CHAPTER 7

The Macro-Economic Perspectives of the Crop Development Systems in the Gezira Scheme

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7.1 INTRODUCTION

7.1.1 The Setting

Agriculture in Sudan falls into three distinct modes; irrigated, mechanized rain-fed and traditional rain-fed. Closely with these modes there is a development of wide-scale traditional livestock raising. With about 4.3 million feddans (1.8 million hectares) under irrigation, the country has the largest irrigated area in Sub-Saharan Africa. Out of this area under the prevailing crop rotations, about 3.5 million feddans, (1.5 million hectare) is grown annually representing about 14% of the total cropped area under the three farming modes.

The main crops grown in the irrigated Sub-Sector are cotton, sorghum, groundnut and wheat, while the major products in both the mechanized and traditional rain-fed areas are sorghum and sesame. In 1991/92, the irrigated areas represented 11.1% of the cereals area, 4.7% of the oilseeds area, 79.2% of the cotton area, and the entire area grown by vegetables, fruits, legume fodder and pulses, (Appendix 1). Irrigated agriculture in Sudan is still considered as an area of emphasis in the strategy for agricultural development to satisfy both food security and export promotion goals.

Further expansion is thus expected in order to use an additional four million cubic meters of water per day (the remaining portion of the water-sharing agreement with Egypt) to develop one million feddans (0.42 million hectare). Other plans towards more diversified and intensified agriculture are part of the agricultural development strategy.

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7.1.2 The Organization of the Irrigated Schemes

Most of the irrigation schemes were developed under public control. They follow a standardized organizational system giving the Ministry of Irrigation (MOI) the responsibility of the construction,, operation and maintenance of the irrigation facilities, while entrusting the agricultural corporations with the agricultural activities. In each scheme, the management has to keep an individual account for each tenant against which the cost of inputs and services, including the irrigation fees, have to be charged. This system was introduced in replacement of the joint account system based on share-cropping arrangements between the Government and the tenants governing the production of cotton.

By this change in the production relationship, the Government shifted from being a partner sharing costs and revenue of the cotton crop to the position of an owner of an irrigation system collecting only fees for land and water use. In spite of this change in the Government role, the organizational system remained unchanged. The new circumstances encouraged relaxation of applying the rules of order and discipline designed to control land and water use. The rules identify the responsibilities and functions of the different partners in the scheme. They help in implementing the crop production plans under the suggested rotations.

7.1.3 The Cropping Pattern and Water Utilization

The area planted during any season is related to a cropping rotation which is still determined by the scheme management according to the recommendations of the Agricultural Research Corporation (ARC). The management is to formulate an annual working plan to facilitate input availability and assure the delivery of services in a timely manner. It has to pursue the financial related matters and maintain good relationship between the tenants and the financing and marketing agencies.

Watering practices in these schemes follow the requirements of the crop rotations. Both MOI and the Corporation meet at the beginning of each season to discuss the cropping plans and approve its water requirements. Based on the sowing and harvesting dates of each crop, the appropriate watering schedules will be designed. MOI engineers are responsible for setting of the water balances in relation to indents presented by the block inspectors of the Corporation. These indents are based in the requirement of the numbers under crops (a number is a rectangular ninety-feddan field bounded by two minor canals and two channels **"Abu Ishreen"**). Each number is divided into smaller parts watered from a tiny ditch **"Abu Sitta"** that takes water from an **"Abu Ishreen"**. Tenants were laid down in each number as narrow rectangular plots parallel to a minor canal.

7.1.4 The Gezira Scheme and the Decision-Making Process

One-half of Sudan's total irrigated area is in the Gezira Scheme. That is why the scheme is playing a key role in Sudan's economy. It produces 65% of the cotton, 12% of sorghum, 25% of groundnut and 65% of wheat.

Cotton production in the Gezira continues as the main export crop, giving the country a considerable portion of its foreign exchange earnings. The crop occupied 25% of the area in Gezira main (1.2 million feddan) when it was operating at 50% cropping intensity since 1930s till the implementation of the diversification policies at the beginning of the 1960s. The cropping intensity was increased to 67% and the cotton continued to occupy 25% of the area. During this period, the Managil extension (0.9 million feddan) and because of 100% cropping intensity, cotton used to occupy 33% of the area. Later, at the end of the 1980s, Managil also adopted a 75% cropping intensity and cotton started to occupy 25% of the area.

