500 ton per day capacity would cost approximately 2 million pounds as against 3 million pounds for a mill with a capacity of 2,000 tons of beets per day. If a 1,000 ton sugar beet mill were installed, the area of plantings required would be one half those given for a 2000 tons per day mill.

Area. An economic sugar beet factory will require a minimum of 8,000 feddans of sugar beets per year. This means that an area must be found where

at least 24,000 to 32,000 feddans of tillable land is available to provide for the necessary rotation. Although the entire area does not need to be in a single block, parcels contributing to it should be within a strictly limited distance from the site for the proposed beet sugar plant. What this distance is depends upon the method used to haul the beets to the plant and the costs involved.

Transportation Requirements. Sugar beet roots are a bulky, heavy, perishable commodity which will require rapid and dependable means of transportation to the factory. This includes heavy duty roads within the lands devoted to sugar beet growing and good roads to the factory or to a loading site if rail transportation is involved. If 8,000 feddans of sugar beets are grown, the harvest would involve a minimum need for the transportation of 160,000 tons of sugar beets. If trucks, with a capacity of 5 tons per load are used, 32,000 truck loads would be required to transport the sugar beets to factory or railroad. Since the factory would require 2,000 tons of sugar beets per day, 400 truck loads per day would be required. The actual number of trucks needed for the operation cannot be determined until the area is specified. If trucks are used to transport beets to the factory, first class main roads must be established and maintained. Good secondary roads would be required to provide ready access points for loading the grower's sugar beets. Since sugar beets must be considered as a perishable crop, once they are removed from the ground, field roads would be required to facilitate the rapid movement of the crop from the field to the factory in an orderly fashion. Sugar beets must be processed within 48 to 72 hours in a hot climate. Fast movement is imperative.

Since the proposed sugar beet industry would probably be integrated into an existing agricultural crop management system, it is probable that the

sugar beets would be grown in geographically separated areas. The beets could then be loaded in railroad cars, if a rail line exists, and shipped to a factory located at a central point. If this is done, the railroad would have to have the facilities to move the beets promptly from their loading points at the daily rate of 100 wagons carrying 20 tons of sugar beets. This would require at least 400 wagons on the following basis: 100 wagons at factory being unloaded; 100 wagons in transit, loaded with the next day's factory requirement; 100 empty wagons in transit to loading points, and 100 wagons being loaded with the third day's tonnage requirement. If we assume train loads of 400 tons, the railroad would have to provide 5 round trip train movements daily to move the empty cars to the field loading points and for the movement of loaded cars to the factory. This would require 5 locomotives and 5 train crews daily. All of these are minimum requirements and assume almost perfect performance on the part of the railroad. A safety margin would require at least a third more equipment to insure an adequate movement of sugar beets to the factory and the maintenance of a supply at the factory.

Since the grower will probably be unable to purchase the trucks (transports), it will be necessary for the factory to be responsible for the entire movement of the sugar beets to factory. The investment in trucks may be reduced by extending feeder railroad tracks into the area on a temporary to permanent basis. The trucks would then concentrate on the pick-up of sugar beets in the field and the movement over short distances to these branch railroads. The movement of rail wagons, from branch railroads to main rail pick-up points, might be done by rubber wheeled tractors. The loading on railroad wagons might well be by mechanical loaders at the railroad loading point. In areas where no railroad exists, the entire movement of sugar beets to factory would,

of necessity, be by truck transport. This could only be feasible in an area where the distance to the factory is relatively short. To make this practical, the 24,000 to 32,000 feddans or more would have to be in one solid area of about 50 square miles.

#### Soil Requirements

Sugar beets are adapted to slightly acid to alkaline soils. They are very salt-tolerant due to the fact that they need sodium in their nutrition. While sugar beets will grow on the very alkaline cracking clays, they will do far better on the more friable neutral silt soils found along the Nile River. The damping off fungus is far more severe in its attack on wet alkaline soils such as the Gezira soils. Since it will be a rotation crop in a minimum area of 24,000 to 32,000 feddans, it is essential that every feddan of the area be irrigable.

#### Labor Requirements

The labor requirement for the field culture of sugar beets is practically the same as that for cotton. The assumption is that the tenants would prepare the land, fertilize, seed and cultivate, using practically the same methods as are employed for cotton culture. The harvest season for sugar beets would follow the cotton harvest season, thus, the labor force available for the entire field operations should be adequate when those operations are incorporated into present systems.

The location of the sugar mill should be at a site convenient to the field area and at a point where a supply of labor would be available. In case of the areas served by a railroad, the mill might be some distance away from the sugar beet fields. In such a case, the location of mill could take full advantage of the local supply of labor, especially technical labor.

## Potential Areas for Sugar Beet Production

Aliab-Mutmir Area, Northern Province. This area was considered to be the best potential area for an initial sugar beet venture. The soils are ideally suited for sugar beets. They are mostly alluvial silt loams and silty clay loams. The following factors make this area an excellent one for the first trial sugar beet industry in The Sudan:

1. Excellent friable soils are well adapted to the growing of sugar beets.
2. The soils are adequately dry, so that beets can be seeded during the last week of September.
3. Damping off disease would not be severe, due to the possibility of keeping a dry soil.
4. The area lies adjacent to the railroad line. Thus, sugar beets could be grown in smaller areas scattered from Shendi to Atbara and shipped by rail to the factory.
5. Adequate labor is available for field harvest of beets because that harvest follows the harvesting of other agricultural crops in the area.
6. The 9,000 feddans necessary for a sugar beet enterprise can be obtained by adding new areas and adjacent areas to existing schemes and through modification of rotation systems throughout the entire area, from Shendi to Atbara.
7. There is a serious shortage of livestock feed during April, May and June. Sugar beets would relieve this shortage by first providing fodder from the tops and secondly by the sugar beet pulp produced in the factory. This is an excellent feed. This could either be sold or returned free to the growers for their livestock.

Experiments should be initiated at once to determine whether or not sugar beets grown in this area will meet the minimum yields in tons of beets and sugar contents which are essential to a successful development of a sugar beet industry in The Sudan.

The Seleim Area. This area has the compactness of available, suitable land essential to the possible development of a sugar beet industry in a region having serious transportation difficulties. All supplies required by the factory and all shipments of sugar to market would depend on river transportation to and from Kareima where it would connect with the railroad system.

All sugar beets grown in this area would have to be transported to the factory by trucks. This area is compact and of the required size. This would minimize the distance which trucks would travel in hauling sugar beets to the factory.

