IRRIGATION AGRICULTURE IN THE SUDAN

NEW HALFA SCHEME: AN EXAMPLE

(A REHABILITATION PROJECT)

by

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THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

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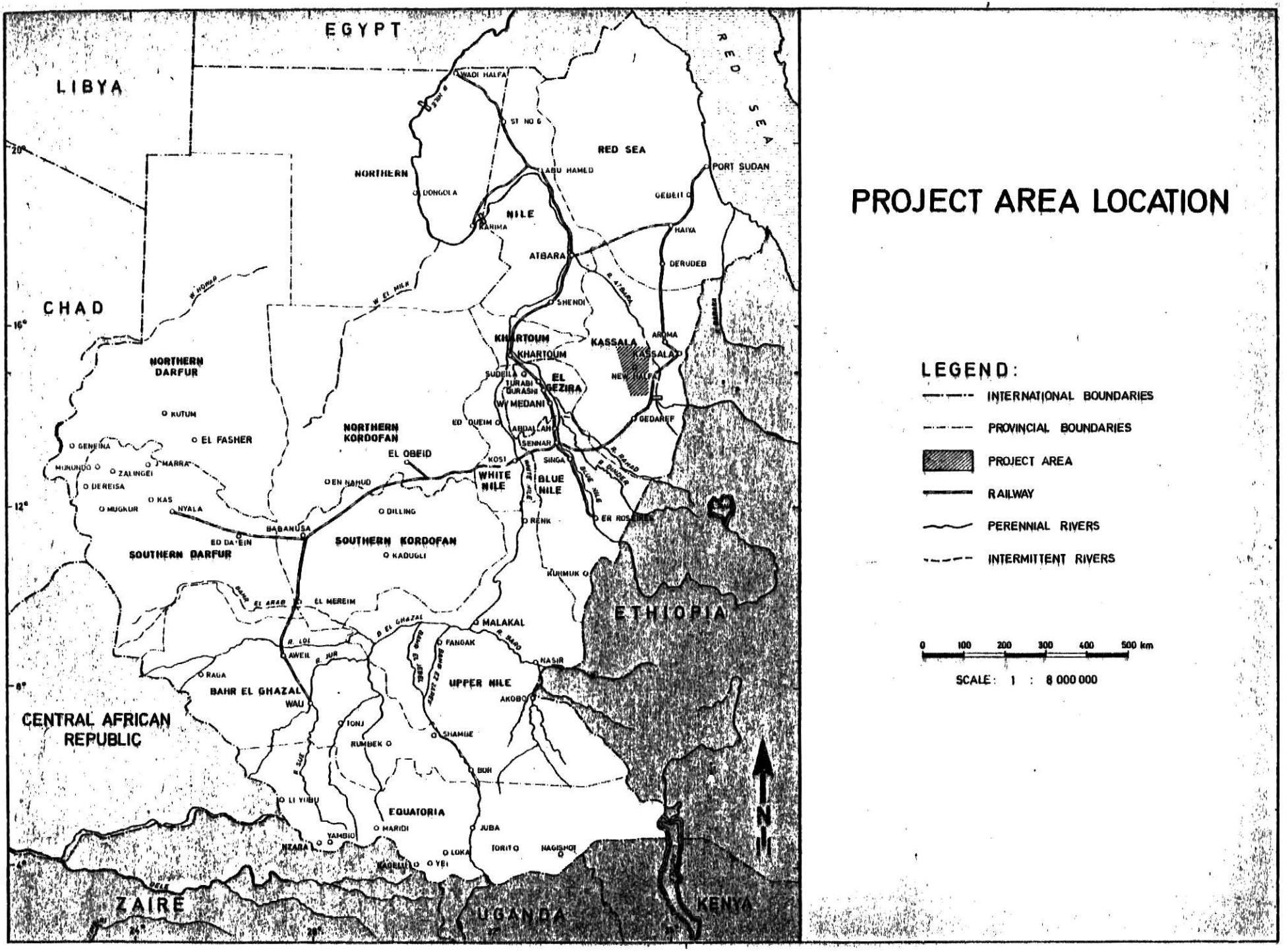

PROJECT AREA LOCATION

LEGEND:

- INTERNATIONAL BOUNDARIES
- PROVINCIAL BOUNDARIES
- PROJECT AREA
- RAILWAY
- PERENNIAL RIVERS
- INTERMITTENT RIVERS

1. INTRODUCTION

> Geography and history have not treated the Sudan kindly. Years ago, when the Turks, and later the Egyptians and the British governed the area, few of them disagreed--nor did the majority of the local inhabitants--that the Sudan was a strange place in which to live. Mostly arid, conquered by many, it is only recently that the Sudan has begun to offer a better life to its people. Today, most of its leaders are working to develop the country into a nation. How well they succeed will affect the fortunes of not only the seventeen million Sudanese but perhaps over one hundred million residents of Africa and the Middle East (Lees and Brooks, 1977).

1.1 Evolution of the Sudanese Economy

The old economy of the Sudan was characterized by:

(1) Traditional pump and flood irrigation along the Nile and in a few other areas (e.g. the Tokar and Gash Deltas).

(2) Some trade in old towns on the Nile (Berber, Shendi, Sennar) and in the nomadic areas.

(3) The livestock economy at a distance from the Nile.

(4) Subsistence mixed farming in the south.

In vast areas of the country the changes which have taken place in the course of this century have been very modest indeed. New means of transport have facilitated movement of foods and people, but have not drastically changed the mode of life of nomads and subsistence farmers.

The establishment of modern means of transport in the Sudan was undertaken for military and administrative reasons. Steamships were brought in as early as 1870s when small steamers operated on the Nile as far south as Uganda. The first railways between Wadi Halfa and Karima and Wadi Halfa and Atbara were built during Kitchener's military campaign at the end of the nineteenth century. The railways and river

transport moved supplies and people for the administration and the army. Trade in products from the Sudan was modest, and so was the trade in supplies to the indigenous population.

The great change in the economy was brought about by the introduction of modern irrigation schemes, starting with the Gezira Scheme in the 1920s, based on gravity irrigation from waters of the Blue Nile stored at Sennar dam. Some irrigation was also carried out through the sagia[1] and shaduf[2]; these are going out of use now and are being replaced by motor-driven pumps. The number of private pump schemes on the Nile and its tributaries grew from 372 schemes irrigating 170,000 feddans[3] in 1944, to 2,229 schemes irrigating 777,000 feddans in 1957. The result of introducing modern irrigated agriculture has been to give hundreds of thousands of people far more security than before, along with reasonable cash incomes.

The Sudan has large areas of land receiving sufficient rainfall to be suitable for crop cultivation. Using traditional methods, only a small fraction of such land could be used for rainfed crop production. In the 1950s, large areas were brought under mechanized cultivation, with the total area reaching about one million feddans around 1960. This development, which was clearly linked with the successful modernization of agriculture in the irrigated areas, took place through private initiative.

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[1] A water wheel worked by oxen.

[2] An elevated lever pump, manually operated with the help of counter-weights.

[3] One feddan = 0.42 ha.

Exploitation of land resources through more modern means has channeled significant private capital and managerial resources into agriculture. During periods of low agricultural prices there was also private interest in the development of manufacturing industries, particularly during the second half of the 1950s. So far, however, industrialization has played a minor role in the modernization of the Sudan by comparison with the growth of irrigated and large-scale mechanized rainfed agriculture.

The pattern of modernization of agriculture has led to a strong geographic concentration. More than 90% of the irrigated land is in Kassala and Blue Nile provinces; almost 90% of the mechanized farming takes place in these two provinces too. Khartoum, the capital city, is close to these rich farm areas, and most of the industrialization has taken place in the capital and neighboring areas. Elsewhere, apart from the scattered development projects, the effects of modernization have been almost unfelt. Thus, one major feature of the structure of the Sudan's economy is a marked geographic dualism. Moreover, provision of public services such as education, health, power and transport has also been concentrated in the higher-income areas, thereby aggravating the regional disparity. Table 1.1 shows the striking contrasts in income distribution between provinces.

Table 1.1 is self-explanatory and it shows the marked degree of income disparity between provinces. But, to a limited extent, the impact of this dualism has been softened by the seasonal participation of large numbers of workers from the west and south in modern sector agriculture, industry, construction, etc. in the high-income areas.

Table 1.1

Income Distribution by Province
in the Sudan, 1960s

Province	Meanworker income (£s)[a]	Province % contribution to GDP
Khartoum	315	31.3
Blue Nile	232	23.1
Kassala	185	18.5
Northern	142	14.0
Kordofan	67	6.7
Upper Nile	30	3.0
Equataria	35	3.4
All Sudan	75	100.0

Source: Adel Amin Beshai, 1976.

[a] £ 1.00 equaled approximately $2.3 in 1978.

Lees and Brooks (1977) wrote about this migration: "The population of the Sudan is mobile to a high degree. It is estimated that at least one million men and women are on the move every year in search of income-earning opportunities." In addition, the Sudan has a large number of nomads who move with their cattle in rhythm with the seasons. Areas that are major recipients of mobile Sudanese include the urban centers and the modern farming schemes (including the mechanized farms and irrigated agricultural areas such as the Gezira). Table 1.2 shows the employment of seasonal labor in some of these areas.

Table 1.2

Employment of Seasonal Labor in Some of the Major Schemes in Sudan, 1973-4

Scheme	No. employed of seasonal in-migrants
Gezira	336,000
Nuba Mts.	70,000
Kassala	100,000
New Halfa Scheme	45,000

Source: Lees and Brooks, 1977.

1.2 Sudan: Facts & Figures

1.2.1 Geography and climate

The Sudan is the largest country in Africa--just under 1 million square miles. It is ten times the size of the United Kingdom or nearly the size of the U.S. east of Mississippi. Stretching more than 1200 miles from north to south, and one thousand miles east and west, the country contains many different climatic, vegetation and physical regions, and includes people from very different ways of life, religions and cultures.

Located mostly in the Sahara Desert, the country is thought of in terms of a vast area of sand dunes. Yet, these occur only in the extreme north-west. The Nile River consists of two major tributaries--the White Nile, issuing from Lake Victoria in Uganda, and the Blue Nile, flowing from Lake Tana in Ethiopia. After leaving Lake Victoria, the White Nile drops off the East African highlands in a series of lakes,

rapids, and waterfalls, but, upon entering the basin, it creates a vast swamp called the Sudd (Arabic for 'obstacle'). It is estimated that about 50 percent of the White Nile's water is lost through evaporation in the Sudd region--probably the largest swamp in the world.

From Lake Tana in Ethiopia the Blue Nile finds its way through the mountains before entering the basin. For centuries the Nile has brought fresh, rich soil which makes the valley so incredibly fertile. The river--Blue Nile--flows north-west, in places almost parallel to the White Nile before the two join at Khartoum. Between the two rivers, near the junction, is the famous Gezira (Arabic for 'island'). Here the Government has developed what is claimed to be the world's largest farm--the two and a half million acre Gezira Scheme.

The Nile basin, as its name implies, has generally little relief and its topography is relatively uniform. Khartoum is some 1200 feet above sea level. Vast undulating clay plains cover most of the basin, giving way in equivalent portions to sand dunes. There are some isolated mountainous areas like Jebel Marra in the west with an elevation of 10,131 feet and the mountains near the Red Sea with its highest peak of 7274 feet at Jebel Eiba.

While lying wholly in the tropics, the Sudan does have several distinctive climatic regions. In the northern section temperatures are high and rainfall is sparse and seasonal, while in the south rainfall is heavy and distributed throughout the year. The extreme south rainfall is equatorial, averaging 50-60 inches annually. Temperatures are not excessively high averaging about 80^{o}F, but humidity tends to be high.

Northwards temperatures tend to increase while rainfall and humidity decrease. At Khartoum rainfall averages less than 5 inches while at the Egyptian border it is under one inch.

1.2.2 Sudan: basic data

In 1971 the United Nations formally established a class of "least developed countries." The criteria for inclusion were a low gross domestic product ($100 or less per capita in 1968), a low share of manufacturing in GDP, and a low literacy rate. The Sudan is one of these twenty-five countries, and Sub Saharan Africa accounts for 16 of them. The economic development prospects of these countries are hampered by poor physical infrastructure, lack of skilled and trained manpower, and lack of resources for investment (mainly capital).

Looking at the basic data of these countries, one can see that the Sudan is holding a favorable position amongst these countries. The country is so rich in terms of untapped natural resources and growth potentialities.[4] The International Labour Office mission to the Sudan wrote in 1976:

> We have analyzed past economic developments and current policies with some care. We suggest that some of our findings are of critical importance for an understanding of the basis on which strategies for the future must build. Our analysis has revealed that the economy has in fact grown more rapidly in the past decade than is usually accounted for; in particular, the growth of rainfed agriculture in the private sector has been nothing less than spectacular. If the economy has in fact been more buoyant than is popularly believed, then our scenario of 6 to 6.5 percent average annual growth of output and incomes over the next decade does not present any very dramatic break with the past; and to accelerate annual growth in the next ten years to this level from a base of 4 or 5 percent seems more

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[4] For comparison, see World Bank: World Development Report, 1979.