Only at the beginning of the 1990s, and after the change in the cropping intensity (70 -80%), the cotton crop occupied only 20% of the area, at best, both in Gezira and Managil. The cropping intensity, as assessed from the beginning of the 1980s, follows the changes in the crop rotations in Gezira and Managil as follows:

Gezira Main Rotations

(1)	Cotton	Wheat	(Sorghum	G/nut)	Fallow	
	25%	25%	12.5%	12.5%	25%	
(2)	Cotton	Wheat	(Sorghum	G/nut)	Fodder	Fallow
	20%	20%	(10%	10%)	20%	20%
(3)	Cotton	Wheat	(Sorghum	G/nut)	(Fodder Fallow)	Fallow
	20%	20%	(10%	10%)	(10% 10%)	20%

Managil Rotations

(1)	Cotton	Wheat	(Sorghum	G/nut)		
	33%	33%	(17%	17%)		
(2)	Cotton	Wheat	(Sorghum	G/nut)	Fallow	
	25%	25%	12.5%	12.5%	25%	
(2)	Cotton	Wheat	(Sorghum	G/nut)	Fodder	Fallow
	20%	20%	(10%	10%)	20%	20%
(3)	Cotton	Wheat	(Sorghum	G/nut)	(Fodder Fallow)	Fallow
	20%	20%	(10%	10%)	(10% 10%)	20%

Each crop, in each of the above crop rotations, has a different yield target. Based on the target areas during the season, the production programs are to be formulated. On the other hand, each crop has a different combination of inputs. The aggregate of these combinations represents the set of a consumption program for a particular rotation in a particular season. These combinations of inputs are developed within different production technologies for the different crops. Based on the latest technical package developed and recommended by the researchers, a set of organizational programs are to be initiated and implemented for the annual operations to start.

The actual outlay of these production, consumption and organizational programs shape the decision-making process within the system. The policy maker should draw the incentives and dis-incentives structures in which these systems can work successfully to achieve the overall objectives of the economic development strategy. The planner in his capacity, guided by the macro-economic indicators, should know the contribution of the system to economic growth (mainly the effects on income generation and employment).

7.2 THE OBJECTIVE AND THE SIGNIFICANCE OF THE STUDY

Since the diversification and intensification policies have been introduced in the Gezira at the beginning of the 1960s, and reached the peak in the mid 1970s and thereafter, many diagnostic efforts were directed towards assessing their impact on the production and income levels. Although they were useful in providing the inherent basic facts about the system, they fell short in putting a focus on the macro-economic perspectives of the crop development systems in this major irrigated scheme. Although the materials available to the researcher might not help in elaborating on this issue, the significance of this study is to reach some findings towards this goal. So, the objective of the study will be to examine the crop development systems of the scheme during the period 1980/81 to 1993/94. To be more specific, it will highlight the distribution related effects of costs and benefits of the main crops-- cotton, wheat, sorghum and ground-nuts-- and examine the services of the agricultural growth. At the end, it will help in bringing some realistic measures that will include efficiency in resources use, improve the tenant's income and the system viability.

7.3 THE GEZIRA CROP DEVELOPMENT SYSTEMS

7.3.1 The Factors Affecting the Decision-Making Process

Recognizing that the land and water resources are common goods to be collectively utilized by the tenants in the Gezira Scheme, the starting point will be to understand how the local capacities, including tenants and public management agencies, are managing these resources.

During the thirteen years that followed the change in the production relationship in 1981/82, tenants became more aware of risk evasiveness and continued in suing their bargaining position for changing the cropping plans. The factors behind this behavior could be due to poor harvest of one or more crops in the last season, or due a to increased input expenses, or the overall price movements that increase household consumption and reduce their savings.

Researchers are worried from the slow adoption of the recommended technical packages, as well as the accompanying fluctuation in the yields. In some cases, they express their dissatisfaction with the limited funds committed to research and the discouraging low salary scale.

Managers are forced, in many cases, to implement programs they did not formulate and expand their duties beyond the available means. They also feel that they are underpaid. Equally frustrated are the staff of the irrigation agency; being a government department, it is tied with strict rules and regulations while Its finance position is determined and controlled by the Ministry of Finance. Within its jurisdiction to supply water, it could be trapped in a situation of uncertainty, whether the budget allocations will not meet the requirements.