The soils in most of the Seleim-Borgeig areas are well suited to sugar beet culture. They consist of silts and silty clay loams of present flood plains and basin areas. An additional area lying to east has a shallow layer of wind blown sand over Seleim silty clay soils. The latter soils will permit the growth of sugar beets if an adequate supply of water can be supplied by deep wells. Wind breaks should be planted to protect sugar beets from the ravages of desert sand storms.

The main disadvantage of this area lies in its long distance from the market and the difficult transportation systems used in getting sugar to market. On the other hand, this area needs an industry to provide an outlet for its surplus labor and a crop which will bring an additional cash income to the area. Sugar beets seem ideal for this purpose.

At present, a portion of this labor supply in this area tends to migrate to and seek employment in a neighboring country. Thus, The Sudan government, in sponsoring a sugar beet industry in this area, might find itself in a position where it would be willing to encourage a marginal economic venture for social reasons.

For example, such an industry would enhance the greater exploitation of the overall agricultural potential by providing outlets for horticultural crops through the medium of fruit processing. Mangoes, for instance, grow well along the Nile River. Canned mangoes could be processed for the domestic and the European markets. The fruit processed from 300 feddans of full bearing mango trees would require 2,000 tons of sugar. The production of jams from fruits and the pickling of cucumbers would make it possible to utilize the sugar from a sugar factory in this area.

It is recommended that experiments be conducted to determine the adaptation of sugar beets to this area. If such trials prove successful, it is suggested that, in the total planning for this area, consideration should be given toward the inclusion of sugar beets to promote the maximum development of the Northern Province.

#### Cost of Production

The cost of producing sugar from sugar beets has been given preliminary study. The cost of field production, based upon hypothetical yield of 3.0 tons of sugar per feddan, was found to be £S 21 per ton of sugar. The cost of recovering the sugar, upon the assumption that the beets would carry 16.0 per cent recoverable sugar, was £S 14 per ton of sugar. The total cost was £S 35 per ton of sugar produced, or 1.59 piastres per pound of sugar. These preliminary figures for the estimated cost of production indicate that, if commercial plantings can attain the minimum yield and sugar content which have been specified, a sugar beet industry would be justified. The cost of producing sugar beets will be comparable to that of sugar produced from sugar cane, if the minimum requirements can be met.

## Recommendations with Respect to Sugar Beets

The first step in the development of a sugar beet enterprise should be the immediate installation of variety trials in a promising location, preferably the Aliab-Mutmir area in the Northern Province. Concurrent studies of the rates of sugar inversion in sugar beets under the climatic conditions in the same locality should be undertaken. If the results of these trials indicate that the yields in tons of sugar beets per acre and the recoverable sugar in each ton of sugar beets delivered at the proposed factory site meet or exceed those suggested, detailed plans for a sugar beet enterprise in The Sudan should be prepared. It has been suggested that a yield of 20 tons of beets per feddan and a sucrose percentage of 16.0 per cent at the factory should be required for the economic security of the venture.

If trials of this sort at Aliab-Mutmir are successful, the possibilities in the Seleim Basin should be explored.

If a sugar beet industry is established, it is suggested that a contract be made between the sugar beet factory and the growers (tenants) which would specify the cultural practices to be utilized by the grower. This should include details with respect to the preparation of land, provision for seed and fertilizer, the methods of applying them to the soil, and the irrigation program to be followed. In addition, the contract should establish a base price for the sugar beets based on a minimum sugar content. A bonus should be added to this base price for sugar content above the minimum. This can be on a sliding scale so as to reward the good grower for his good husbandry. It should be said that this is standard practice in progressive sugar beet areas. The final return paid to the grower will have all advances to the grower for seed, fertilizers, transportation and other approved items deducted from it. This may include the

requirement that the grower accepts the factory pulp as a livestock feed at a nominal charge to cover the cost of returning it to him.

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APPENDIX I

TABLES RELATING TO THE ECONOMICS

OF THE REPUBLIC OF THE SUDAN

TABLE 23

## GEOGRAPHICAL PATTERN OF TRADE, 1953-1957

(Value in Millions of Sudanese Pounds)

Country	1953		1954		1955		1956		1957	
	Value	%	Value	%	Value	%	Value	%	Value	%
	SOURCE OF IMPORTS									
United Kingdom	21.1	41.5	15.7	32.5	14.7	30.6	12.5	27.6	16.7	26.5
India	4.0	7.8	5.7	11.8	15.3	10.9	15.5	12.2	7.5	12.0
Egypt	4.2	8.3	5.0	10.4	5.5	11.3	6.3	13.6	4.6	7.4
Japan	--	--	0.2	0.4	1.7	3.5	1.0	2.4	3.5	5.5
Federal Republic of Germany	2.7	5.3	2.3	4.7	2.0	4.1	1.7	3.9	4.5	7.1
Netherlands	1.8	3.7	1.9	3.9	1.1	2.2	1.2	2.7	1.3	2.1
USA	1.3	2.6	0.9	1.8	1.1	2.2	1.0	2.2	2.1	3.3
Italy	3.0	5.9	2.4	4.9	1.5	3.0	1.5	3.4	2.4	3.8
Czechoslovakia	0.8	1.6	1.2	2.5	0.6	1.3	1.7	3.7	1.3	2.0
Uganda	0.3	0.7	0.6	1.2	1.0	2.1	1.1	2.6	1.2	1.9
Australia	0.4	0.7	0.3	0.6	0.7	1.5	0.7	1.7	1.0	1.5
France	1.3	2.6	1.3	2.6	1.8	3.7	0.9	2.0	1.0	1.6
Other	9.9	19.3	11.0	22.7	11.8	23.6	10.1	22.0	15.9	25.3
TOTAL	50.8	100.0	48.5	100.0	48.8	100.0	45.2	100.0	63.0	100.0
	DESTINATION OF EXPORTS									
United Kingdom	18.0	41.9	16.8	43.1	13.8	28.3	22.0	33.4	10.6	22.1
Egypt	2.3	5.5	3.4	8.7	4.8	9.8	7.4	11.2	7.7	16.8
India	5.6	13.1	1.7	4.4	7.3	15.0	8.8	13.5	5.3	11.6
Italy	2.7	6.2	3.1	7.9	4.7	9.6	5.8	8.7	4.3	9.3
France	2.9	6.9	2.2	5.7	4.6	9.5	3.2	4.8	3.5	7.8
Federal Republic of Germany	4.7	10.8	2.5	6.6	4.1	8.5	4.7	7.1	2.3	5.1
Saudi Arabia	0.6	1.4	0.6	1.7	0.3	0.6	1.0	1.5	1.3	2.7
USA	1.1	2.5	1.5	3.8	1.2	2.4	1.4	2.2	1.2	2.7
Netherlands	--	3.5	1.6	4.1	1.1	2.2	1.4	2.0	1.3	2.9
Japan	0.2	0.5	0.2	0.5	0.4	0.8	1.8	2.7	0.7	1.4
Other	4.9	7.7	5.3	13.5	6.5	13.3	9.3	12.9	9.9	17.6
TOTAL	43.0	100.0	38.9	100.0	48.8	100.0	66.8	100.0	48.1	100.0