Table 1.3 Sudan: Basic Data

Area		Population		Education	
1. Total area	2.506 Mill km^2	1. Total population 1975 (in million inhabitant)	17.7	1. Adult literacy rate (in percent of total population)	20%
2. Arable area--estimated, possible	70-75 Mill ha	2. Rural population 1964/65 (in million inhabitants)	13.2	2. Primary school enrollment--(in percent of total population)	7%
3. Arable area (in percent of total area)--estimated, possible	30%	3. Rural population (in percent of total population)	75%		
4. Cropped area	7,100,000 ha	4. Population density (inhabitants/km^2)	7.1		
5. Cropped area (in percent of possible arable area)	9.5%	5. Population density of arable area	24.4		
6. Irrigated area	1,349,000 ha	6. Crude birth rate 1960	45		
7. Irrigated area (in percent of cropped area)	19%	7. Crude death rate 1977	19		
		8. Growth rate (percent)	2%		

Gross Domestic Product (GDP)		Health		Nutrition	
GDP at current market prices = $3,777.0 Mill (1974/75)		1. Life expectancy 1977	46	1. Calorie intake (per day/capita)	2,200
of which in percent:		2. Population/physician 1976	9,760	2. Calorie intake (in percent of requirements)	94%[a]
1. Agriculture	38.5	3. Population/hospital bed 1970	610	3. Protein intake (in gram/day/capita) 1975	65
2. Industry	9.1			4. Protein intake (in percent of requirements)	100%[a]
3. Building construction	3.8				
4. Electricity & water supply	2.2				
5. Transportation & communication	6.2				
6. Commerce	34.3				
7. Other services	5.9				
	100.0				

Source: World Bank: World Development Report, 1979.

[a]Recommended by FAO Experts Food Supplies and Nutrition April, 1973.

> promising of success than doing so from a base of 2 to 3 percent. In view of this reassessment of the Sudan's growth performance in the recent past, a target of little more than 5 percent annual growth over the next five years, followed by a growth rate below 7.5 percent in the early 1980s, might be considered too modest (ILO, Khaztoum 1976).[5]

Table 1.3 shows some of these basic data about the Sudan.

It is clear that the Sudanese economy is dominated by agriculture through this sector's contributions to food consumption, economic growth, foreign trade, national income and employment. Agriculture, forestry and fisheries account for over 38% of the country's GDP. The significance of agriculture can be demonstrated by the fact that the composition of Sudanese exports has always been limited almost entirely to agricultural products. Table 1.4 illustrates.

Table 1.4

Export Commodities
(in percent of total exports)

	1973	1974	1975	1976
£s Mill	152.2	122.2	152.4	193.0
1. Cotton	55.4	35.4	46.0	50.7
2. Groundnuts	8.5	14.8	22.5	20.2
3. Sesame	7.0	13.5	7.8	9.0
4. Gum Arabic	4.8	11.6	4.9	5.8
5. Hide-Skin	4.0	3.1	2.1	1.9
6. Others (including non-agricultural)	20.3	18.6	21.6	12.4

Source: O'Hagan, 1978.

[5] The mission was to provide an independent view of the Sudan's employment and development problems and potentials, as well as to suggest strategies and policies for action.

Therefore, agricultural performance necessarily conditions the basic features of the whole economic process, domestically as well as in relationships with the outside world. The national economy has accordingly been affected by the serious problems and constraints under which the agricultural sector has been performing.

1.3 Objectives of the Report

The main objectives of this report will include:

(1) Statement of the role of agriculture, particularly irrigation agriculture, in the Sudanese economy. Chapter 2 of this report deals with this.

(2) Definition and critical economic analyses of the problems and constraints that faced (and are facing) the New Halfa Irrigation Scheme, the second largest irrigation scheme in the country. Chapter 3 deals exclusively with these analyses.

(3) Analysis of the economic feasibility of injecting an input package to cover such major areas as the scheme's irrigation system, farm machinery, infrastructure and organization and management. This is considered in Chapter 4.

The economic feasibility of capital investment will be tested using the following computer programs:[6]

(1) Master Projection Program (MPJ)

(2) Internal Rate of Return (IRR) Program

(3) Financial Statement Program

(4) Financial Rate of Return (FRR) Program.

Chapter 4 deals with these analyses.

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[6] These computer programs are prepared by Dr. Richard Phillips and others in the Food and Feed Grain Institute of Kansas State University.

2. ROLE OF THE AGRICULTURAL SECTOR IN THE SUDANESE ECONOMY

2.1 How Agriculture Holds a Pivotal Position Amongst the Different Sectors of the Economy

Agriculture is the dominant sector in the Sudanese economy and is likely to remain so for several decades. At present, it contributes 38 percent to GDP, it constitutes over 95 percent of exports, it contributes directly and indirectly over 50 percent of Government revenues, and it provides income and employment for 79 percent of the population. Given the extraordinary area of unsettled arable land with access to potential irrigation water or adequate rain--one estimate puts the potential arable land surface at about 200 million feddans compared with the 15 million feddans now under crops--and a favorable climate for plant growth, the Sudan's comparative advantage clearly lies with agriculture and agro-industrial exports. The potential for food grain and oilseed development, for sugar, cotton textile and the processing of other primary outputs, may well be characterized as unique.

2.2 Systems and Modes of Agriculture in the Sudan

There are different types and forms of agriculture followed in the Sudan. Among these, four major systems are recognized.

2.2.1 The traditional rainfed agriculture

In the Sudan, as in most developing countries, the majority of the rural population is engaged in, or dependent on, some form of traditional farming; some estimates put the figure at about 10 million persons, perhaps 500,000 families in the Southern Region, and 1,200,000 families

in the rest of the country. The systemsof farming followed tend to be location-specific but they normally use primitive cultivation methods, with hand implements rather than mechanical ones, relatively low-yielding crop varieties and a little or no inputs of fertilizers or pesticides.

Each rural family is a working group--the extended family--the chores being done by all members of the family. The husband normally does the land-clearing and other heavy work such as digging. His wife or wives do most of the sowing, weeding and harvesting. Daughters help their mothers and sons their fathers. In some situations, husband and wife work separate plots. The production role of women--completely ignored and unfelt at present--is very important and needs to be taken into account when planning ways of transforming or modernizing traditional agriculture.

Because of the need for land to lie fallow in order to regenerate fertility and avoid the heavy weed infestation caused by continuous cultivation, the traditional farming system often involves shifting cultivation. Agriculturally, this may be a defensible practice where, as in many parts of the Sudan, land is abundant; in other areas, however, the increasing population and the increasing use of land for new purposes (ranching, mechanized farming or other forms of modern agriculture) are beginning to make shifting cultivation less viable.

To have an idea about the contribution of this sector to the Sudanese economy, we may look at Table 2.1 which shows the areas and production of some of the crops which are grown traditionally.

2.2.2 Traditional livestock-raising

The Sudan is one of the African countries most rich in livestock, if not the richest. Recently, increasing attention is being given to

Table 2.1 Major Crops in Traditional Agriculture in the Sudan, 1973/74 - 1974/75

Province	1973/74			1974/75		
	Area (1000 fed.)	Av. Yield (kgs/fed)	Production (in tons)	Area (1000 fed.)	Av. Yield (kgs/fed.)	Production (in tons)
Dura (Sorghum):						
Northern	25.4	303	7,697	86.0	438	37,668
Khartoum	19.2	50	960	24.0	117	2,808
Gezira	25.0	700	17,500	98.0	384	37,632
White Nile	337.1	222	74,836	127.1	337	42,833
Kordofan	90.0	135	12,150	80.0	150	12,000
Darfur	147.0	339	49,833	256.4	284	72,818
Bah el Ghazal	99.0	217	21,483	209.0	158	33,022
Upper Nile	353.0	388	136,964	435.0	295	128,325
Equatoria	170.0	300	51,000	214.8	260	55,848
Groundnuts:						
Blue Nile	12.3	1,000	12,300	14.2	1,380	19,595
White Nile	55.0	200	11,000	62.4	359	22,402
N. Kordofan	36.0	127	4,572	47.0	320	15,040
N. Darfur	212.0	360	76,320	360.0	340	122,400
Bah el Ghazal	32.0	375	12,000	51.0	255	13,005
Upper Nile	5.0	225	1,325	6.0	222	1,332
Equatoria	85.0	329	27,965	127.8	280	35,784
Sesame:						
Blue Nile	150.0	156	23,400	197.0	147	28,959
White Nile	85.0	137	11,645	83.0	224	18,592
N. Kordofan	20.0	158	3,160	23.0	158	3,634
N. Darfur	75.0	147	11,025	69.0	186	10,764
Southern Region[a]	65.0	115	7,475	93.0	240	22,320

Source: Sudan Yearbook of Agricultural Statistics, Khartoum, June 1977.

[a]Comprises Bah el Ghazal, Upper Nile & Equatoria Provinces.

development of the livestock sector in the country by both national and international agencies. The Arab Fund proposed projects and the FAO International Meat Development Scheme Mission are manifestations of this interest. If feasible livestock projects can be identified, it is probable that capital for investment would be forthcoming. The problem is that about two-thirds of the 120 to 150 million hectaresof potential grazing land is currently being exploited by a large population of traditional animal-holders. Forty percent of the Sudan's total population derive all or part of their income from animal husbandry. Table 2.2 gives an idea about the Sudan's animal wealth.

Table 2.2 Livestock Population in Sudan, 1974/75

Province	Cattle	Sheep	Goats	Camels
Northern	706,080	550,960	338,551	82,500
Khartoum	88,320	55,096	338,551	57,750
Blue Nile	1,236,480	3,760,302	2,511,830	255,750
Kassala	397,440	1,157,016	688,023	649,000
Kordofan	2,075,520	3,016,506	1,026,574	1,254,000
Darfur	4,945,920	3,016,506	2,621,040	451,000
Upper Nile	1,913,600	730,022	1,229,599	---
Equatoria	647,680	495,864	895,622	---
Bah el Ghazal	3,208,960	991,728	1,201,310	---
Total Sudan	15,220,000	13,774,000	10,921,000	2,750,000

Source: Sudan Yearbook of Agricultural Statistics, Khartoum, June 1977.

2.2.3 Mechanized rainfed agriculture

Whereas small-scale peasant, dryland and irrigated farming has been practiced in the Sudan for many centuries, mechanized farming is a relative newcomer. The first mechanized farms were started in the Gadaref area in 1945. Initially there were operational difficulties, but mechanized farming developed rapidly after 1953, when the Government decided to allot land to private entrepreneurs if they cleared the land themselves.

Since 1960, the technique has been extended to other areas in the clay land belt. By 1968 the Government had alloted 1.8 million feddans to private farmers and another estimated 1 million feddans were cultivated in unauthorized mechanized farms. In the same year of 1968 the Mechanized Farming Corporation (MFC) was established by the Government to take over the responsibility of mechanized farming projects and be responsible for:

(1) Mechanized crop production schemes in which the MFC allocates land to private farmers, who clear the land and provide machinery, usually with credit from commercial banks or from the Agriculture Credit Bank.

(2) Mechanized farming projects, in which MFC carry out, or supervise the land-clearing operation and other farming practices and provide credit for the purchase of machinery.

(3) State farms, directly operated by the MFC.

Mechanized farming is now practiced in four provinces but most of it is still concentrated in the Kassala and Blue Nile provinces. Table 2.3 illustrates the cropped areas by provinces.

The total area in mechanized farms is considerably larger than the cropped area because part of the land must be left fallow, and also

farmers are not obliged to crop their allotment completely in the first year. The mechanized area is now estimated as over 4 million feddans. About 320,000 feddans of the cropped area are state farms, another 300,000 feddans are in mechanized farming projects and about 2.5 million feddans are in the private farms, authorized and unauthorized.

Table 2.3 Cropped Area in Mechanized Farms, 1973/74
(Thousand feddans)

Province	Sorghum	Sesame	Cotton
Kassala	1,391	442	20.6
Blue Nile	651	230	1.4
Kordofan	124	10	12.0
Upper Nile	256	48	
Total	2,422	730	34.0

Source: ILO, Khartoum, 1976.

There are substantial expansion plans for the next 10 to 15 years, mostly in South Kordofan and South Darfur provinces. In these provinces

much of the flat clay land is difficult to manage in the rainy season by means other than the mechanical means. Studies done by the MFC show that 1.4 million feddans in the Kassala/Blue Nile area, 1 million feddans in South Darfur and 2 million feddans in South Kordofan are on their way to be included as new extensions and are expected to be developed by 1983. So, it is assumed that by 1985--at most--additional 4.5 to 5 million feddans would be under mechanized farming, of which 3.6 million feddans is expected to be actually planted. Table 2.4 shows the possible impact of this projected increase in area on the country's export earnings.

2.2.4 Irrigated agriculture

Irrigation with Nile water was practiced in the Sudan many centuries ago, but modern irrigated agriculture was only introduced in the second quarter of this century. In 1911 the Sudan Experimental Plantation Syndicate organized some cotton growing trials on irrigated plots. The experimental results indicated that cotton could be grown on a commercial basis and consequently funds were raised to build a dam across the Blue Nile at Sennar. The dam construction, completed in 1925, made possible the start of gravity irrigation on a large scale in the Gezira area. The area under cotton increased from 22,000 feddans in 1923 to 80,000 feddans in 1925 and to 600,000 feddans in recent years.

Operation of the Gezira Irrigation Scheme was originally in the hands of the Plantation Syndicate but in 1950 the scheme was nationalized and placed under the direction of the Sudan Gezira Board (SGB). The SGB is now responsible for the original Gezira, as well as the Managil and Guneid extension schemes, whose total area is 2.1 million feddans.