The government in its turn is often pushed to fight many evils at the same time; the prolonged state of unrest in southern Sudan, the repeated occurrence of drought, the continued budgetary and trade deficits, and trying to restructure the economy within this status of instability.

With an understanding of the above features, the economic decision framework under which the Gezira scheme is operating is the result of the interaction of many factors. There are roughly 42 thousand tenants in the Gezira main and 60 thousand tenants in the Managil extension. The standard tenancy in the Gezira main is 40 feddans, but what is prevailing is mostly half this size. In the Managil, the standard size is 15 feddan. According to the crop rotation, the tenants are placed in equal plots at different numbers (90 feddan rectangular plots) i.e. three numbers for three course rotation, four numbers for four course rotation, etc..

The crop calendars and irrigation schedules are as follows:

		Sowing	Irrigation Schedule (400 m^3 every 14 days)
Cotton	M.S	15 July - 31 July	12 irrigation.
Cotton	L.S	End July - 10 August	15 irrigation.
Sorghum		01 July - 15 July	4 irrigation.
G/nut		End April - Early June	10 irrigation.
Wheat		Mid October - End Nov.	8 irrigation.

In practice, there are certain rules which are to be followed for irrigation management in the Gezira scheme. These rules are based on the fact that water released at the headworks of Sennar Dam and conveyed in the main canals of the Gezira and Managil are adequate for crops grown in half of the area of the Gezira system. The boundaries of the responsibilities and functions are as follows:

a) Crop water requirements are based on the recommendations of the Agricultural Research Corporation (ARC).

b) The actual field requirements are based on indents prepared by SGB.

c) The authorized releases are organized by the Gezira Irrigation Operation of MOI.

d) The actual deliveries from the minor canals are controlled by SGB water gaffirs under the supervision of field inspectors who inform the tenants by the time of deliveries to attend their fields.

At the beginning of each season, the cropping plan is approved by the Ministry of Agriculture (MOA), the SGB and MOI determine the crops water requirements. SGB will further look on managing other resources expressed as capital and labor requirements, specially for the cotton and wheat development programs. The magnitude of these two programs and their requirements continued throughout the study period to be decided by the Government and imposed on the system, in spite of the policies and programs pursued towards the liberalization of the economy.

To follow any of the crop development programs, each tenant will be entitled to a package of inputs and services delivered by the scheme management. The only area that is left to the tenants decision is the hiring of labor required for some farm activities.

7.3.2 The Change in the Crop Development Components

A. The Change in the Cropped Land and Productivity

The cropped area and land use intensity in the Gezira for the period 1981/82 - 1993/94 is shown in Appendix 2. Land use intensity varies from 53% in 1983/85 to 75% in 1991/92. The contribution of each crop, as a percentage of the cropping pattern in each year, is calculated in Table 7.1. The continuous reduction in the cotton area and the steady increase in the area of both wheat and sorghum, explain the tendencies towards food security.

To analyze the data on the crop development systems, the period is divided into four segments, with the initial period 1981/82 -1983/84 taken as base period. For comparison, the trend factors were established for area, yield and production in Tables 7.1, 7.2, 7.3, and 7.4, respectively.

Table 7.1. The cropping pattern (%) in the Gezira during 1981-94.

Year	Cotton	Wheat	G/nut	Sorghum	Vegetables	Fod. & oth.
81/82	32.3	19.9	19.6	25.5	2.7	
82/83	42.6	13.7	13.0	28.2	2.5	
83/84	37.0	19.7	10.1	30.5	2.7	
84/85	41.4	-	18.9	37.4	2.3	
85/86	29.6	17.9	7.6	42.7	2.2	
86/87	33.8	14.6	12.3	36.4	2.9	
87/88	31.3	20.6	13.0	31.8	3.3	
88/89	32.1	21.7	8.8	33.8	3.6	
89/90	27.0	29.6	6.0	33.2	4.2	
90/91	17.0	41.7	2.7	34.4	4.2	
91/92	13.6	33.5	2.2	44.6	2.8	3.3
92/93	11.5	33.7	10.7	40.7	3.2	0.2
93/94	10.4	35.9	12.8	37.5	3.0	0.4

Source: Calculated from Appendix 2.