Source: "Foreign Trade and Internal Statistics", The Republic of The Sudan, January 1958.  
 "Annual Foreign Trade Report for 1955" and "1956".

TABLE 24

## BALANCE OF TRADE 1948-1957

(Thousands of Sudanese Pounds)

Year	Imports (1)	Exports and Re-exports			Total 1/ Exports 2 + 3 + 4 (5)	Balance 5 - 1
		Cotton (2)	Other (3)	Re-exports (4)		
1948	22,408	16,016	7,234	629	23,879	1,471
1949	23,870	19,022	7,413	1,001	27,436	3,566
1950	27,056	22,868	9,214	1,031	33,113	6,057
1951	41,966	47,450	14,708	1,741	62,778	20,812
1952	61,696	28,967	12,198	1,606	42,771	-18,925
1953	50,776	26,753	16,285	1,381	44,419	-6,357
1954	48,490	21,681	17,221	1,493	40,395	-8,095
1955	43,804	30,122	13,779	2,473	51,374	2,570
1956	45,248	41,691	23,650	1,448	66,789	21,541
1957	62,987	21,247	24,335	2,551	48,133	-14,854

1/ Prior to 1953, export values were recorded free along ship (f.a.s.). This did not include export duties, profit of exporters, quay dues and handling charges at the port. Since 1953, however, export values are f.o.b., but are still exclusive of exporters' profits. It is officially estimated that f.o.b. figures are on the average 10 per cent higher than f.a.s. values. An informal estimate by Gorgis Marzouk in his Sudan's Balance of Payments, 1938-53, puts it at 16%.

Source: "Annual Foreign Trade Reports", The Republic of The Sudan (Ministry of Social Affairs, Department of Statistics).

**VALUE OF EXPORTS BY MAJOR COMMODITY GROUP AND PRINCIPAL COMMODITIES**  
 (Thousands of Sudanese Pounds), 1954-1957

Commodity	Year			
	1954	1955	1956	1957
Food Products, Beverages and Tobacco	4,085	2,962	3,625	4,587
Live Animals	(1,178)	(914)	(1,520)	(1,908)
Meat and Meat Preparations	(383)	(203)	(128)	(123)
Salted Fish	(133)	(137)	(110)	(135)
Cereals, Largely Dura and Maize	(1,310)	(279)	(584)	(1,409)
Dates	(257)	(262)	(295)	(272)
Vegetables, Largely Beans	(672)	(966)	(742)	(560)
Chilies	(109)	(142)	(191)	(126)
Animal Feeding Stuffs	972	994	968	807
Cotton and Oil Cake	(456)	(292)	(524)	(465)
Sesame Oil Cake	(349)	(401)	(286)	(286)
Oil Seeds, Nuts and Kernels	6,306	7,924	11,367	12,252
Groundnuts	(1,144)	(2,388)	(3,788)	(263)
Groundnuts Shelled	--	--	--	(4,101)
Cotton Seed, Sakel	(2,695)	(2,459)	(4,253)	(4,540)
Cotton Seed American	(275)	(523)	(422)	(445)
Sesame	(1,530)	(1,794)	(2,050)	(2,632)
Fats and Oils, Animal and Vegetable, and Waxes	522	501	636	727
Cotton Seed Oil	(438)	(387)	(441)	(662)
Groundnut Oil	(26)	(43)	(100)	b/
Chemicals and Fertilizers	8	9	8	11
Wood, Cork and Manufactures	a/	a/	1	a/
Hides, Skins and Leather	1,142	995	1,076	980
Textile Materials	21,684	30,367	41,702	21,262
Ginned Sakel Cotton	(18,131)	(26,702)	(38,587)	(19,639)
American Rain Grown	(2,987)	(3,139)	(2,391)	(1,401)
American Irrigated	(345)	(276)	(489)	(112)
Ginned Scarto Cotton	(217)	(238)	(224)	(95)
Textile Products	2	4	10	8
Common Salt	37	58	60	63
Cement	36	51	57	1
Manganese	--	--	63	74
Miscellaneous	4,077	4,939	5,716	4,752
Mother of Pearl	(33)	(39)	(86)	(47)
Trochans Shell	(109)	(27)	(147)	(68)
Raw Ivory	(10)	(5)	(11)	(6)
Sinna	(55)	(35)	(30)	(44)
Gum Arabic	(3,633)	(4,680)	(5,368)	(4,488)
Miscellaneous Manufactured Items	8	8	12	7
Returned Goods and Special Transactions	22	19	29	33
Gold Metal and Specie	1	5	11	13
Total Domestic Exports	38,902	48,836	65,341	45,582
Reexports	1,493	1,673	1,448	2,551
Total All Exports	40,395	50,509	66,789	48,133

a/ Less than £ 500.

b/ Not shown separately.

Source: 1956 and 1957 "Foreign Trade and Internal Statistics",  
 The Republic of The Sudan, January 1958.  
 1954 and 1955 "Annual Foreign Trade Report", The  
 Republic of The Sudan, 1956.