Table 2.4 Estimates of Output and Value of Export per Crop in Mechanized Agriculture, 1973/74, 1985

	1973/74 (Actual)		1985 (Projected)			% change	
	Output (thousand tons)	Value of export (US $ million)[a]	Price per ton ($)[b]	Output (Thousand tons)	Value of export (US $ million)	Output	Export Value
Sorghum	835	52.4	190	1780	111.5	113.2	112.7
Sesame	108	45.4	600	230	96.6	118.5	112.7
Cotton	5.2	1.04	200	11	2.2	111.5	111.5
		97.84			210.3		

Source: ILO, Khartoum, 1976.

[a]Only 33 percent of sorghum output and 70 percent of sesame output are exported. Cotton output 100 percent exported.

[b]Prices at 1976 constant prices.

In addition, about 1.4 million feddans are irrigated by pumps in schemes south of Khartoum, 400,000 feddans by gravity in the New Halfa Scheme and about 70,000 feddans by both gravity and pumps in small schemes along the Nile north of Khartoum. This gives a total irrigated area of about 4 million feddans in the whole country. Table 2.5 shows the net area per crop under irrigation for the year 1974/75.

Table 2.5 Area by Crop under Irrigation in the Sudan, 1974/75

Crop	Area (1000 feddans)
Long staple cotton	856.4
Medium staple cotton	165.6
Sorghum	305.0
Wheat	591.0
Groundnuts	384.0
Pulses	36.0
Vegetables	136.0
Citrus	24.0
Mangoes	14.0
Sugar cane	40.0
Total	2579.0

Source: Sudan Yearbook of Agricultural Statistics, 1977.

Organizationally speaking there are three types of irrigation schemes in the Sudan:

(1) Large schemes, managed by government-related bodies and cultivated by tenants; the Gezira is the largest scheme of this type.

(2) Pump schemes, started by private enterprises but nationalized in 1968 (Agrarian Reform Act of 1968) which are now managed by Provincial Agricultural Corporations.

(3) Nine pump-gravity schemes along the Nile north of Khartoum, managed by the Northern Province Agricultural Corporation.

In addition to these, there are a great number of small irrigation schemes spread all over the country.

Anyone who wants to focus on irrigated agriculture in the Sudan must put special emphasis on the Gezira Scheme, being the largest and the oldest amongst the modern irrigated schemes in the Sudan. However, and as I stated before, the major concern of my study will be the New Halfa Irrigation Scheme.

In the Gezira Scheme, production relationships are based on a tripartite partnership between the Board, Government and tenants. However, the SGB and the Government retain absolute influence in determining things as cropping patterns, and producer prices. There are 96,000 tenant farmers in the scheme. The size of the tenancy was originally set at 40 feddans, but successive subdivisions and new entries reduced the average to 26 feddans. In the Managil extension the standard size of a tenancy is 15 feddans.

A complicated system of sharing of costs and returns used to exist in the scheme regarding the cotton crop. But, various changes and modifications were introduced into the system that led to steady improvement in the position of the tenant. These changes and modifications were meant to attract the farmer's interest in the cultivation of cotton.

The tenant is responsible for such operations as cultivation, weeding, sowing, thinning and cleaning. The Government, through the

Ministry of Irrigation, is responsible for supply of water and canal maintenance. The Sudan Gezira Board (SGB) pays for deep ploughing, supply of seeds, fertilizers, pesticides and crop protection, picking, collection and transport of seed cotton, ginning and transport of lint to Port Sudan.

To see the impact of these changes, let us look at Tables 2.6 and 2.7.

The improvement in the position of the farmers is shown by the fact that their total costs percentage (relative to the other two parties) dropped from 56 percent to 48 percent, while the percentage of their share in the net returns increased by 15 percent (from 35 percent to 50 percent). It has also been found that during the four years 1962/63 to 1965/66, the average yield per feddan was 0.45 ton, whereas in the period 1968/69 to 1971/72 it was 0.72 ton/feddan, reflecting the increasing interest of the farmers in cotton growing.

The second group of schemes, run by the provincial corporations, consists of a great number of pumping schemes along the Blue and White Niles, south of Khartoum. The Blue Nile schemes cover a strip from about 40 km north to 120 km south of Sennar. There are 62 schemes, with a gross area of 282,000 feddans. The expansion possibilities are estimated as 97,000 feddans. The 186 White Nile schemes cover a strip of 380 km south of Jebel Aulia, close to Khartoum, with a gross area of 419,000 feddans and an estimated expansion potential of 284,000 feddans. Many of these schemes are small, the diesel pumps are old, and the canals are badly maintained. The Ministry of Irrigation, requested by the

Table 2.6 Total Costs per Feddan of Cotton, 1961/62, 1971/72 (£S)

	1961/62	1971/72
Outlay of tenants	19,407	23,727
Outlay of Government	10,117	16,873
Outlay of SGB	4,864	8,280
Total outlays	34,388	48,880

Source: ILO, Khartoum, 1976.

Table 2.7 Share of Partners in Costs and Net Returns per Feddan of Cotton, 1961/62, 1971/72 (£S)

		1961/62	1971/72
1.	Total gross returns	81,185	71,209
	Total costs	34,388	48,880
	Total net returns	46,798	22,329
	Tenant's share: gross return	35,722	34,893
	total costs[a]	19,407	23,727
	net returns	16,315	11,166
2.	Shares of total costs (% ages)		
	Tenants	56	48
	Government	29	35
	SGB	15	17
3.	Shares of net returns (% ages)		
	Tenants	35	50
	Government	42	36
	SGB	19	10
	Local council	2	2
	Social Development Fund	2	3

Source: ILO, Khartoum, 1976.

[a]Costs to the farmer include his own labor.

Corporation, has reviewed the situation in these schemes and formulated a program which aimed at the regrouping of these schemes into larger units, with the supply of electric motor pumps and improvement of the existing set of canalization. The cost of this program to be executed over a number of years was estimated in 1972 at about £s 66 million. The program is now under execution (with the help of the World Bank) and the gross area will increase from about 700,000 feddans to 1,080,000 feddans, or by more than 50 percent.

This will, of course, create more jobs and employment opportunities for the people living in the area, plus the expected increases in incomes, of the farmers as well as the increase in the Government's export earnings (from the sale of cotton and the movement towards self-satisfaction in wheat).

The third group of irrigated schemes are those in the narrow strips of land along the banks of the Nile north of Khartoum. They were started by the Government during the First World War and expanded in 1926 and 1935. One of the schemes has been submerged by the waters of the High Dam at Aswan and the Old Halfa people consequently moved and resettled in the New Halfa Scheme. There are now nine government pump schemes in the Northern province with a gross area of 36,000 feddans, growing crops, such as sorghum, wheat, citruses, mangoes, dates and broad beans. Techniques applied in these schemes are considered backward, and the management of the schemes is relatively expensive due to the small size of the schemes. Suggestions for improving these schemes were made years ago but little has been done towards the implementation

of them, mainly because of the difficulties in raising funds as well as the defective land tenure system adopted in these areas, characterized by severe family disputes that led to excessive land fractionation and fragmentation.

The focus of the Sudanese agricultural policy has been on the use of the Nile water for irrigation. Much has been achieved in this field, and much is still projected to come in the form of large irrigation projects. Table 2.8, however, shows the present situation.

Table 2.8 Area Under Irrigation and Water Intake by Major Schemes, 1974/75

	Area (1000 feddans)	Water intake (milliard m^3)[a]
Gezira scheme	2,052	6.85
Pump scheme	1,404	5.52
New Halfa scheme	450	1.62
N. Province schemes	70	0.25
Total	3,976	14.24

Source: Ministry of Irrigation
[a]Milliard = 1,000 million.

The Nile Waters Agreement between the Sudan and Egypt was revised in 1959 with the following allocations:

The average flow of the Nile at Aswan is	84.0 Mrd.m^3
of which the portion allocated to Egypt is	55.5
the portion allocated to the Sudan is	18.5
and evaporation at Aswan Lake is	10.0
	84.0

The Sudan allocation of 18.5 milliard m^3 at Aswan is considered equal to

20.5 milliard m^3 at Khartoum, because of evaporation and losses in between the two places.

By the end of this year 1981, an area of 470,000 feddans will be added to the already existing 4 million feddans under irrigation. This constitutes the Rahad Scheme Phase 1 (300,000 feddans), three sugar plantations (140,000 feddans) and a kenaf plantation (30,000 feddans). These will cost about £s 200 million and add over 10 percent to the irrigated acreage. However, this sizable increase requires 1.64 milliard m^3 of water, raising the total use to 15.88 milliard m^3. Intensification of the Gezira would add another 2.15 milliard m^3, raising the total to 18.03 milliard m^3 by the early 1980s, leaving a surplus of 2.47 milliard m^3 of Nile water. So far, the country's position in respect to water supply will be comfortable until the early 1980s. However, there are further expansion plans for the 1980s. They are as follows:

Rahad II	500,000 feddans
Four sugar plantations	182,000
Expansion of pump schemes	380,000
Setet/upper Atbara scheme	600,000
Total	1,662,000

The above expansion schemes would require an additional 5.8 milliard m^3 of irrigation water, and assuming they are implemented as planned in the 1980s, then Sudan would have an irrigation water deficit of 3.33 milliard m^3.

Realizing this fact, work is now undergoing in the construction of the so-called Jonglei canal in the Sudd area of the White Nile and it is expected to furnish an additional 4 milliard m^3, half of which

will go to the Sudan and the other half to Egypt. However, this would not cut the whole deficit of the 3.3 milliard m^3. Therefore other projects are being considered. These are:

(1) Draining the Manchar swamp, east of Malakal towards the Ethiopian boarder; this would save 4 milliard m^3.

(2) Draining the Bahr el Ghazal and further reducing the evaporation in the swamps; this would save 7 milliard m^3.

Moreover, there is the possibility of using the water that is now available more efficiently by cutting down water wastages.

2.3 Conclusion

So, this is agriculture and its position in the Sudanese economy. It contributes 38 percent to the country's GDP, constitutes over 90 percent of its exports, generates incomes and provides employment to the hundreds of thousands of the population. The economy is, thus, agriculturally based and shall continue to remain so for a number of decades to come.

However, is the strong focus the Government is giving irrigated agriculture at the expense of traditional and mechanized agriculture justified? It is quite clear that the Government is very committed to expanding the irrigated acreage, even though irrigation agriculture involves high investment rates and is capital intensive compared to the traditional and mechanized rainfed types of agriculture. Table 2.9 gives cost comparisons between the three types.

Maybe irrigation agriculture provides more employment, generates over 50 percent of the Government revenue, contributes nearly 20 percent to the country's GDP and minimizes the risk of weather failures involved

in the other two types. But, in terms of benefiting larger numbers of people, I believe that traditional agriculture and livestock raising are clearly the most promising modes, having regard to the possibilities of increasing incomes in these activities and the fact that this is where present standards of living are the lowest. So, developing traditional agriculture and livestock in the west and south, especially if accompanied by the expansion of public services such as education, health and water supplies, would contribute significantly to reducing interregional differences in standards of living.

Table 2.9 Cost of Crop Agriculture, per Feddan, Farm Family and Farm Worker

	Estimates in 1975 in £s		
	Traditional	Mechanized	Irrigated
1. Cost per feddan including feeder roads and water	12	30	300
2. Cost per farm family, owner or tenant	120	30,000	5,500
3. Cost per farm worker	25	140	1,000

Source: ILO, Khartoum, 1976.

3. THE NEW HALFA SCHEME: AN EXAMPLE

3.1 Background

The idea of establishing the New Halfa Scheme goes back to the year of 1954 when the Government thought of settling the nomads in the area. The area west of the Atbara river was selected for the following reasons:

(1) Suitable soil for agriculture (it lies at the north-eastern end of the central clay plains).

(2) Suitable site for a dam on the Atbara river.

(3) Use of the dam water to feed the scheme by gravity irrigation, based on the system adopted in the Gezira Scheme.

(4) The need of the nomads in the area for settlement.

The execution of this idea did not start until the year 1959 when the Nile Waters Agreement between Egypt and the Sudan was revised. The new agreement allowed the Egyptians to construct the High Dam at Aswan and subsequently large Sudanese and Egyptian areas on the banks of the Nile were expected to be flooded. On the Sudanese side, about 50,000 persons living in the Wadi Halfa District had to be resettled.

The same agreement permitted the Sudan to utilize additional waters of the Nile Basin by raising its share from 6 milliard m^3/year to 18.5 milliard m^3/year. So, it was decided to use the water of the Atbara river, a tributary of the Nile, for the development of agricultural lands on which the Halfa people could be resettled and inhabitants of the area (the nomads) established as resident farmers.

The irrigation system for the scheme was constructed between 1962 and 1969. Table 3.1 shows the developmental phases.

Table 3.1 Irrigation System Construction, By Phase, New Halfa

Phase	Period	Feddans
1	1962-64	175,000
2	1965-66	100,000
3	1966-67	45,000
4	1967-68	62,000
5	1968-69	65,000
	Total gross area	447,000

Source: Osman Idris, 1978.

However, the agricultural lands served by the Atbara river and the dam reservoir are divided as in Table 3.2.