Table 7.2. The crop areas in the Gezira Scheme.

PERIOD	COTTON		WHEAT		G/NUT		SORGHUM		VEGETABLE		TOTAL LAND-USE	
	Ave Area	Trend Factor	Ave Area	Trend Factor	Ave Area	Trend Factor	Ave Area	Trend Factor	Ave Area	Trend Factor	Ave Area	Trend Factor
81/82-83/84	472453	1.00	229742	1.00	183013	1.00	358543	1.00	33425	1.00	1227175	1.00
84/85-86/87	426798	0.90	211183	0.92	155481	0.85	482275	1.34	30584	0.92	1235927	1.01
87/88-89/90	381842	0.81	306286	1.33	116652	0.64	449253	1.17	47508	1.42	1271641	1.04
90/91-93/94	198267	0.42	545757	2.38	106469	0.58	596320	1.66	49644	1.49	1511347	1.23

Source: Calculated from Appendix 2.

Table 7.3. The crop yields in the Gezira Scheme.

PERIOD	COTTON		WHEAT		G/NUT		SORGHUM	
	Av. Yield Ka/Fed	Trend Factor	Avr Yield Ton/Fed	Trend Factor	Avr Yield Ton/Fed	Trend Factor	Avr Yield Ton/Fed	Trend Factor
81/82-83/84	4.53	1.00	0.436	1.00	0.48	1.00	0.392	1.00
84/85-86/87	4.50	0.99	0.423	0.97	0.55	1.15	0.433	1.10
87/88-89/90	4.63	1.02	0.564	1.29	0.58	1.21	0.451	1.15
90/91-93/94	4.33	0.96	0.600	1.37	0.77	1.60	0.690	1.76

Table 7.4. The crop production in the Gezira Scheme.

PERIOD	COTTON		WHEAT		G/NUT		SORGHUM	
	Avr Yield Ka	Trend Factor	Avr Yield Ton	Trend Factor	Avr Yield Ton	Trend Factor	Avr Yield Ton	Trend Factor
81/82-83/84	2130528	1.00	100397	1.00	87846	1.00	140549	1.00
84/85-86/87	1930012	0.91	89330	0.89	85515	0.97	208825	1.49
87/88-89/90	1765966	0.83	172745	1.72	67658	0.77	202613	1.44
90/91-93/94	663190	0.41	327454	3.26	81981	0.93	411461	2.93

B. The Change in the Foreign Exchange Requirement

The two crop development programs that rely heavily on imported inputs are the cotton and wheat programs. Based on the 1992/93 prices, and the technical coefficients in Appendix 7, the overall foreign exchange requirements were calculated for both the initial period (1981/82 - 1983/84) and the final period (1990/91 - 1993/94). The estimates are as follows:

The Cotton Program	**The Wheat Program**	**The two programs**
F. E. Requirement	F. E. Requirement	F. E. Requirement
(US $ 000)	(US $ 000)	(US $ 000)
Initial period 55325	12888	68213
Final period 23236	30616	53852

C. The Change in the Demand for Water

Using the crop water requirements shown in Appendix (8), the total water demand was calculated as an average for each period (Table 7.5). The general trend gives a slight increase in the final period, while it stayed at the same level in the other periods. If the total demand is compared to total supply, expressed as annual releases from Sennar Dam (Appendix 9) at a conveyance efficiency of 87%, the overall water balance looks satisfactory.

Table 7.5. The changes in the demand for water (000 m^3).

Period	Cotton	Wheat	G/Nut	Sorghum	Vegetable	Total	Trend Factor
81/82-83/84	2124000	586790	750849	1101053	318813	4863505	1.00
84/85-86/87	1921500	521803	636585	1478294	299491	4857673	1.00
87/88-89/90	1719000	756738	480051	1377083	463728	4796600	0.99
90/91-93/94	891000	1351896	434918	1827932	483050	4988856	1.03

D. The Changes in the Demand for Labor

If the farm business coefficients are used as shown in Appendix (10), the demand for labor estimates for each crop, and the total demand, then Table 7.6 shows a steady reduction in the use of labor with changes in cropping pattern during the studied period. An overall reduction of 22% is detected in the final period (equivalent to more than fifty thousand job opportunities calculated at an annual rate of 200 man-days for each hired individual). This reduction is attributed mainly to the reduction in the cotton areas. Of course, the implications will go also to other sectors if it is taken into consideration that the cotton sector used to absorb almost 15% of the total labor force in its various activities.