TABLE 26

## VALUE OF IMPORTS BY MAJOR COMMODITY GROUP AND PRINCIPAL COMMODITIES

(Thousands of Sudanese Pounds)

1954-1957

Commodity	Year			
	1954	1955	1956	1957
Food Products, Beverages, Tobacco	13,815	12,995	12,083	16,183
Coffee	(1,878)	(1,508)	(1,921) <sup>c/</sup>	(2,052) <sup>c/</sup>
Tea	(3,545)	(3,174)	(1,731) <sup>d/</sup>	(2,782) <sup>d/</sup>
Wheat Flour	(1,324)	(1,732)	(1,318) <sup>a/</sup>	(2,047) <sup>a/</sup>
Sugar	(3,654)	(3,200)	(4,638) <sup>b/</sup>	(5,779) <sup>b/</sup>
Tobacco	(749)	(707)	(680)	(715)
Fats and Waxes, Animal and Vegetable	212	204	328	789
Chemicals and Pharmaceuticals	2,262	3,249	2,595	3,645
Soap	(404)	(512)	(194)	(122)
Fertilizers	(442)	(979)	(908)	(1,361)
Rubber and Manufactures <sup>c/</sup>	489	664	623	734
Wood, Cork and Manufactures <sup>f/</sup>	954	1,052	1,101	1,422
Pulp, Paper and Cardboard Manufacturers	366	442	491	909
Hides, Skins and Leather	94	90	60	92
Textiles	8,769	8,779	8,747	10,925
Artificial Silk Piece Goods	(1,628)	(1,713)	(1,788)	(2,134)
Piece Goods of Artificial Silk and Cotton	(798)	(581)	(511)	(446)
Woolen Piece Goods	(101)	(134)	(69)	(255)
Grey Cotton Piece Goods	(2,551)	(2,526)	(2,896)	(3,192)
Cotton Piece Goods Bleached	(1,229)	(1,393)	(1,224)	(1,769)
Cotton Piece Goods Dyed	(1,052)	(941)	(797)	(966)
Cotton Piece Goods Printed	(270)	(194)	(311)	(220)
Clothing and Made-Up Textiles	2,437	3,047	3,058	3,790
Products for Heating, Power and Lubricants	3,101	3,421	3,490	4,608
Non-Metallic Minerals	1,282	797	807	1,612
Base Metals and Manufacturers	5,271	4,032	3,071	5,327
Machinery, Apparatus, Vehicles	7,221	8,257	6,946	11,087
Miscellaneous	2,217	1,773	1,848	1,863
Total	48,490	48,802	45,248	62,936

<sup>a/</sup> Largely from Australia and the Federal Republic of Germany.<sup>b/</sup> Largely from U. K., Taiwan and France.<sup>c/</sup> Largely from Uganda, Belgian Congo and Ethiopia.<sup>d/</sup> Largely from Ceylon, India and Indonesia.<sup>e/</sup> Largely from Tiris and Tubis.<sup>f/</sup> Almost entirely Miniber.Source: 1956 and 1957 "Foreign Trade and Internal Statistics",  
The Republic of The Sudan, January 1958.1954 and 1955 "Annual Foreign Trade Report", The Republic  
of The Sudan, 1956.

TABLE 27  
BANKING STATISTICS  
(Thousands of Sudanese Pounds)

Date	Government Deposits			Other Deposits			Total Deposits	Loans and Advances Discounted, Negotiated, Etc.	Percent Loans and Advances Are of Total Deposits
	Current Accounts	Deposit Accounts	Total	Current Accounts	Deposit Accounts	Total			
December 31, 1953	1,688	--	1,688	10,994	2,864	13,858	15,546	8,801	56.6
December 31, 1954	1,118	6,500	7,618	14,072	2,939	17,011	24,629	18,741	76.1
December 31, 1955	3,266	9,000	12,266	15,901	3,072	18,973	31,239	22,289	71.3
December 31, 1956	2,727	2,500	5,227	20,262	4,625	24,887	30,114	22,957	76.2
December 31, 1957	3,342	6,500	9,842	15,080	5,404	20,564	30,406	26,331	86.6
March 31, 1956	1,712	8,500	10,212	16,963	4,932	21,895	32,107	22,118	68.9
June 30, 1956	4,575	5,000	9,575	20,930	5,483	26,413	35,988	24,632	68.4
September 30, 1956	2,488	6,000	8,488	17,039	5,022	22,111	30,599	20,814	68.0
December 31, 1956	2,727	2,500	5,227	20,262	4,625	24,887	30,114	22,957	76.2
March 31, 1957	2,494	8,000	10,494	14,197	4,497	18,694	29,183	23,340	80.0
June 30, 1957	5,061	--	5,061	18,926	4,687	23,613	28,674	26,589	92.7
September 30, 1957	4,298	5,168	9,466	14,743	4,731	19,474	28,940	24,141	83.4
December 31, 1957	3,342	6,500	9,842	15,080	5,404	20,564	30,406	26,331	86.6
March 31, 1958	3,010	4,500	7,510	18,778	5,925	24,703	32,213	29,334	91.1
June 30, 1958	1,948	2,500	4,448	17,963	5,817	23,780	28,228	27,986	99.1

Source: "Foreign Trade and Internal Statistics", The Republic of The Sudan, (Department of Statistics, Ministry of Social Affairs), January 1958 and August 1958.

APPENDIX II

DETAILS OF CAPITAL REQUIREMENTS FOR FIELD OPERATIONS, TABLE 28

BUILDING REQUIREMENTS OTHER THAN FACTORY FOR EFFECTIVE  
MILL OPERATION, TABLE 29

UNIT OPERATION COSTS IN SUGAR CANE PRODUCTION,  
SENNAR AREA, TABLE 30

MILL MANNING DURING GRINDING SEASON, TABLE 31

MILL MANNING DURING DEAD SEASON, TABLE 32

TABLE 28

DETAILS OF CAPITAL REQUIREMENTS FOR FIELD OPERATIONS

	<u>Total Cost</u>
<b>A. Buildings and Houses</b>	
8 houses for technicians	20,000
25 houses, 5 rooms, for chief farmers	20,000
1 office building	6,400
192 houses, 5 rooms, for temporary imported labor, each room houses 2 workmen <u>1/</u>	153,600
200 houses, 4 rooms, for families <u>1/</u>	140,000
4 stores for general goods	6,000
Total cost of buildings	346,000
<b>B. Field Equipment</b>	
2 Caterpillar D8 tractors with #25 double drum control	29,638
1 Fleco model #8 tool bar S/NTB 135 with sheave blocks and Fleco AF8 "A" Frame S/NAF 249	1,200
1 Fleco root rake for D8, 10 tooth, 5 top guards; 10 plain blade shoes	1,100
1 SA Angle-Dozer	1,766
1 Root cutter, V-knives with coulter	1,063
2 Heavy duty cab guard	332
9 furrowers	1,350
4 sets hoeing discs	680
4 high clearance wheel tractors, 3 point hitch	4,800
1 Weklust ditching plow, GP 2	2,050
1 Weklust ditching plow, GP 1	1,200
1 Rome 10 x 36" plow	2,000
8 Caterpillar D4 tractors	44,800
8 Thompson cane loaders machines	32,000
9 4-wheel traction tractors, 3 point hitch	14,625
120 rubber tires, steel cane carts, 4' high, 5' wide at bottom, 7' wide at top, 12' long	54,000
1 work shop, equipped with mechanic's tools, including repair parts	28,866
10 transfer cranes	7,000
trucks	10,000
6 fertilizer machines	460
Total field equipment	238,930
<b>C. Railroad Equipment</b>	
4 locomotives	41,800
15 kms of railroad	52,260
60 wagons, 15 ton capacity each	104,520
Total railroad equipment	198,580