Production on the scheme, which was expanded until 1969 when the total irrigatable area was reached, is scheduled with tight time-tables, and the core feature is the organization of a centrally controlled technical service upon which production on the holdings depends. Tenancies are arranged for the convenience of operation of the central service and irrigation, the latter being the responsibility of the Ministry of Irrigation and Hydro-electric Power with its branch offices at Khashm el Girba and New Halfa.

Water for the scheme is brought from the dam at Khashm el Girba by one main canal which extends 26 kilometers after the first regulator.

At this point the canal is divided into three branch canals (Eastern, Western, and Sabir). Minor canals branch off from these three canals, and finally the water is distributed through lateral field channels (Abu 20). Each of these serves 18 or 36 tenancies.

Table 3.2 Land Use in the New Halfa Scheme

		Feddans
1.	New Halfa Agricultural Production Corporation (NHAPC), subdivided into 15 feddan tenant plots	332,000
2.	The Sugar Estate[a]	41,000
3.	Freehold land[b]	25,250
4.	Rest pieces[c]	19,000
5.	Research sub-station	1,000
6.	Afforestation	2,500
	Total area used	420,750

Source: Osman Idris, 1978.

[a]A state-owned sugar estate which does not follow NHAPC.

[b]Lands given to Halfa people in compensation for their flooded lands in the Wadi Halfa.

[c]These are cutlands, not included in the rotation.

The scheme is divided into five sections, and the sections into inspection areas of which there are 19 altogether, each headed by an Inspector of Agriculture and with a number of specialists, junior staff and water guards attached. Sanctioned by a tenancy

agreement, a system of responsibilities exist between management (the Agricultural Production Corporation) and tenants, particularly with respect to cotton production. The corporation is responsible for the overall development, and the various operations are carried out partly by the management and partly by the tenants who may employ hired labor. Three state-owned ginning plants have been constructed in the town of New Halfa, the commercial, administrative and educational centre of the scheme, and marketing of cotton is handled by a Khartoum-based corporation.

For the settling of costs, a joint account system exists on the following basis:

The Cotton Public Corporation (i.e. CPC, located in Khartoum) after selling the cotton deducts the following:

(1) 6.5%, which goes to the CPC as commission.

(2) 2.0%, which goes to the Sudan Government.

(3) 0.5% is allocated to the price stabilization fund.

From what is left, the NHAPC deducts the following:

(1) The joint account.[7]

(2) Farmer's individual account.[8]

(3) 5.0% which goes to the social services fund.

(4) 2.0% which goes to the local government.

The net remaining is then divided equally between the corporation and the farmers (i.e. 50% each).

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[7]Refers to cost of such operations as land preparation (plowing) seeds, fertilizers, crop protection and ginning which are all, except for fertilizer application, done by the corporation on behalf of the farmer.

[8]Refers to the loans given to the farmer by the corporation to carry out such operations as watering, weeding, thinning and harvesting. Sometimes this account includes the cost of groundnut and/or wheat land preparation.

With reference to wheat and groundnuts, the Tenancy Agreement specifies that: "The tenant shall bear all costs of production...and thereby enjoys their full benefits and profits."[9]

Sociologically the scheme is complicated, having one third of its population composed of the resettled Halfa people while the other two thirds are settled nomads of local origin, the two groups having different backgrounds and ways of life. Of the scheme's 21,968 tenants, there are 11,632 from the Shukriya (the major tribe among the nomads of the area), 6,407 are Nubians from Wadi Halfa and the remaining 3,929 are mostly members of the Bija and Rashaida tribal categories.

There are 24 Nubian villages inside the scheme all located in the Phase 1 area and with 250-300 houses each. Each village has its own primary schools, piped water supply, sanitation facilities, a mid-wife and a medical assistant, and five of them even have electricity supply.

In the nomadic areas, there are now 33 villages of various sizes. Houses have not, as in the Nubian case, been constructed for the settlers. Mud and straw together with wooden and bamboo poles have been used in the construction of their dwellings, but a number of tenants still live in traditional tents inside the scheme (mainly the Rashaida). Inadequate and much less extensive social services and amenities were provided for in the development plan compared to those provided in the Nubian Phase 1. However, in the education area in particular, the settlers have shown much initiative themselves and have been able to build a number of schools themselves.

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[9] The Establishment Document of New Halfa Scheme, 1962.

3.2 Economic Background

Among the different objectives of New Halfa Irrigation Scheme is the scheme's contribution to an increase in export earnings through the production of cotton and groundnuts and, by making the national economy less dependent on food imports, through the production of wheat and sugar. While sugar is produced on a state-owned cane plantation, the other crops are grown by tenants on 15 feddans (i.e. 6.3 hectare) farms.

In the context of Sudan's irrigated agriculture the New Halfa Irrigation Scheme is a major project, producing 33 percent of the medium staple cotton, 14 percent of the wheat and 21 percent of the groundnut production in 1975/76. It is thus a nationally important scheme making a valuable contribution to the nation's agriculturally based economy.

In respect to foreign exchange earnings, the scheme also contributes substantially to the country's total earnings and savings. Table 3.3 shows the contribution of the scheme to the country's export earnings.

Table 3.3 Quantity, Price and Value of Exports: New Halfa Scheme, 1976.

	Quantity (tons)	Price (£s/ton)	Total Value (£s million)
Cotton	14,000[a]	421[d]	5.9
Wheat	28,500	64	1.8[b]
Groundnuts	10,000[c]	150[d]	1.5
Total			9.2

Source: Ministry of Finance, Khartoum, 1977.

[a]Quantity of lint

[b]Amount saved of foreign exchange that would have otherwise gone for import of wheat, calculated as c.i.f. (cost, insurance and freight).

[c]Shelled groundnuts

[d]f.o.b. (free on board).

The scheme's foreign exchange earnings and savings are thus estimated at 9.2 million annually, which represented 4.8 percent of the country's total exports in 1976.

Considering the scheme's foreign exchange contribution, plus the thousands of jobs[10] it makes available every year for the in-migrant labor of the west and south regions of the country, we can think of its social benefits as relatively satisfactory, at the national level. This is apart from the scheme's social profitability which refers to the societal returns minus societal costs, the latter two for which I don't have empirical data or estimates.

However, the scheme's economics at the farmer level are unsatisfactory. For cotton the average farmer has actually made a small loss in recent years, a loss which would have been even greater apart from a hidden subsidy to the tenants by the corporation, in the form of low mechanization costs. The position is equally unsatisfactory for wheat and it is only from groundnuts that a satisfactory farmgate level return is obtained. I shall deal with the empirical analysis of costs and returns later in chapter four.

3.3 Review and Critical Analysis of the Scheme: Present Situation

3.3.1 General

Though the original thinking and concepts on which the scheme was based were sound, like many schemes of this size and complexity, difficulties and problems, some of a serious nature, have become apparent with the passing of time. The greater part, though not all of these difficulties and problems are logistical, concerned with the availability of

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[10] Estimated at 45 thousand jobs annually.

agricultural machinery, spare parts and fuel supplies. However, other major constraints to productivity lie in the fields of organization and management, communications (physical), communications and coordination between the various responsible authorities, housing of technical staff, marketing, and the accounting procedures used in determining the returns due to the farmers (Idris, 1976).

To these I would like to add another factor I consider as major, and as equally determinent of production, that is the percentage of active cultivators in the scheme. It is my belief that the participation rate of the farmer and his family in the field work, and the prevelance of absenteeism among the tenants have contributed much to yield fluctuations since the beginning of the scheme. I shall come to this, in detail, later in this chapter.

3.3.2 The situation of the three crops

Generally the scheme has experienced low and fluctuating yields since its establishment in 1964. Having spent some time in the scheme, I felt that we, as management, would only be satisfied if cotton yield reached 0.70 ton/feddan, and wheat and groundnuts yields reached 1 ton/feddan. None of these figures were ever obtained. These figures are based on the costs and returns as well as on the scheme's record of crop production since its establishment in 1964.

To show the yield fluctuations we may look at Figs. 3.1, 3.2, and 3.3.

Figures 3.1, 3.2, and 3.3 clearly show that yields have been too low and continuously fluctuating and when I ran a Master Projection Program (MPJ) through the computer, cotton and wheat yields even showed a tendency to decline.[11] Table 3.4 gives the results of the run.

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[11]The details of this computer program and others are in chapter four.