Table 7.6. The changes in the demand for labor (000 Man-Days).

Period	Cotton	Wheat	G/Nut	Sorghum	Total	Trend Factor
81/82-83/84	30680	1495	8912	11739	52876	1.00
84/85-86/87	27755	1372	7549	15761	52437	0.99
87/88-89/90	24830	1989	5698	14682	47199	0.89
90/91-93/94	12870	3549	5162	19489	41070	1.78

7.4 CROP COSTS AND BENEFITS

Efficient and widespread income generation is the most important role of the economy. Therefore, the important issue resulting from growing a crop is the size of the income stream that is realized. It is very important to have favorable macro-environments in which the micro-decisions are to be made. In other words, one can say that the macro policies condition the structure of crop costs and benefits.

After assessing the changes in the crop development components in the preceding section, the costs and benefits of the initial period 1981/82 -1983/84 with the final period 1990/91 - 1993/94 can be compared as shown in Table 7.7 and Table 7.8.

Table 7.7. The crop costs & benefits during 1981/82 - 1983/84 (L.S).

CROP	COST	GROSS RETURN	NET RETURN	NET RETURN PER FEDDAN
COTTON	8929362	13848432	4919070	10412
WHEAT	1984971	2509925	524954	2285
GROUND NUT	1322818	1474407	151589	828
SORGHUM	2115404	1686588	(428816)	(1196)
TOTAL	14352555	19519652	5167097	4328

Table 7.8. The crop costs and benefits during 1990/91 - 1993/94 (L.S).

CROP	COST	GROSS RETURN	NET RETURN	NET RETURN PER FEDDAN
COTTON	3747246	5610735	1863489	9399
WHEAT	4715340	8186350	3471010	6360
GROUND NUT	769558	1375969	606411	5696
SORGHUM	3518288	4937532	1419244	2380
TOTAL	12750432	20110586	7360154	5035

The parameters used in the analysis are those of the farm business estimates in Appendix 10.

7.4.1 Cotton Costs and Benefits

Cotton has the best chance for giving the highest net return per feddan both in the initial period and the final period. Clearly the slight reduction in profitability is due to the slight reduction in yield. Another important result is that while the profitability of cotton was four-and-one-half times that of wheat in the initial period, it is only one-and-one-half times in the final period.

7.4.2 Wheat Costs and Benefits

Wheat production in the Gezira is qualifying itself to a higher ranking position among the Gezira crops. The profitability (73.6%) is already more than doubled when comparing the final period with the initial period. Beyond the level fixed in the five course rotation (20% of the area), wheat will compete with cotton. The decision of more wheat and less cotton should always be weighed against their competitiveness.

7.4.3 Groundnut Costs and Benefits

There is a sharp increase in the profitability obtained in the final period when compared with the initial period. This is mainly attributed to the high yield realized in the final period. Actually, this pushed profitability from 11.5% to 78.8%.

7.4.4 Sorghum Costs and Benefits

In the initial period, the sorghum development program was operated at a loss, while in the final period it's profitability was assured but at a magnitude less than the other three crops. Many theses were developed in the past to reject keeping sorghum within the irrigated sector. But lately, with the development of hybrid sorghum and improvements in some of the local varieties, the tendency is towards grabbing the opportunity of the high yielding varieties and increasing the contribution of the irrigated sector in the production of the main staple food.

7.5 ASSESSMENT OF AGRICULTURAL GROWTH AND ITS SOURCES

7.5.1 The Sources of Agricultural Growth

In the present study, information on agricultural growth and its sources will help to highlight the growth path due to changes in crop rotation, while seeing the effects of these changes on resources use. The estimates calculated for the initial and final periods will be used for this purpose. They will be used to calculate the change in the net return realized for each crop in relation to the different growth sources.

a) That due to change in the area planted with the yield held constant.
b) That due to change in yield on the area planted in the initial period.

The average growth of crop production in the two studied periods, related to each source, were then calculated using the sources of growth expressed in absolute terms and change in percentage which are shown in Table 7.9.