APPENDIX II

Table 28 continued:

D. <u>Roads and Telephone Lines</u>	LS	20,000
E. <u>Irrigation Pumps</u>		144,000
F. <u>Main Canal</u>		16,800
G. <u>Deforestation and Clearing</u> 11,250 feddans		31,500
H. <u>Contingency</u> 15% of LS 995,810		<u>149,371</u>
I. <u>Total Capital Cost</u>	LS	1,145,181
	Say LS	1,150,000

TABLE 29

BUILDING REQUIREMENTS OTHER THAN THE FACTORY  
FOR EFFECTIVE MILL OPERATION

Main Office	LS	10,450
Guest House		5,225
Manager's House		5,225
Chief Engineer's House		2,825
Superintendent of Fabrication's House		2,825
Assistant Chief Engineer's House		2,250
Assistant Superintendent of Fabrication's House		2,250
3 Shift Assistants to Chief Engineer's Houses		3,500
3 Shift Assistants to Superintendent of Fabrication's Houses		3,500
Accountant's House		2,250
15 Duplex Houses for Specialized Personnel		25,000
15 Houses of 4 Dwellings Each for Married Workmen		10,000
25 Houses of 5 Dwellings Each for Unmarried Workmen		18,000
General Store		7,000
Small Hospital		<u>5,225</u>
	LS	105,525

TABLE 30

## UNIT OPERATION COSTS IN SUGAR CANE PRODUCTION, SENGHAR AREA

Operation	Tools and Methods and Rates of Performance	Costs per Feddan		
		1st Year	2nd Year	3rd Year
Deforesting and Clearing of Land	Area to be cleared is 15 Fs/day, using two shifts with the same tractor. Work to be done by Caterpillar D3 tractor with root rake attachments (1) (2) (3), 2 shifts.	.947	.947	.947
Clearing of Deforested Land	Cost LS 6,000/day, area cleared = 6 feddans (1) (2) (3)	1.000	1.000	1.000
Preparation of Fields	(a) Clearing of roots done by Caterpillar D3 and V-Knives with coulter attachment, output 17.5 Fs/day (1) (2) (3), 2 shifts.	.813	.813	.813
	(b) Ploughing is done by Caterpillar D3 tractor and a Rome 10 x 36" disc plough, output is 17.5 Fs/day (1) (2) (3), 2 shifts.	.813	.813	.813
Burrowing	One tractor operator does 3 Fs/day. Use 2 shifts, 3 crews/day--(1) (2) (3).	.334	.334	.334
Making Canals	Caterpillar D3 and ARUKX ditching machine (1) (2) (3)	.323	.323	.323
Planting of Cane	50 Feddans daily, 2 shifts/day at 5 Fedds. 5 crew. One tractor operator and 7 workmen (1) (2) (3).	.939	.939	.939
Covering of Planted Cane	One tractor operator. Use 2 shifts and 3 crews, output 40 Feddans/day (1) (2) (3)	.305	.305	.305
Cost of Fertilizer	431 Kgs. sulfate of ammonia 20.5% N2 LS 8.62 114 Kgs. triple super phosphate 45% P2O5 LS 3.53 159 Kgs. sulfate of potash 40% K2O5 LS 3.97 = LS 16.120	16.120	16.120	16.120
First Application of Fertilizer	Output 15 Fs/day, 3 crews, (1) (2) (3)	.206	.206	.206
Second Application of Fertilizer	(1) (2) (3)	.206	.206	.206
Application of Insecticide	Cost of insecticide included.	.850	.850	.850
Irrigation	2 Feddans/day/ran at 20 P/day, applying 15 waterings (1)	1.500	1.500	1.500
Irrigation	Cost of running pumps	.980	.980	.980
Hoeings	3 hoeings/Feddan at LS 0.305 per hoeing, using wheel tractor and hoeing discs, (1) (2) (3)	.915	.915	.915
Harvesting Expenses	(a) Cutting of sugar cane: one man cuts one ton/day at 20P/day; 1st year = 47.5 tons/Feddan; 2nd year = 39.4 T/Fed.; 3rd year = 35 T/Fed. (1) (2) (3)	9.500	7.880	7.000
	(b) Loading of cane into rubber tire cane carts is done by loading machine; transport to transfer crane included.	2.123	2.059	2.059
	(c) Transportation of cane from transfer crane to sugar mill storage yard by railroad, 5P/ton/mile: 1st year = (47.5 x 5 x 3) 2nd year = (39.4 x 5 x 3), average distance from cane field to factory = 3 miles 3rd year = (35.0 x 5 x 3)	7.125	5.910	5.250

Note: 4600 feddans for first year  
6600 Feddans for second year  
9000 Feddans for third year

TABLE 31

MILL MANNING DURING GRINDING SEASONRailroad Cane Yard

3 Foremen  
3 Locomotive Drivers  
6 Locomotive Drivers' Helpers  
9 General Workmen

Handling Cane at Mill Cane Yard

3 Foremen  
3 Tilting Table Operators  
6 Helpers  
2 Hammer-head Crane Operators  
2 Feed Table Operators  
15 Laborers

Cane Weighing Scales

3 Weighers  
3 Helpers

Mill Tandem

3 Auxiliary Cane Carrier Operators  
3 Main Cane Carrier Operators  
3 Mechanics  
3 Mill Turbine Operators  
3 Oilers  
9 Juice Pan Attendants  
3 Raw Juice Pump Attendants  
6 Workmen (General)

Boilers

3 Feed Water Attendants  
3 Firemen  
6 Firemen Helpers  
3 Bagasse Feeder Attendants  
3 Feed Water, Induced and Draft Fan, Attendants  
12 Men for Bagasse Storage and Handling

Raw Juice Scales

3 Weighers

Juice Heaters, Sulpho-Defecation, Sulphur Burners, Clarification, etc.