Figure 3.1 Yield Fluctuations of Wheat, New Halfa, 1964/65 - 1977/78

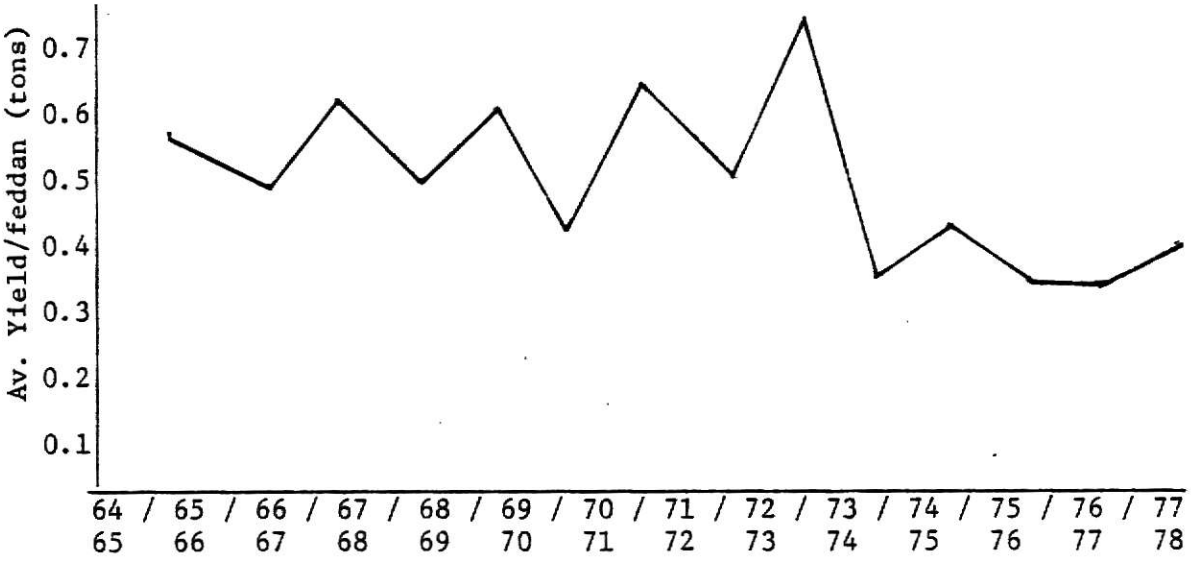

Figure 3.2 Yield Fluctuations of Groundnuts, New Halfa, 1964/65 - 1977/78

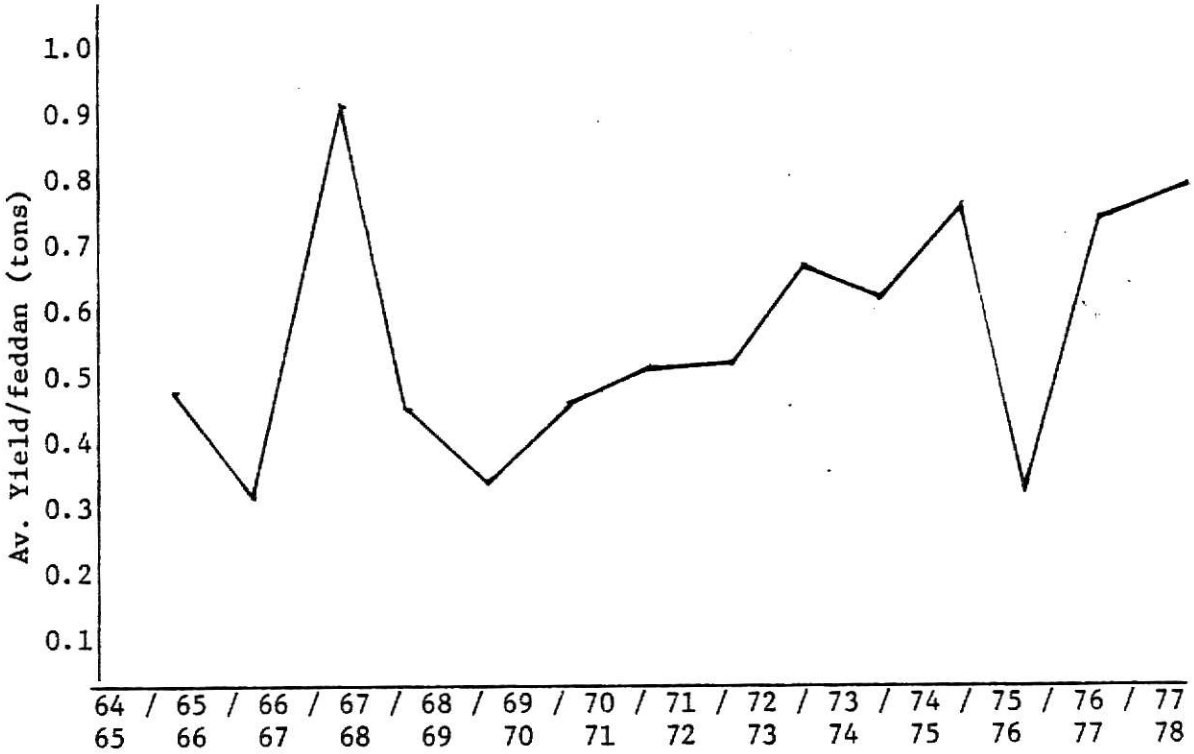

Figure 3.3 Yield Fluctuactions of Seed Cotton, New Halfa, 1964/65 - 1977/78

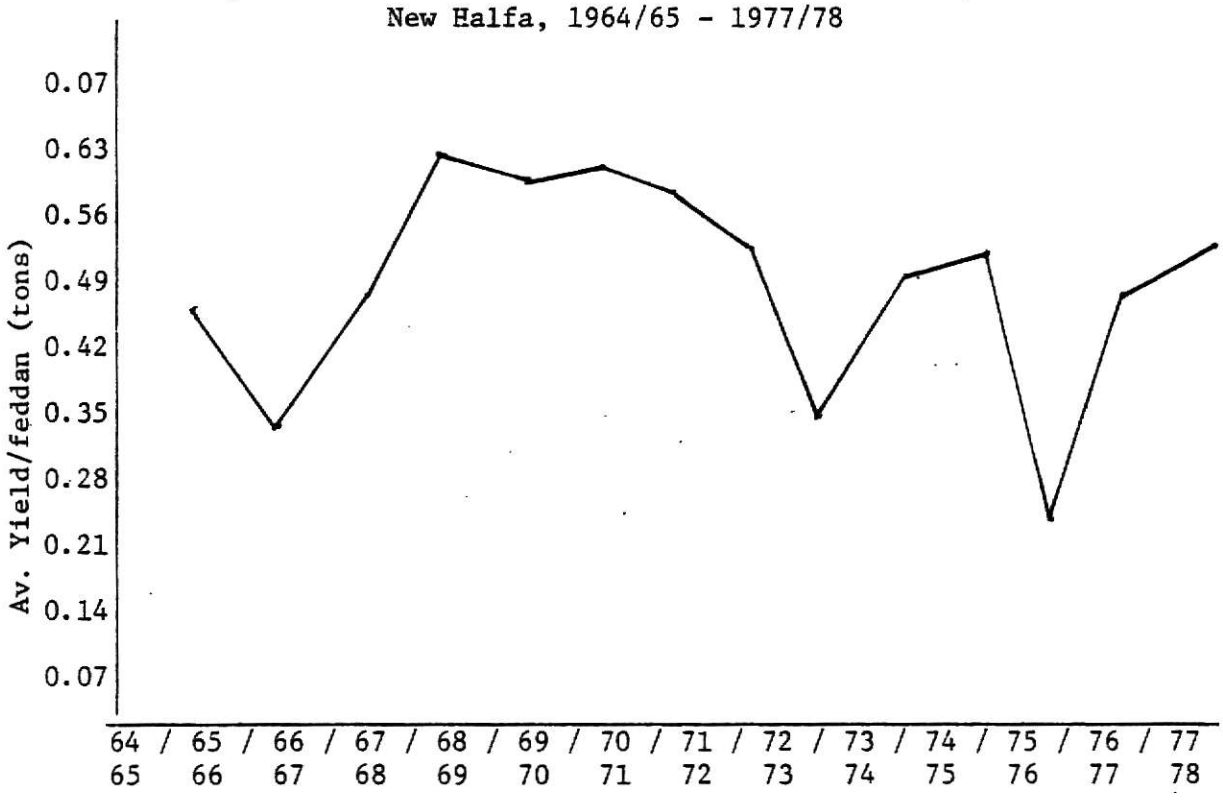

Table 3.4 Actual Average Yields of Cotton, Wheat and Groundnuts (1964-78), with Statistical Projections to 1988, New Halfa Scheme

Year	Actual Average Yields (tons/feddan)		
	Cotton	Wheat	Groundnuts
1964	0.494	0.450	0.500
1965	0.353	0.400	0.200
1966	0.508	0.750	0.960
1967	0.691	0.390	0.460
1968	0.659	0.480	0.340
1969	0.677	0.350	0.460
1970	0.639	0.520	0.510
1971	0.579	0.410	0.520
1972	0.369	0.600	0.700
1973	0.547	0.280	0.670
1974	0.567	0.350	0.800
1975	0.251	0.280	0.320
1976	0.570	0.315	0.600
1977	0.520	0.260	0.450
1978	0.540	0.320	0.690
	Projected Average Yields (tons/feddan)		
1979	0.504	0.276	0.616
1980	0.501	0.250	0.624
1981	0.498	0.232	0.633
1982	0.494	0.214	0.642
1983	0.491	0.197	0.651
1984	0.488	0.179	0.660
1985	0.484	0.161	0.668
1986	0.481	0.144	0.677
1987	0.478	0.126	0.686
1988	0.474	0.108	0.703

Projected yields of wheat in Table 3.4 are sharply declining while those of cotton are slightly declining, and it is only in groundnuts that the projected yields are showing a tendency to rise.

3.4 Factors Contributing to Low Crop Productivity

Like many schemes of its size and complexity, the New Halfa Scheme is facing difficulties and problems, some of a serious nature.

These problems and production constraints led to low and fluctuating levels of crop production. The principal ones that led to these failures appear to cover such major areas as the irrigation system, agricultural engineering and fuel supply, infrastructure (housing, roads, telecommunication, etc.), absenteeism and off-scheme interests, marketing and prices as well as organization and management.

3.4.1 Irrigation

Two factors can be recognized within the irrigation system of the scheme that affect crop yields and productivity. These are the dam and rainfall variability.

3.4.1.1 The dam

Irrigation water is provided by seasonal regulation of the Atbara river, a tributary of the Nile, which rises in the Ethiopian highlands. The project is allocated 1.62 milliard m^3 per year of Sudan's share of the Nile Basin Waters. The dam at Khashm el Girba, 55 m high, retains an 80 km long reservoir with an original storage capacity of 1.3 milliard m^3 per year. Sedimentation (siltation), a serious problem in Sudan not only for this reservoir, has reduced the live storage to 0.90 milliard m^3 in 1977 and is expected to be reduced to 0.50 milliard m^3 by 1997 (Osman Idris, 1978). The inflow of water from the Atbara river varies from about 5,000 - 7,000 million m^3/month in August to nil flow in February - May. Desiltation is carried once or twice every year, and it is done only for the dam gates. The operation usually takes about a week, a time during which the scheme faces water shortages.

Hydro-electric power is generated at Khashm el Girba dam, but at times this conflicts with the water needs of the scheme. Power is

also required by the Scheme itself. During the 1960s, with the reservoir relatively unsilted and the project not fully developed, the irrigation demands were less than at present. At that time the situation was distinctly advantageous from the power generation point of view.

As the irrigation demand built up with the completion of the phased construction of the project, and the reservoir capacity was reduced by siltation, the availability of water for power generation became far more limited. This situation was made more critical by the introduction of a pumped extension to the project with a significant additional electric power demand.

If we are to intensify the crop rotation of the scheme, then alternative sources of stored water have to become available. One of these sources is the implementation of the proposed Upper Atbara new dam, which the government is now seriously considering. It has also been found (according to the Ministry of Irrigation Engineers) that between 1974 and 1978 the average water consumption of the scheme was 1.39 milliard m^3 per year and that the water requirement was only 1.24 milliard m^3 per year. This is an excess of 12 percent of wasted water which has to be reduced drastically in the future, through better and strict water controls and regulations. The drainage system which is practiced now at the field level, in my opinion, is in fact undesirable as it would encourage greater wastage of irrigation water. To sum up, we need the following:

(1) Construction of the Upper Atbara new dam to increase the upstream storage.

(2) Better and stricter irrigation water control to minimize water wastage.

(3) Additional ditching and canal clearing equipment to facilitate better flow of irrigation water, and to control weeds as well.

These, I believe, will solve the irrigation water scarcity which has primarily had its effect on the wheat crop which is the last to be harvested (in April): wheat is supposed to have at least 7-8 waterings, but it never gets more than 4 waterings during the growing season. During 1972, only half the area allocated for wheat was actually sown because of the water problem, but so far, due to the tenants reluctance to cultivate groundnuts (reasons discussed later), crop water requirements have not been considered a constraint on the overall scheme operation.

3.4.1.2 Rainfall variability

Crop production also fluctuates enormously due to climatic reasons, and in the nomadic areas, the rate of fluctuation may be as much as plus or minus 30 percent (Osman Idris, 1975). The critical period is July-September when the rainy season starts at the same time as cotton and groundnuts are grown. Precipitation sometimes obstructs agricultural operations and makes access to the fields impossible. 1975 was a typical example of this, when the rains led the scheme to its worst production record of the three crops (Figures 1, 2, and 3). There were continuous rains up to the first week of September, and it was impossible not only to carry out the different operations on time, but also to clear the weeds that grew very fast. When the land dried out and operations could be undertaken, only 25 percent of the tractor force could be operated as a result of shortage of diesel fuel.

3.4.2 Agricultural Engineering and Fuel Supply

The main objective of the Corporation machinery organization is to do all the mechanized operations for the cotton crop. As there are insufficient machines in the private and cooperative sector to do the wheat and groundnuts cultivations the corporation also does a percentage of these. At present this percentage is small.

In a mechanized irrigation project with scheduled production and tight timetables, it is important that the farm machinery, or the vehicle pool, is sufficient and enough to secure satisfactory performance standards, but this is currently not the situation in the New Halfa Scheme.

3.4.2.1 Farm machinery

The farm machinery includes tractors, harvesters, landrovers, and lorries. Looking at these we find that out of a total of 338 tractors (290 Belaruss, 48 Massy Ferguson) in 1975, 243 remained, but of these 190 had outlived their operational span and had become a heavy burden on the budget of the Agricultural Engineering Section. Moreover, for political reasons, imports of Russian spare parts for the Bilaruss had stopped altogether by 1972.

As far as landrovers are concerned, only 103 out of 248 vehicles were running in 1975. Problems associated with these were the lack of spare parts, insufficient or almost non-existent maintenance, plus the fact that most of these cars dated back to the first years of the scheme. This very poor situation adversely affected the ability of the field inspectors and agricultural personnel to supervise the fields.

Regarding harvesters for wheat, the scheme was serviced by two brands, one Russian make and the American John Deere. Due to maintenance

and spare parts problems, the harvesters became very inefficient and underutilized. The results were that a large part of the wheat crop often remained in the fields after harvesting. Recently, in 1976, the Scheme management brought in 50 Swiss made Klass harvesters which have helped considerably.

3.4.2.2 Fuel shortages

During August-September of 1975, when agricultural operations were delayed by the heavy rainfall, an additional problem turned out to be shortage of diesel fuel. Therefore, when the land dried out, only 25 percent of the tractors could actually be used. The railway line between Port Sudan and Khashm el Girba washed out, and when sizeable supplies were about to arrive from Sennar, the Sennar-Khashm el Girba line also washed out (Osman Idris, 1975).

This may sound exceptional, but fuel shortages were a recurrent phenomenon during the four years that followed. In 1976/77 operations for all crops were delayed considerably. Only 80 percent of the cotton tenancies received green ridging.[12] Also land preparation stopped for more than 40 days in January 1977. In addition cotton picking was threatened during the same period, and it was impossible to stop animals entering the scheme. Meanwhile, wheat and groundnut cultivations were delayed, and the fuel for airplanes--which are used for spraying cotton and wheat--did not arrive in time leading thus to widespread outbreaks of pests and diseases on the cotton.

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[12] Two to three weeks after germination of cotton seeds, green ridging is done to help control weeds, facilitate better aeration for seedlings, and help irrigation water passage.

These fuel shortages arise mainly because the scheme lacks the necessary storage facilities. If supplied, the scheme could store its fuel requirements early, before the onset of rainfall.

3.4.3 Weed infestation

The scheme is heavily infested with weeds, most of which are noxious, like Sedge and Nagil (Cyprus rotundus and Cynodon dactylon) and Ankonj (local name). These three types of weeds are difficult to control and they seriously threaten the scheme. The reasons behind this weed infestation are many, such as high rainfall, fallow lands which function as harbors and breeding areas, lack of equipment to service weed control, lack of heavy subsoil ploughs and insufficient allocations for control operations.

A conference was held in 1970 at New Halfa to seek ways of combating the weeds and fully eradicate them, but since that time very little has been done in this field. Clearing of weeds is therefore a budget item that now makes up a large share of the production costs for each tenant.

3.4.4 Roads and telecommunications

In general roads are in a poor condition and funds for maintenance limited. There are no paved roads, even in New Halfa Town, the scheme HQ. During the wet season the majority of the roads become impassable and input supplies to the different sections and divisions of the scheme are very hampered.

The telephone network within the New Halfa Irrigation Scheme covers the whole project area and connects the centers of the Agricultural Corporation and the Irrigation Department in the scheme with

their HQ's in New Halfa Town. This system today hardly functions at all. Lack of maintenance, spare parts, vehicles and poor road connections are the main reasons behind its failure.

3.4.5 Housing

The housing situation in the scheme area is not satisfactory and in almost all the divisions of the scheme the number of existing houses fall far below those required. Table 3.5 shows the housing situation in the scheme.

Table 3.5 The Number of Existing and Required Staff Houses, by Division, 1978[a]

Division	Existing			Required		
	A	B	C	A	B	C
Dibaira	11	17	64	11	37	203
Sasarabe	6	20	22	11	37	203
Sedaira	5	23	33	11	37	203
Dumyat	8	11	6	11	37	203
Sheikh Omer	5	7	40	11	37	203

Source: Osman Idris, 1978.