3 Workmen  
6 Workmen  
15 Laborers

Evaporation

3 Evaporator Operators  
3 Helpers  
6 Laborers

Vacuum Pans

6 Sugar Boiler's Helpers

Syrup and Molasses Tanks

6 Attendants

Crystallizers

6 Attendants

Centrifugals

6 Centrifugal Operators  
3 Auxiliary Mechanics  
3 Oilers  
3 Pump Attendants

Dryers and Sugar Elevators

3 Operators  
6 Helpers

Bagging and Weighing

3 Sugar Weighers  
3 Operators Bag Sewing Machine  
6 Helpers

Sugar Warehouse

3 Foremen  
3 Operators, Main Sugar Bag Conveyor  
6 Operators Auxiliary Conveyors  
12 Workers Stacking Sugar Bags

Power Plant

3 Turbo-Alternators Operators  
3 Helpers  
3 Electricians (General Maintenance Work)  
3 Helpers

General Factory Pumps

9 Attendants

Water Treatment Plant

3 Attendants  
3 Helpers  
6 Laborers

Factory Spares and Materials Warehouse

3 Men  
5 Men

Laboratory

3 Analysts  
6 Analysts' Helpers  
9 Men for Taking Samples to the Laboratory

Timekeepers

6 Timekeepers

Factory Machine Shop

1 Blacksmith  
2 Carpenters  
4 Helpers  
6 General Workmen

Repairs to Wagons

2 Auxiliary Mechanics  
1 Blacksmith  
4 Helpers

Field Railway Maintenance

1 Foreman  
1 Assistant Foreman  
8 Laborers

Sundry Jobs, Watermen, Gardeners, Sweepers, etc., for Factory and Grounds

6 Men  
9 Men  
15 Men

TABLE 32  
MILL MANNING DURING DEAD SEASON

Cane Handling Equipment (Tilting Table, Hammer-head  
Crane, Cane Carriers, Knives, Feed Table, etc.)

2 Men  
3 Men  
3 Men

Mill Tandem

2 Mechanics  
3 Helpers  
4 Workmen

Boilers

3 Bricklayers (for General Furnace Repairs)  
2 Auxiliary Mechanics  
2 Helpers  
5 Workmen

Heating, Sulpho-Defecation, and Clarification Department

2 Men  
3 Men  
3 Men

Sugar Boiling Department (Including Evaporators, Vacuum  
Pans, Syrup and Molasses Tanks, etc.)

2 Auxiliary Mechanics  
2 Helpers  
4 Workmen

Centrifugals Department (Including Centrifugals, Sugar  
Elevators, Dryers, etc.)

3 Auxiliary Mechanics  
3 Helpers  
4 Workmen

Pumps

2 Auxiliary Mechanics  
2 Helpers  
2 Workmen

Power Plant Department (Including Motors,  
Lighting System, etc.)

3 Electricians (General Maintenance Work)  
3 Helpers

Machine Shop (Main Factory)

1 Blacksmith  
2 Carpenters  
2 Helpers for Welders  
2 Helpers for Machine Tool Operators  
4 General Workmen

Railway Equipment Repair Shop (Cane Wagons, etc.)

2 Auxiliary Mechanics  
1 Blacksmith  
5 Helpers

Field Railway Maintenance

1 Foreman  
1 Assistant Foreman  
6 Laborers

Timekeepers

3 Timekeepers

Sundry Jobs (Watchmen, Gardeners, Sweepers, etc.  
for Factory and Grounds

3 Men  
6 Men  
15 Men

APPENDIX III

GOVERNMENT POLICY TOWARDS THE ENCOURAGEMENT  
OF LOCAL AND FOREIGN CAPITAL IN THE FIELD OF INDUSTRY  
AND ITS ATTITUDE TOWARDS FOREIGN CAPITAL IN GENERAL

THE REPUBLIC OF THE SUDAN

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GOVERNMENT POLICY  
TOWARDS THE ENCOURAGEMENT OF  
LOCAL AND FOREIGN CAPITAL IN THE  
FIELD OF INDUSTRY AND ITS ATTITUDE  
TOWARDS FOREIGN CAPITAL IN GENERAL

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-1-

GOVERNMENT POLICY TOWARDS THE  
ENCOURAGEMENT OF LOCAL AND FOREIGN CAPITAL  
IN THE FIELD OF INDUSTRY AND ITS ATTITUDE  
TOWARDS FOREIGN CAPITAL IN GENERAL

---

An all-round development of the Sudan in every field with a view to securing the material and moral progress of the people is in the forefront of the Sudan Government's Objectives. This requires coordinated and integrated planning in every field, e.g., Agriculture, Multi-purpose projects dealing with Irrigation, Power and Flood Control, Industrial Development, Communications, Transport, Education, Public Health etc. with due regard to all physical human and monetary resources that are available and can be tapped.

2. So far as the Industrial field is concerned, it may be stated that in this country Railways, Ordnance works and certain public utilities are already very largely State-owned and State-operated. This arrangement will naturally continue. Government will give a high priority to the development of the Hydro-Electric power which is the only means of substantially making good the handicap of absence of coal and oil in the Sudan. Apart from Railways, Ordnance works and Public Utilities, the Government, may, if it considers it desirable and if resources permit, embark upon Industrial schemes as State enterprises without any implication that the State intends to create a monopoly or nationalise those particular Industries. In an undeveloped country where private enterprise, initiative and knowledge are wanting and private capital is either shy or not forthcoming such participation by the State has been proved by the experience of other countries to be one of the means of making the people industrially-minded. It is, however, the intention of the Government of the Sudan that all Industries other than Railways, Public Utilities etc. referred to earlier, should be open to private enterprise. Government has already indicated on several occasions its intention to encourage private enterprise and development activities which are in the public interest and also to create conditions which attract foreign capital to this country for such enterprises.

-2-

3. Having given the matter careful consideration the Government is now in a position to be more specific about its intentions and the purpose of this statement is to make these known to the public.

4. The Government intends to set up an Advisory Committee to which all applications for Government assistance from private enterprise, whether local or foreign, will be referred. The Committee which will include some members from outside the Civil Service, will forward its recommendations to the Government.

5. The Committee will make an assessment as to whether each application is worthy of classification as an 'approved' or 'pioneer' enterprise. In making assessments, the Committee will be guided by such criteria as are considered appropriate. In particular, to qualify as an "approved" or "pioneer" enterprise the enterprise must pass the following tests:

- (i) It must be beneficial to the public interest, for example by increasing the national income, by saving foreign exchange or for strategic reasons.
- (ii) It must have a favourable prospect of successful development.
- (iii) Its function must not already be adequately performed within the country.
- (iv) Initial assistance is shown to be necessary.
- (v) Adequate capital and efficient management will be available.

Once an enterprise has been classified as an 'approved' or 'pioneer' enterprise the manner in which the Government will give assistance will depend on the particular requirements of the enterprise. But in all cases, the 'approved' or 'pioneer' enterprise will be entitled to Business Profits Tax relief.

-3-

6. This relief which the Government proposes to give to an 'approved' or 'pioneer' enterprise may be summarised as follows:

The period during which relief will be given will vary according to the capital employed:

- (i) If the capital employed is less than Rs. 20,000 at the end of two years the period of relief will be two years.
- (ii) If the capital is greater than Rs. 20,000 at the end of two years, the period of relief will be three years.
- (iii) If the capital is greater than Rs. 100,000 at the end of three years, the period of relief will be five years.

In the period of relief, the following easements will be given for the purpose of assessing Business Profits Tax:

- (a) Depreciation at double the normal rates.
- (b) Profits up to 5 per cent, of the capital employed will be exempt with additional profits taxed at half the standard rates.
- (c) Any net loss incurred over the period of relief will be regarded as a loss incurred in the last year of the period of relief.
- (d) Any dividend paid in the period of relief will be exempt from tax.

7. 'Approved' or 'pioneer' enterprises may also be given assistance in one or other or several of the following forms (the list being informative rather than exhaustive):

- (i) Reduction of import duties on raw materials.
- (ii) Preferential railway tariff rates.

-4-

- (iii) Assured Government orders for a prescribed period.
- (iv) Facilities for entry of necessary qualified technicians and other foreign employees.
- (v) Provision of commercial intelligence and expert advice.
- (vi) Protective duties on competitive articles from abroad on the basis of the recommendations of an impartial expert body.

8. It is the Government's intention to put before Parliament such legislation as is required to give effect to the arrangements outlined above which will apply equally to local and to foreign enterprises. (Please see Pages 5-8, this Appendix.)

9. Foreign Industrialists must undertake to provide reasonable facilities for the training of Sudanese personnel and for the progressive participation of such personnel in their establishments.

10. The question of association of local capital, whether Government or Private, with foreign capital will be a matter for negotiation at the commencement and not for compulsion.

11. Foreign employees will be permitted to remit bona fide savings to their country of origin.

12. Government accepts the principle that foreign Industrialists should have the right to remit profits to the country of the origin of the capital and furthermore, it would give an assurance in respect of the payment of fair and equitable compensation in the event of acquisition of any property for nationalisation and will grant facilities for the repatriation of such compensation. It would further give an assurance of non-discrimination between foreign and local enterprise.

13. The conditions described in this statement refer to new enterprises but the Government is also prepared to consider applications from existing enterprise if it satisfies the criteria described. The assistance or relief to be afforded in such instances will depend on the merits of the case.

-5-

THE APPROVED ENTERPRISES (CONCESSIONS)  
ACT 1956.

(1956 Act No. 8)

Assented to on 11.2.1956.

An Act to encourage and assist certain industrial and other similar enterprises in the Sudan.

Be it hereby enacted by Parliament as follows:-

Title.

1. This Act may be cited as the Approved Enterprises (Concessions) Act 1956.

Definitions.

2. In this Act, unless the context otherwise requires:  
"Approved Enterprise" means an industrial or other similar undertaking or a future industrial or other similar undertaking in the Sudan, which, in the opinion of the Minister, is such an enterprise.

"Advisory Committee" means the Committee established under Section 3 of this Act.

"Minister" means the Minister of Commerce Industry and Supply.

"Prescribed" means prescribed by rules made under this Act.

Establishment and Constitution of Advisory Committee.

3. (1) The Minister shall establish an Advisory Committee for the purpose of this Act.

(2) The Advisory Committee shall consist of:-

- (a) Director, Ministry of Commerce, Industry and Supply.
- (b) P.U.S. Ministry of Finance and Economics
- (c) P.U.S. Ministry of Interior.
- (d) Director of Agriculture.
- (e) Commissioner of Labour.
- (f) Two persons nominated by the Minister.

-6-

Powers and Duties of Advisory Committee.

4. (1) Any person desiring to obtain the concessions authorised by or under this Act shall make an application in writing to the Minister setting out such details and giving such other information, and in such form as may be prescribed.

(2) Upon receipt of an application under subsection (I), the Minister shall arrange to have the same considered by the Advisory Committee who shall recommend to the Ministry whether or not the enterprise concerned is to be classified as an approved enterprise.

(3) No enterprise shall be classified as an approved enterprise unless:-

- (a) its promotion is in the interest of the general public.
- (b) it has reasonable prospects of successful development.
- (c) its field of activities is not already sufficiently covered in the Sudan.
- (d) it has sufficient capital and managerial resources for entering upon its proposed activities.

(4) When the Advisory Committee is of the opinion that an enterprise should be classified as an approved enterprise, it shall forward its recommendation to the Minister along with their opinion as to the extent of the manner in which and the terms and condition on which any concession or assistance is to be provided to it.

(5) Upon receipt of the recommendation of the Advisory Committee in relation to any enterprise the Minister may accept, alter or reject the same, and make an order accordingly, which, in cases where an application is not rejected, shall have effect notwithstanding anything to the contrary contained in any other law for the time being in force concerning Business Profits Tax, Import, Export and Excise Duties, Railway Tariff rates, entry into Sudan of foreign technicians, or any other similar law which, in the absence of this Act, would in the opinion of the Council of Ministers operate as a restriction on the enterprise; and such law shall to such extent and in relation to such enterprise be deemed to have been amended by this Act.

-7-

(6) The Advisory Committee shall have the power to invite any person to assist them in their deliberations, provided that no such person shall have the right to vote.

(7) The opinion of the Minister as to whether or not an enterprise is an approved enterprise shall be final and shall not be called into question before any court or any other authority.

Relief.