[a]A, B, and C in the table refer to specific types or classes of houses.

Table 3.5 clearly reveals the severe housing shortage the New Halfa Scheme is facing. This would, of course, affect to a large extent the scheme's staff recruitment program.

3.4.6 Absenteeism and off-scheme interests

In a sample survey carried out by the Corporation in 4 Nubian villages, it was found that 433 tenants (43 percent) worked as farmers

only, 200 tenants (20 percent) lived in the area but combined cultivation with other jobs, 129 female tenants (12 percent) did not work their lands, and 247 tenants (25 percent) were absent from their villages. Table 3.6 shows the effect of participation rates on average yields per feddan in these four villages.

Table 3.6 Participation Rates and Average Yields per Feddan of Seed Cotton, 1975-1977

Village	Percentage of active cultivators[a]	Yield (tons/feddan) by season[b]		
		1974/75	1975/76	1976/77
No. 4	56	0.64	0.31	0.54
No. 7	37	0.55	0.15	0.44
No. 10	56	0.67	0.22	0.47
No. 11	21	0.51	0.10	0.34

Source: New Halfa Scheme Annual Report, 1978.

[a]Those tenants who do the work by themselves, or at least supervise the hired labor.

[b]Average yield by year for village including active and non-active cultivators.

Table 3.6 shows that yields were higher in villages (4 and 10) with a high percentage of active cultivators.

Low family labor input is prevalent in both the Nubian and nomadic areas of the scheme. Nubian women no longer constitute an important part of the agricultural labor force, as they did at Wadi Halfa, the reason being that the fields are far from the villages and are only accessible by car or donkey, the latter never mounted by a Nubian woman. Among the nomads, it is also rare to see women in the fields, particularly among the Shukriya, but cotton picking is often done by the whole family.

The scheme's management feels that there is no doubt, however, that family labor input could be raised inside the scheme, but we must bear in mind the following:

(1) At the present time, it is extremely hard for a tenant to see a clear correlation between labor input, yields and income.

(2) It is also quite clear that the wage differential between what the farmer gets from his tenancy and what he gets from his off-farm job is large enough to convince him not to work his own land i.e. the marginal product of the farmer's own labor is less than off-the-scheme wage rate.

I know farmers in the New Halfa Scheme, and I believe they have tremendous potentialities for being good farmers. There are certain problems which have to be solved among which are the marketing of crops, especially groundnut, and the cotton accounting procedures which, in their present situation, do not allow the farmer to get the proceeds from the sale of his cotton in a timely manner. Also by solving the scheme's chronic problems, such as farm machinery and irrigation system problems, crop productivity could be raised to a point where non-agricultural employment is no longer attractive to the farmers. It is therefore important to eliminate those factors that distort any positive correlation between labor input, yields and income.

3.4.7 Marketing and prices

The cotton is marketed exclusively by the Corporation. Seed cotton is ginned by NHAC's own ginneries in New Halfa. Approximately one third of the lint is sold to domestic textile factories, while the remainder is exported. The by-product cottonseed is sold to oilseed mills in the Sudan for further processing. Physical operations are hampered by the lack of storage facilities and transport facilities

and by power failure in the ginneries.

On the other hand the complicated sharing system of the proceeds from cotton sales has led to a comparatively small income from cotton for the majority of the tenants, with the result that cotton tends to be neglected by them.

Conservative estimates of the proportion of the annual cotton harvest which is just not picked, due to the low incentives for the tenant caused by the present pricing system, range between 10 and 15 percent. Therefore, in order to interest the farmer in cotton cultivation and thus in cotton picking:

(1) The present pricing system should be improved in favor of the farmer. This could be done through removing the excessive export taxes on cotton, and through export incentives similar to those for groundnut.

(2) The Corporation should pay the farmer an advance payment upon delivery of his seed cotton at the collection center, since at present the farmer has to wait up to two years before getting his final payment.[13]

Groundnut marketing, which is solely the farmer's responsibility, faces difficulties of storage and handling facilities which are not sufficient. The tenants also fall victims to local merchants, who work together to keep the prices down. These, and the high cost of production, lead to the farmers reluctance to grow groundnut.

However, the present wheat marketing is characterized by certain circumstances and conditions which result in relatively easy marketing. Among these factors are the existence of a flour mill in New Halfa, the wheat consumption pattern of the Nubians, and the fact that wheat is still imported by the Sudan.

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[13]This happens when the Cotton Public Corporation stores the lint at Port Sudan while waiting for the cotton international prices to improve.

4. NEW HALFA SCHEME: REHABILITATION PROJECT

Discussion in Chapter 3 revealed that the New Halfa Irrigation Scheme is faced at the present with some major problems and production constraints, resulting in low yields and productivity. These problems cover the areas of:

(1) Agricultural engineering and fuel supply which include:
   a. Farm machinery
   b. Fuel shortages

(2) Irrigation system includes:
   a. The dam
   b. Rainfall variability

(3) Infrastructure which includes facilities as:
   a. Housing
   b. Roads
   c. Telecommunications

(4) Marketing and prices

(5) Absenteeism and off-scheme interests

(6) Organization and management.

Yields have been very much affected as a result of these problems, and consequently farmers and Government incomes are much lowered.

Considering domestic demand and export requirements, crops grown in the New Halfa Scheme are among the most important primary products the Sudan is relying upon. To demonstrate their importance, Table 4.1 shows the national production targets for cotton, wheat and groundnuts.

To obtain such targets, the country's strategy for development should emphasize vertical expansion that aims at optimizing resource utilization in the existing schemes, amongst which is the New Halfa Scheme. And this is an attempt, from my part, to rehabilitate the

New Halfa Scheme, with the objectives stated at the end of Chapter one.

Table 4.1 National Production Targets for Cotton, Wheat, and Groundnuts

Area in thousands feddans, yield in Kgs per feddan, output in thousands MT

	1974/75 Actual			Base year 1976/77 (Provisional)			Target - 1982/83			
Crop	Area	Yield	Out-put	Area	Yield	Out-put	Area	Yield	Out-put	% Ann. incr.
Cotton										
Long staple	856	617	529	760	635	483	790	707	559	2.5
Medium staple	222	459	102	210	500	105	350	849	297	18.9
Short staple	141	116	16	155	122	19	350	200	70	24.3
Wheat	591	461	269	622	500	311	890	750	668	12.6
Ground-nuts	1,792	519	930	1,840	456	839	2,900	541	1,568	11.0

Source: Production Targets of the Six Year Plan 1977/78 to 1982/83.

4.1 A Ten-Year Rehabilitation Project

The Project comprises an input package that includes the following fund allocations:

(1) Agricultural Machinery:
The scheme's farm machinery situation is poor, especially tractors and vehicles (Landrovers). There are 19 inspectorates in the scheme with an average rotation area of more than 15 thousand feddans each. For these inspectorates to handle these areas and carry out the agricultural operations in time, each of them would need 9 tractors (with linkages)

and at least 4 vehicles, a situation I believe would be excellent. The supply of other farm machinery would be a pool for the scheme as a whole; these include such items as D_7 and D_8 crawler tractors, canal maintenance equipment, abu 6 and abu 20 ditchers...etc. The heavy crawler tractors (sub-soilers) help renew the soil by bringing new soils from beneath (they go 14" deep), as well as controlling weeds and soil pests. Table 4.2 shows the details of the farm machinery input package.

Table 4.2 Agricultural Field Machinery Required, with Estimated Costs and Prices

Item:	No.	Unit cost (£s)[a]	Total cost (£s)
70 HP Wheeled tractor	180	5,590	1,006,200
Linkages (plows)	120	1,060	127,200
Groundnut combine harvester	75	9,210	690,750
Wheat combine harvester	50	19,850	992,500
Abu 6 ditcher	20	585	11,700
Land leveller	20	2,430	48,600
$D_{7,8}$ crawler tractor	10	67,110	671,100
Deep blading implements	10	7,740	77,400
Abu 20 ditcher	10	5,840	54,400
Canal maintenance equipment			693,150
Vehicles	70	9,200	644,000
Total			5,021,000

[a]Financial prices at 1977/78 constant prices. Estimates of prices are taken from the Wad Salman Project Feasibility Study, 1978.

(2) Housing:
Table 3.4 showed the poor situation of housing in the scheme. Based also on estimates put for the Wad Salman Project (conditions are similar in both schemes), I put the following fund allocations for housing in New Halfa Scheme.

Table 4.3 Type, Number and Cost of Houses Required

Type of house	No.	Unit cost (£s)	Total cost (£s)
A	12	24,240	290,880
B	70	8,170	571,900
C	200	4,590	918,000
		Total	1,780,780

(3) Warehouses and Fuel Storage Tanks:
Most of the scheme's fertilizer and chemicals[14] are presently kept on open land, thus exposed to the sun and bad weather conditions. This leads to chemical deterioration as well as physical losses. Fuel storage tanks help reduce the hazard of gasoline shortages during the rainy season. For 5 warehouses and 5 fuel storage tanks (stationary) I put an estimate of £s 1,240,000.[15]

(4) Roads:
They constitute bottlenecks, especially during the wet season when the majority of them become impassable thus hampering input supplies to the different sections and divisions of the scheme. The estimated input figure for roads is £s 1,350,000 which will cover the distance of approximately 300 miles of major roads as well as a large number of feeder roads which are as necessary as these major roads.[16]

(5) Workshops:
Presently there is one main workshop in the New Halfa Town (The Mechanical Engineering Section). Tractors and vehicles

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[14]Include insecticides and herbicides.

[15]Estimates of inputs are based on the components of the New Halfa Scheme Annual Budget of 1977/78.

[16]These and following other estimates are based on the estimates of the Wad Salman Feasibility Study (Sir M. Macdonald and Partners, 1978).

used to be sent for repairing to New Halfa from the distant scheme divisions. This takes time and incur unnecessary costs. So, the construction of 5 workshops at the division HQs would take care of, at least, the minor repairs. This will save both money and time. Input allocation for these workshops is estimated at £s 1,050,000.

(6) Storage and Marketing Facilities.
These would be mainly for wheat and groundnuts. Presently these facilities are lacking with the result that tenants fall victims to the local merchants when the farmers are forced to sell the crop at low farmgate prices as they lack the ability to store or transport the crop to New Halfa. The estimated input for building 5 division-located warehouses plus 10 trucks, is £s 970,000.

(7) Telecommunications:
The telephone network, as it is now in the scheme, hardly functions at all. The system is of vital importance to the scheme as it connects the different scheme divisions with the HQ at New Halfa. It is expected to speed up decision-making, save time and effort, provided it works efficiently. The estimated fund for this is £s 120,000, which is expected to cover the purchase of some spare parts as well as 5 motor vehicles to facilitate and speed the repairing process in each of the scheme's 5 divisions.

(8) Experimental Farm & the Whitefly Program:
The purpose of the experimental farm is to investigate and evaluate crop production techniques followed now in the scheme for the purpose of further suggestions to improve the cropping situation. The farm is to deal with the following areas: agronomy, soils and water, agricultural engineering, training and extension.

In the early 1960s, the whitefly (now the major pest of cotton) was still controlled with one or two sprays. However, since 1968, 6 to 7 sprays have been applied annually with no better results since the fly usually remains throughout the growing season. The whitefly has serious effects on yield as well as grade of cotton (stickiness) and, of course, as a consequence affect the cotton price both nationally and internationally. The fund allocation for the experimental farm and the whitefly research program is estimated at £s 1,749,000.

(9) Rural Water Supply:
Of the scheme's 33 nomadic villages, only 4 have been provided with cylinder filters. The state of village

water supply, at the present, is quite poor and villagers take their water directly from the irrigation canals-- a situation which is hazardous to their health and results in intestinal diseases (canal water is polluted most of the time). This is mainly in the nomadic area. For the construction of 20 new filters and to provide the nomads with clean water I put an estimate of £s 750,000.

(10) Health:
Health services are not sufficient and the few existing ones have not been appropriately maintained due to lack of staff, inefficient procedures, shortage of supplies, equipment and transportation. Malaria is almost becoming an epidemic. Investment costs for health (buildings, equipment, vehicles) were estimated as £s 460,000.

(11) Administration, Supervision & Training:
Being the primary body for executing this project, members of the administration of the New Halfa Scheme should receive more emphasized training. Staff should be trained and strengthened, especially in the areas of irrigation, crop production, agricultural engineering as well as the financial management of the scheme. In-service training should be expanded and more staff be recruited. The estimated investment figure for this is £s 535,000.

4.2 The Economics of the Scheme: With and Without Project

"While projects aiming at horizontal expansion of agricultural production largely achieved their objectives, those aiming at increased productivity succeeded only partially and in some cases productivity actually went down. Inadequate capital investment was identified as the main cause, and this was at least partly due to the lack of basic infrastructure and supporting services." (ILO, 1976)

For such schemes as New Halfa Scheme, if to survive economically, then long term priority must be to significantly raise the yields per feddan and the net return to the farmers. At present the farmers economic situation is poor and the average farmer may receive negative returns. Table 4.4 shows the present production situation of the three crops.

Table 4.4 Acreage, Yields and Production of Cotton, Wheat and Groundnuts 1977/78 (Without Project)

Crop	Acreage (feddan)	Yield (in tons/fed.)	Production (in tons)
Cotton	102,800	0.54	55,512
Wheat	94,900	0.30	28,470
Groundnuts	51,400	0.64	32,890

Source: Osman Idris, 1978.

Knowing that the rotation in the scheme is an intensified 3-course rotation, then from Table 4.4 we can see that the areas alloted to wheat and groundnuts are not fully utilized. These fallow lands act as breeding areas for weeds and crop pests plus, of course, the opportunity cost of leaving them uncropped (groundnuts is a legume and is meant to regenerate soil fertility).

The situation of crop production with the Project can be demonstrated by Table 4.5. Table 4.5 shows that the crop intensity is increased for the three crops. The percentage increase in acreage is 2 percent, 10 percent and 39 percent for cotton, wheat, and groundnuts respectively. The table also shows that production objectives include a target of 0.682 ton/feddan for cotton, 0.485 ton/feddan for wheat and 0.887 ton/feddan for groundnuts. If we know that the scheme obtained an average yield of 0.691 ton/feddan for cotton in 1967/68, 0.61 ton/feddan for wheat in 1972/73 and 0.96 ton/feddan for groundnuts in 1966/67, with its present production constraints, then the targets which I put

(provided the investment input is forthcoming) would seem quite conservative and most liable to be obtained, if not surpassed.

Table 4.5 Acreage, Yields and Production of Cotton, Wheat and Groundnuts (With Project)

	Cotton		Wheat		Groundnuts	
Project Year	Area (feddan)	Yield (tons/fed.)	Area (feddan)	Yield (tons/fed.)	Area (feddan)	Yield (tons/fed.)
1	105,100	0.560	105,100	0.320	94,100	0.700
2	105,100	0.567	105,100	0.340	94,100	0.752
3	105,100	0.581	105,100	0.370	94,100	0.780
4	105,100	0.590	105,100	0.400	94,100	0.820
5	105,100	0.600	105,100	0.430	94,100	0.864
6	105,100	0.614	105,100	0.470	94,100	0.887
7	105,100	0.630	105,100	0.485	94,100	0.887
8	105,100	0.665	105,100	0.485	94,100	0.887
9	105,100	0.682	105,100	0.485	94,100	0.887

Table 4.5 also shows that the target for cotton is reached in the final year of the Project. I assumed here that the benefits from the whitefly research program would be maximized by the end of the Project. Wheat and groundnut targets reached in the 7th and 6th years of the Project respectively, would be due to the effect of application of more careful and sufficient land preparation, enough irrigation as well as provision of extension services especially on wheat to the nomads.

The Project objectives can, therefore, be summarized as the following:

(1) to intensify the rotation of the three crops.

(2) to obtain production targets of 0.682 tons per feddan, 0.485 ton per feddan and 0.887 ton per feddan for cotton, wheat and groundnuts respectively.

The economic feasibility of the input package will be tested using the following computer programs:

(1) Internal Rate of Return Program (IRR)

(2) Financial Statement Program

(3) Financial Rate of Return Program (FRR)

4.3 Procedures and Analyses

4.3.1 The Internal Rate of Return (IRR)

This program is used to measure the earning power of total capital investment, regardless of how the enterprise is financed and how the earnings are distributed. The rate of return is calculated by solving for "r" in the formula:

$$I_o + \frac{I_1}{1+r} + \frac{I_2}{(1+r)^2} + - - - - - + \frac{I_n}{(1+r)^n} =$$

$$B_o + \frac{B_1}{1+r} + \frac{B_2}{(1+r)^2} + - - - - - + \frac{B_n}{(1+r)^n}$$

where:

I is defined as the schedule of total investment, including replacement of depreciable assets as needed,

B is defined as the schedule of net earnings before depreciation, interest payments and income tax.

The total capital outlay, except for replacement, should be entered only once in the investment schedule.[17] The replacement of worn-out equipment

[17]This is a specification of this program which probably understates the IRR relative to scheduling investment over the life of the Project.

and other depreciable assets should be entered in the appropriate period at the net replacement cost (total cost minus any recovered salvage value for the replaced equipment). The remaining depreciated value of fixed assets at the end of the last accounting period is entered in the following period as a negative outlay.

Input data for this program are shown in Table 4.6.

For the purpose of sensitivity analysis of the Project components, I employed the following six alternatives to the base case:

(1) Outlay of facility increased by 10 percent.

(2) Outlay of facility decreased by 10 percent.

(3) Capital outlay (facility investment, equipment investment and working capital) and revenue increased by 10 percent.

(4) Capital outlay and revenue decreased by 10 percent.

(5) Outlay for equipment increased by 15 percent; cotton sales decreased by 1.4 percent; wheat sales increased by 4.7 percent; groundnuts sales increased by 2.85 percent.

(6) Operating expense increased by 7.2 percent.

The results of the IRR came out as follows:

(1) The base case gave an IRR of 18.51 percent, which I considered reasonable, and later used for the financial statement program.

(2) The Project seemed to be insensitive to changes in outlay of facilities when it gave a minor decrease of 1.35 percent for alternative 1 and a minor increase of 1.51 percent for alternative 2.[18]

(3) However, the Project proved to be sensitive to changes in revenues giving an increase of 7.3 percent for alternative 3 and a decrease of 9.18 percent for alternative 4.

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[18]Deviations are measured from the value of 18.51 percent of the base case.

Table 4.6 Input Data for IRR Program, New Halfa Scheme Rehabilitation Project[a]

Period	Costs				Revenues[b]		
	Facility invest.[c]	Equip. invest.[d]	Working capital	Operating expense	Cotton sales	Wheat sales	Groundnuts sales
1978	10004.	5021.	0.	0.	0.	0.	0.
1979	0.	0.	186.	12459.	7840.	2258.	4167.
1980	0.	0.	0.	12459.	7938.	2400.	4477.
1981	0.	0.	0.	12459.	8134.	2612.	4643.
1982	0.	0.	0.	12459.	8260.	2823.	4881.
1983	0.	0.	0.	12459.	8400.	3036.	5142.
1984	0.	0.	0.	12459.	8596.	3317.	5280.
1985	0.	0.	0.	12459.	8820.	3423.	5280.
1986	0.	0.	0.	12459.	9310.	3423.	5280.
1987	0.	0.	0.	12459.	9548.	3423.	5280.
1988	-3874.	0.	-186.	0.	0.	0.	0.

[a]All figures are in £s 1000.

[b]Calculated by multiplying areas and average yields in Table 4.5 by the following prices: cotton = £s 133.2 /ton; wheat = £s 67.15 / ton and groundnuts = £s 63.26.

[c]The total investment cost of items (2) to (11) discussed under section 4.1.

[d]Total investment cost of farm machinery.

(4) Alternative 5 gave a very slight decrease of 0.19 percent, the reason being that the increase in outlay of equipment plus the decrease in cotton sales is offset by the increases in wheat and groundnuts sales.[19]

(5) As for alternative 6, the Project showed some sensitivity by giving a 5.9 percent decrease when increasing the operating expense by 7.2 percent.

4.3.2 The Financial Statement Program

This program is designed to develop a proforma financial statement and test the financial viability of projects which have a satisfactory internal rate of return, and it uses as its primary input requirement data used in computing the IRR.

I ran this program to determine depreciation schedules for buildings, warehouses, roads, equipment and other outlays of facility investment; borrowing situation and repayment; total interest payments over the life of the Project; and other fund statements e.g. paid-in-capital, capital reserves and capital surplus (these three forms of capital constitute the total equity capital which is the net worth of capital earned within the Project).

Table 4.7 shows the input data for this program. Data in Table 4.7 is used in addition to the input data of the IRR run, and summary of the output can be seen in Table 4.8.

4.3.3 The Financial Rate of Return (FRR)

This program is used to measure the earning power of equity capital (paid-in-equity + capital reserves + capital surplus) in the enterprise after payment of all depreciation, interest and income tax expense.

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[19] I expect, in the future, the prices of cotton to decrease while those of wheat and groundnuts to increase, the former effect being offset by the latter. And it is for this reason that I kept the prices of the three crops constant throughout the Project period.

Table 4.7 Input Data for Financial Statement Program, New Halfa Scheme (in £s 1000)

Period	Land[a]	Buildings[b]	Warehouses[b]	Roads[b]	Equipment	Others[b]
1	1260.	450.	0.	500.	5021.	2150.
2	1800.	750.	270.	250.	0.	888.
3	0.	581.	0.	150.	0.	600.
4	0.	0.	780.	150.	0.	400.
5	0.	0.	0.	100.	0.	400.
6	0.	0.	190.	100.	0.	370.
7	0.	0.	0.	50.	0.	370.
8	0.	0.	0.	50.	0.	250.
9	0.	0.	0.	0.	0.	206.
10	0.	0.	0.	0.	0.	0.
Asset life		25	30	10	7	4
Percent salvage		5	7	1	5	10

[a]Fixed asset, not included in total investment cost.

[b]The sum of these give the total facility investment in Table 4.6.

Table 4.8 Output of Financial Statement Program, New Halfa Scheme Project

Period	Paid-in equity	Capital reserve	Capital surplus	Interest payments	Depreciation rate
1978	0.	0.	- 1807.	0.	1808.
1979	772.	0.	- 306.	565.	1547.
1980	1579.	37.	184.	843.	1144.
1981	1669.	152.	762.	723.	683.
1982	0.	267.	1333.	429.	408.
1983	0.	339.	1695.	356.	373.
1984	0.	0.	2088.	197.	361.
1985	0.	0.	2324.	81.	335.
1986	0.	0.	2495.	51.	514.
1987	0.	0.	2606.	123.	457.
1988	-4020.	-795.	-11374.	0.	0.

Table 4.9 gives the input data for the FRR program.

I did two runs; in the first one I left the capital surplus as it was in the proforma run (Table 4.9) and I got 43.22 percent financial rate of return. However, in the second run, and starting from the 6th year of the Project, I put zero value for the capital surplus throughout the rest of the Project period. I made this on the assumption of reinvesting this same capital surplus elsewhere or plowing it back into the Project. And that is why this second run (which I recommend) gave me a 54.42 percent financial rate of return.

Table 4.9 Input Data for FRR, New Halfa Scheme Project (in £s 1000)

Period	Paid-in equity	Capital reserve	Capital surplus	Operating expense	Interest payments	Depreciation rate	Cotton sales	Wheat sales	Groundnuts sales
1978	0.	0.	- 1807.	0.	0.	1808.	0.	0.	0.
1979	772.	0.	- 306.	12459.	505.	1547.	7840.	2258.	4167.
1980	1579.	37.	184.	12459.	843.	1144.	7938.	2400.	4477.
1981	1669.	152.	762.	12459.	723.	683.	8134.	2612.	4643.
1982	0.	267.	1333.	12459.	429.	408.	8260.	2823.	4881.
1983	0.	339.	1695.	12459.	356.	373.	8400.	3036.	5142.
1984	0.	0.	2088.	12459.	197.	361.	8596.	3317.	5280.
1985	0.	0.	2324.	12459.	81.	335.	8820.	3423.	5280.
1986	0.	0.	2495.	12459.	51.	514.	9310.	3423.	5280.
1987	0.	0.	2606.	12459.	123.	457.	9548.	3423.	5280.
1988	-4020.	-795.	-11374.	0.	0.	0.	0.	0.	0.

The reasons behind this high FRR could be:

(1) I did not employ an income tax (assuming that this is a public project financed and raised by the Government itself.

(2) The rate of interest on capital borrowed from the Central Bank--Bank of Sudan--is low, which is 9 percent.

4.4 Economic Justification of Project

The New Halfa Irrigation Scheme is the second largest irrigation scheme in the Sudan, following the Gezira Scheme. The economic contributions of such a scheme would, no doubt, be substantial as it currently produces 33 percent of the medium staple cotton, 14 percent of the wheat, and 21 percent of the groundnut production on the Sudan. The scheme's total foreign exchange earnings and savings are estimated at £s 9.2 million annually, which represents 4.8 percent of the country's total exports in 1976.

Besides, the scheme also furnishes a livelihood for some 22 thousand tenants and their families, as well as tens of thousands of jobs for the in-migrant labor from the west and south. Therefore, we can think of the scheme's economics, at the national level, as being relatively satisfactory. But the economics at the farmer level are unsatisfactory; for cotton the average tenant has actually made a small loss in recent years; the position is equally unsatisfactory for wheat and it is only from groundnuts that the farmer obtains some returns. Table 4.10 demonstrates this situation.

Table 4.10 Net Returns to the Farmer From the Three Crops, New Halfa, 1978

	Av. Yield (tons/fed.)	Farmgate Price (£s/ton)	Cost of Production[a] (£s/fed.)	Net Returns (£s/fed.)
Cotton	0.54	133.20	73.40	-1.472
Wheat	0.30	67.15	22.40	-2.255
Groundnuts	0.64	63.26	25.40	+15.086

Source: Scheme's Annual Budget, 1977/78.

[a]Part of the cost includes the farmer's own labor.

However, the effects of the Ten-Year Project could be summarized as follows:

4.4.1 At the tenants level

During the Project, crop intensity as well as average yields of the three crops are increased. Table 4.11 illustrates.

Table 4.11 Crop Intensity and Yields with and without the Project

Crop	Crop Intensity (in %)		Average Yields (tons/feddan)		
	Without Project	With Project	Without Project	With Project	Percent increase
Cotton	93	95	0.54	0.682	26.3
Wheat	85	95	0.30	0.485	61.6
Groundnuts	46	85	0.64	0.887	38.6

If we keep prices and cost of production at 1978 constant prices, then the net returns per ton of output at present and with the Project can be seen in Table 4.12.