5. (1) The Nature and measure of the relief to be given to an approved enterprise shall be as follows:-

Under the Business Profit Tax Ordinance:-

- (a) profits up to five per centum shall be exempt from taxation, and those in excess of the said percentage shall be taxed at half the rates that would apply but for the provisions of this Act.
- (b) depreciation shall, on application, be allowed at a rate double of that which would be allowed but for the provisions of this Act.
- (c) any net loss incurred over the period of relief shall be deemed to be a loss incurred during the last year of such period.

(2) The period of relief under sub-section (1) shall be:-

- (a) two years, if the capital employed is less than £s. 20,000 at the end of two years.
- (b) three years, if the capital employed is more than £s. 20,000 but not more than £s. 100,000 at the end of two years.
- (c) five years, if the capital employed is more than £s. 100,000 at the end of three years.

(3) The period of relief shall be computed as commencing from the date of the order sanctioning concessions or from the date on which an approved enterprise begins to operate in the Sudan, whichever occurs on a later date.

-8-

No Discrimination.

6. For the purpose of classifying an enterprise as an approved enterprise no discrimination shall be made against foreign enterprises.

Imposition of Conditions for Relief.

7. Any relief that may be given by or under this Act may be subject to such conditions as may be specified by the order of the Minister granting concessions under this Act.

Repatriation of Compensation.

8. If at any time any property belonging to an approved foreign enterprise is compulsorily acquired by the Sudan Government in furtherance of nationalisation of any industry, fair and equitable compensation shall be paid for the same and the said compensation shall be permitted to be remitted out of the Sudan.

Rules.

9. The Minister may make rules for the proper implementation of any of the provisions of this Act.

APPENDIX IV

ACKNOWLEDGEMENTS

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ACKNOWLEDGEMENTS

The field work summarized in this report would have been impossible without the sympathetic assistance which was extended by officers of The Republic of The Sudan, by officers and managers of commercial agricultural enterprises, by commercial equipment dealers and by the personnel of the United States Operations Mission, under the direction of Mr. Robert K. Kitchen, Jr., in Khartoum. The scientists in the several agricultural research stations have been most helpful.

A list of all persons who have been of assistance would be impractical because of its length. The thanks of the team are extended to all of them. Specific mention should be made of the following people who contributed most generously to the work:

Blue Nile Province

Sayed Abdel Aziz Omir El Amin, Governor, Blue Nile Province  
Sayed Ali Awadalla, Deputy Governor, Blue Nile Province  
Dr. Hanna, A. D., Director, Gezira Agricultural Research Station,  
Ministry of Agriculture  
Sayed Hussein Idris, Senior Agronomist, Tozi Agricultural Research  
Station  
Sayed Macawi Sulleiman Akral, Managing Director, Gezira Board  
Dr. Rai, K. D., Soil Specialist, Tozi Agricultural Research Station  
Mr. Sauer, G., Plant Breeder, Tozi Agricultural Research Station  
Mr. Toms, A. M., Spraying and Experiment Officer, Gezira Board, Barakat.

Equatoria Province

Sayed Mohammed Abdel Aal, Senior Agricultural Inspector, Equatoria  
Province  
Sayed Osman Gad El Rab, Deputy Governor, Equatoria Province

Khartoum Province

Sayed Abdel M. Hamadto, Commissioner for Development, Ministry of  
Finance

#### APPENDIX IV

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Sayed Hassen Mutwakil, Ministry of Agriculture  
Sayed M. A. Mihgimied, Deputy Director, Department of Animal Production,  
Ministry of Animal Resources  
Sayed Mahmoud Ahmed Abdalla, Director, Geological Department,  
Ministry of Mineral Resources  
Mr. Malta, P. C., Consulting Agriculturist  
Sayed Mohamed S. Agabani, Agabani Trading Company  
Sayed Mekkawi Mustafa, Acting Director, Ministry of Commerce,  
Industry and Supply  
Dr. Nour, M. A., Dean, Faculty of Agriculture, Shambat  
Mr. Kitchen, Robert W. Jr., Director, USOM/Sudan  
Mr. Pra Sisto, Victor J., Food and Agriculture Representative, USOM/Sudan  
Mr. Renford, F. R., Sudan Merchantile Company, Khartoum  
Sayed Yogoub el Hilu, Ministry of Agriculture

#### Northern Province

Sayed Mirghani El Amin, Governor, Northern Province  
Sayed Tahir, Ishasen, Inspector of Agriculture, Government Estates,  
Merowe Area

#### Upper Nile Province

Sayed Abbas Ahmed, Inspector of Agriculture, Er Renk

APPENDIX V

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REFERENCES

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APPENDIX VI

ICA TASK ORDER NO. 234

TASK ORDER

OFFICE OF INDUSTRIAL RESOURCES  
INTERNATIONAL COOPERATION ADMINISTRATION  
Washington 25, D. C.

ICA NO. 234

Date: June 27, 1958

TO: Tudor Engineering Company

ICA Project No. and Title: Sudan Sugar Development

Country: Sudan

Project Engr./Mgr.: Clifton H. Day/S. H. Manian

Phone Extension: 3882 - 482

Assignment: To make an investigation of the possibilities of the development of sugar production in The Sudan. Such survey and report shall include but not be limited to:

1. An investigation of the suitability of the soils and climate for such an industry.
2. Relationship of such industry to the overall economy of The Sudan.
3. Investigation of market for sugar and by-products.

Target Date:

Remarks: Cost Estimate: Approximately 3 months and approximately \$37,500.  
Due date: 3 months after approval of team members and departure for The Sudan.

Acknowledged:

/s/ John G. Marr  
Tudor Engineering Company, 6/27/58  
(Please return one signed copy to ICA)

/s/ N. E. Thompson  
Norman E. Thompson  
Chief, Industrial Engineering Division

Tudor Project No. 234

Task Engineer:  
Phone: Sterling 3-5313

ICA-10-70  
(6-56)

Task Order 234 continued:

4. Recommendations as to the extent of development as to acreage, size of facility and use of by-products.
5. An analysis of the possible production costs and the profitability of the recommended facilities.

To accomplish this task order, three consultants particularly qualified in analyzing the conditions, and in developing the possibilities for sugar production and refining shall be employed by Tudor Engineering Company and sent to The Sudan in company with a representative of the Department of Commerce. These consultants shall include a team leader, who shall be responsible for the coordination of the team effort and in the preparation of a final report, an agronomist and soils specialist, and an industrialist who is skilled in the design, operation of a sugar refinery and in the efficient production and use of by-products.