Table 4.12 Gross Value and Net Returns of Output per Tenancy[a] Before and After Project

	Gross returns (£s)		Net Returns (£s)	
	Without Project	With Project	Without Project	With Project
Cotton	359.64	454.20	- 7.36	87.20
Wheat	100.73	162.80	-11.27	50.80
Groundnuts	202.44	280.50	+75.44	153.50
Total per tenancy	662.81	897.50	56.81	291.50

[a]A tenancy is equal to five feddans, and the tenant will have, therefore, a total of 15 feddans, five feddans for each of the three crops.

The percent increase in net benefits is more than 400, the reason being that I kept prices and cost of production constant throughout the Project horizon. This is an unrealistic situation, since costs of production are expected to go up, cotton prices to go down while there may be an increase in the prices of wheat and groundnuts.

Accordingly, I want to employ the following assumptions:

(1) Cost of production increases by 35 percent.

(2) Price of cotton decreases by 8 percent.[20]

(3) Price of wheat increases by 36 percent.[21]

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[20]I took this estimate from: World Bank, International Cotton Market Prospects, June, 1978.

[21]Foodgrains prices are expected to substantially increase as the World's population is increasing day by day while food production is lagging behind population growth.

(4) Price of groundnuts increases by 4 percent.

The new farmgate prices will therefore be as in Table 4.13.

Table 4.13 Farmgate Prices per Ton at Present and for Project

Crop	At Present	For Project	% Change
Cotton	133.20	122.54	- 8
Wheat	67.15	91.32	+36
Groundnut	63.26	65.80	+ 4

Changes in the cost of production can be demonstrated by Table 4.14.

Table 4.14 Farmgate Cost of Production at Present and During Project, £s per tenancy

Crop	At Present	With Project	% Increase [a]
Cotton	367.00	399.0	15.0
Wheat	112.00	199.0	41.0
Groundnuts	127.00	220.0	44.0
Total/tenancy	606.00	818.0	35.0

[a]Calculated as percent of total increase in cost of production.

Therefore, according to the assumed changes in both farmgate prices/ton and cost of production/feddan of the three crops, we can calculate gross value and net benefits per tenancy by the end of the Project. Table 4.15 illustrates these calculations.

Table 4.15 Gross Value and Net Benefits per Tenancy With and Without Project (£s)

Crop	Gross Value		Net Returns[a]	
	With Project	Without Project	With Project	Without Project
Cotton	417.86	359.64	18.86	- 7.36
Wheat	221.45	100.73	22.45	- 11.27
Groundnuts	291.82	202.44	71.82	+ 75.44
	931.13	662.81	113.13	56.81

[a]Calculated by subtracting cost of production in Table 4.14 from gross values in Table 4.15.

Table 4.15 shows that the farmer has an increase in his cash income of some £s56.3 (98 percent) by the end of the Project.

4.4.2 At the National level

The New Halfa Scheme presently contributes 4.8 percent of the country's total exports. Accordingly, and due to the incremental increases in average yields of the three crops, the £s contribution of the Scheme to the country's foreign exchange earnings may consequently increase.

The investment input and the economic activities accompanying it will add to the employment levels in the area. This is beside the improvements in the social life of the farmers brought by the introduction of new services and social amenities.

The situation as far as foreign trade is concerned is given in Table 4.16.

Table 4.16 Changes in Scheme's Foreign Exchange Contribution Due to the Project

	At Present		After Project	
	Quantity exported (tons)	Value of export (£s million)	Quantity exported (tons)	Value of export (£s million)
Cotton	14000[a]	5.9	18000	7.81
Wheat	28000	1.8	51000	4.64
Groundnuts	1000[b]	1.5	25000	3.80
Total		9.2		16.25

[a]Quantity of lint.

[b]Quantity of shelled groundnuts.

5. SUMMARY AND CONCLUSION

The production record in the New Halfa Irrigation Scheme is very disappointing both to the farmers and the Government. Yields have been too low and continuously fluctuating. Some of them are even showing a tendency to decline (see Table 3.4). A number of factors have accounted for the scheme's crop failures and among these factors the irrigation system, farm machinery, infrastructure, organization and management have been recognized as being major contributors to low and fluctuating yields.

When the 1971-77 Six-Year Plan results were evaluated it was found that projects which aimed at horizontal expansion have succeeded and in fact largely achieved their objectives while those aiming at increased productivity succeeded only partially. Inadequate capital investment and lack of basic infrastructure were identified as the main causes for vertical expansion failure. Among the latter category was the New Halfa Scheme. In spite of substantial investments and experience over a 15-year period, yields and outputs have not been satisfactory, at least at the farmer's level.

There is much room for improvement in the New Halfa Scheme. The potential for higher yields is good, and most of the production limitations can be removed, especially those which are beyond the farmer's control. Irrigation water is scarce, but apart from the siltation of the dam, poor canal maintenance and improper utilization of water are factors which could be controlled. Provision of canal clearing equipment

and strict controls on farmers during irrigation of the crops will save larger amounts of water that would otherwise be lost through evaporation, precipitation and wastage.

The chronic shortages in farm machinery (tractors and vehicles), fuel supplies and the necessary supportive facilities like roads and housing are technical factors which could be solved through sufficient supply and proper maintenance.

Chapter three of this report critically analyzed the situation of crop production in the New Halfa Scheme at the present time, while chapter four deals with the economic analyses and feasibility of a 10-Year Project that comprises an investment package which is meant to meet the limitations in the irrigation system, farm machinery, infrastructure, organization, and management.

The proposed total for facility investment was £s 10.004 million, for farm machinery was some £s 5.021 million, and the total operating expense was £s 12.46 million (based on the current cost of production of cotton, wheat, and groundnuts, the three crops sonstituting the rotation).

The internal rate of return obtained in the base case was 18.51 percent and considered to be satisfactory. Some sensitivity tests were made to test the potential impact of changes in costs and benefits on the base case results. The results of these tests showed that the Project was insensitive to changes in outlay of facilities while it proved to be sensitive to changes in revenues as well as in operating expenses.

As a result, the following assumptions were employed:

1) On the cost side:

   a. The cost of production increases by 35 percent.

2) On the revenue side:

   a. Price of cotton decreases by 8 percent.

   b. Price of wheat increases by 36 percent.

   c. Price of groundnuts increases by 4 percent.

The economics of the Project were calculated based on these assumptions.

Economically, the Project increased the farmer's net cash income by 98 percent by the 10th year while it increased the Government total foreign exchange earnings from the scheme by 76.6 percent, i.e., from £s 9.2 million to £s 16.25 million.

However, to stabilize yields and consequently incomes in the New Halfa Irrigation Scheme, there are some longer-term measures which must be considered in the future and further studied. These will include the cotton account system which must be thoroughly reviewed, the problem of absenteeism and off-farm interests, the labor situation at the family level, and the establishment of credit systems--especially for the wheat and groundnut crops.

BIBLIOGRAPHY

Agouba, M. 1974. The New Halfa Scheme and its Effect on Social Development. Extra-Mural Studies, University of Khartoum, Sudan.

Beshai, Adel A. 1976. Export Performance & Economic Development in Sudan 1900-1967. Ithaca Press, London.

Christie, M. and Scott, G. 1977. Zambia: An Agricultural Development Strategy for the Next 25 Years. EDI Seminar Paper No. 14, World Bank, Washington, D.C.

Department of Agricultural Economics 1974. Sudan Yearbook of Agricultural Statistics. Ministry of Agriculture, Food and Natural Resources, Khartoum.

_____. 1977. Sudan Yearbook of Agricultural Statistics. Ministry of Agriculture, Food and Natural Resources. Khartoum, 1977.

El-Hassan, A. M. 1976. An Introduction to the Sudan Economy. Khartoum University Press, P.O. Box 321, Khartoum, Sudan.

Gaitskell, A. 1959. Gezira: A Story of Development in the Sudan. Faber and Faber, 24 Russell Square, London.

Gusten, Rolf. 1966. Problems of Economic Growth and Planning: The Sudan Example. Springer-Verlag OHG, Berlin.

International Labor Office Geneva. 1976. Growth, Employment and Equity: A Comprehensive Strategy for the Sudan. Populaires, Geneva, Switzerland.

Lees, Francis A. and Brooks, Hugh C. 1977. The Economic and Political Development of the Sudan. Westview Press, Boulder, Colorado.

New Halfa Agricultural Corporation. 1979. General Budget of the Scheme, 1978/79.

_____. 1978. Evaluation of 1976/77. Season Production. Khartoum University Press, Khartoum, Sudan.

_____. 1979. Guide to New Halfa Agricultural Corporation. E Tamaddon LTD. Press, Khartoum, Sudan.

O'Hagan, J. P. 1978. Growth and Adjustment in National Agricultures. (Case Study of the Sudan pp. 205-236). Allanheld, Osmun/Universe Books & Co. Montclair, N.J.

Phillips, R., Schruben, L. W. and Tiao, J. M. 1975. User's Guide to Computerized System for Feasible Agribusiness Development. Volume One: Text and Charts. Food & Feed Grain Institute, Manhattan, Kansas 66506.

_____. 1979. User's Guide to Computerized System for Feasible Agribusiness Development. Volume Two: Computer Programs. Food & Feed Grain Institute, Manhattan, Kansas 66506.

Saeed, Osman I. 1978. New Halfa Scheme: Past and Present. Arrow Commercial Press, Khartoum.

_____. 1975. Evaluation of 1974/75 Season Production. New Halfa Scheme. 1975.

Sir M. Macdonald & Partners and Hunting Technical Services Limited. 1978. Blue Nile Waters Study, Phase IC. Wad Salman Project: Feasibility Study Volume I Main report. Khartoum, Sudan.

_____. 1978. Blue Nile Waters Study, Phase IC. Wad Salman Project: Volume II Supporting reports. Khartoum, Sudan.

Sorbo, G. M. 1977. How to Survive Development: The Story of New Halfa. Khartoum University Press, P.O. Box 321, Khartoum, Sudan.

World Bank 1978. Agricultural Sector Planning Models: A Selected Summary and Critique. A World Bank Staff Working Paper No. 297, 1818 H Street, N.W. Washington, D.C. 20433, U.S.A.

_____. 1978. World Development Report, 1978. The International Bank for Reconstruction and Development/The World Bank, Washington, D.C.

_____. 1978. The Technology of Rural Development. World Bank Staff Working Paper No. 295, 1818 H Street, N.W. Washington, D.C. 20433, U.S.A.

_____. 1978. International Cotton Market Prospects. World Bank Staff Commodity Paper No. 2. 1818 H Street, N.W. Washington, D.C. 20433, U.S.A.

_____. 1979. World Development Report, 1979. World Bank Publications, Oxford University Press.

_____. 1975. Evaluation of 1974/75 Season Production. New Halfa Scheme. New Halfa, 1975.

IRRIGATION AGRICULTURE IN THE SUDAN
NEW HALFA SCHEME: AN EXAMPLE
(A REHABILITATION PROJECT)

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IRRIGATION AGRICULTURE IN THE SUDAN
NEW HALFA SCHEME: AN EXAMPLE
(A REHABILITATION PROJECT)

The Sudanese economy is dominated by agriculture through this sector's contributions to food consumption, economic growth, foreign trade, national income and employment. Agriculture, forestry and fisheries account for over 38 percent of the country's GDP, constitute 95 percent of its total exports and provide 50 percent of the Government revenues.

The objectives of this report are as follows:

1. To state the pivotal position of the agricultural sector amongst the other sectors of the economy, and to define the role played by agriculture in the Sudanese economy i.e. concerning its contribution to foreign exchange earnings, incomes and employment. (Special emphasis is put on irrigation agriculture, being the major contributor of income, employment and Government revenue).
2. A 10-Year Rehabilitation Project of the New Halfa Irrigation Scheme, the second largest irrigation scheme in the country with a gross area of .5 million acres. The Rehabilitation Project is in the form of an input package to be injected throughout the ten years of the Project. The investment package is meant to cover the deficiencies and shortcomings of such

major areas as the scheme's irrigation system, farm machinery, infrastructure (supportive facilities like housing, roads, telecommunications, etc.), organization and management.

The economic feasibility of this investment package has been tested using the following computer programs:[1]

1. Internal Rate of Return (IRR) Program, which measures the earning power of total capital investment.

   Results of this Program:

   Total investment cost £s 15.025 million[2]

   IRR 18.51 percent

2. Financial Statement Program:

   This Program is designed to develop a proforma financial statement and test the financial viability of projects which have a satisfactory IRR.

3. Financial Rate of Return Program:

   Measures the earning power of equity capital (i.e. the net worth of the Project). FRR obtained was 54.42 percent, which is relatively high due to the following reasons:

   (i) how interest rate employed in the run,

   9 percent

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[1] These Programs are designed by Dr. Richard Phillips and others. Food and Feed Grain Institute, Kansas State University, Manhattan, Kansas 66506.

[2] £s1.00 = $2.3 in 1978.

(ii) no income tax was employed, since the scheme is public, raised and financed by the Government itself.

By the end of the Project, the farmers net income would be expected to increase by over 90 percent, the scheme's foreign exchange earnings expected to increase by 75 percent (from £s 9.2 million to £s 16.25 million).