7.5.2 The Analysis of the Growth Rates and Interpretation

The calculation of the growth rate of the studied factors for each crop is shown in Table 7.10.

The expansion of food crops in the irrigated sector at attractive yield levels is reasonable to expect. The other thing is that it is also reasonable when the area under cotton is reduced then expanding the area under wheat to use the excess stored water during winter is also reasonable. But it is also clear that 93.4% of the reduction in the total return of the cotton program, estimated as 62.1%, can be attributed to the reduction in cotton area estimated as 58.0%. The slight reduction in cotton yield had a minor effect. Therefore, the cotton program could easily expand to its limits in the rotation with the possibility of adding to the total return of the overall program. Generally, at higher cropping intensities, with adequate program requirements, a higher return is expected. From the calculations in Table 7.9, the total return changed is 42%, while the total area changed by only 16.3%. About 38.5% is attributed to the change in area, while 52.9% is attributed to the change in yield. This return supports the argument that low input, or even zero input, at lower intensities does not help the objective of improving agricultural growth and farm income. Crop development programs at higher intensities and adequately supported with improvement technologies, are the ones that have to be pushed to achieve higher contribution towards income levels and the balance of payments.

Table 7.9. Sources of growth in absolute terms and change in percentage.

Crop	Initial Period Area Feddan (1)	Final Period Area Feddan (2)	Growth Feddan (3) %	Initial Period Net Ret/Fed L.S. (4)	Final Period Net REt/Fed L.S. (5)	Growth L.S. (6)	Initial Period Total Return L.S. (7)	Final Period Total Return L.S. (8)	Growth L.S. (9) %
COTTON	472453	198267	-274186 -38.0	10412	9399	-1013	4919070	1863489	-3055581 -62.1
WHEAT	229742	545757	316015 +137.6	2285	6360	4075	524954	34710	2946056 +561.2
GROUNDNUT	183013	106652	-76361 -41.7	828	5696	4868	151589	606411	454822 +300.0
SORGHUM	358543	596320	237777 +66.3	1196	2380	3576	428816	1419244	1848060 +431.0
TOTAL	1243751	1446996	203245 +16.3	4154	5087	937	5167097	7360154	2193057 +42.0

The estimates of the growth rates will include the following:

$\Delta A^i Y_o^i$ Effect of change in area with yield held constant = Column(3) x Column (4) ÷ Column (9)

$\Delta Y_i A_o^i$ Effect of change in yield on the area planted in the initial period = Column (1) x Column (6) ÷ Column (9)

$\Delta Y^i A^i$ Effect of change in yield on the change in the planted area = column (3) x Column (6) ÷ Column (9)

ΔV^i Change in the net return of the crop = $\Delta A^i Y_o^i + \Delta Y^i A_o^i + \Delta Y^i A^i$

Table 10: Calculations related to agricultural growth rates by crop (%).

Crop	$\Delta A^{i}Y_{o}^{i}$	$\Delta Y_{i}A_{o}^{i}$	$\Delta Y^{i}A^{i}$	Total
Cotton	-93.4	-15.7	+9.1	100.0
Wheat	+24.5	+31.8	+43.7	100.0
Groundnut	-13.9	+195.9	-81.7	100.3
Sorghum	-15.3 (^{2})	69.4	46.0	100.1
Total	38.5	52.9	9.8	

7.5.3 The Agricultural Growth and the Effect on Water Use

To relate the crop performance with water use, it is important to estimate water use efficiency for the two studied periods. If the vegetable program is excluded, the total net return as estimated for the other four crops will be compared with the total demand for water.

First, the initial period

The total net return	=	516709 (L.S. 000)
The total demand for water	=	45544693 (m^3 000)
The net return per m^3 of water	=	1.145 L.S.

Second, the final period

The total net return	=	7360154 (L.S. 000)
The total demand for water	=	45058063 (m^3 000)
The net return per m^3 of water	=	1.633 L.S.

The result of this analysis indicates that the crop development program for the final period was more remunerative for the water resource used.

7.6 THE MACRO-ECONOMIC PERSPECTIVE

7.6.1 The Structure of the Irrigated Sub-sector

The economy regards agricultural growth as the main source for employment, income generation, and external and internal fiscal balances. In spite of that, there has been periods of decline resulting from insufficient services and negligence of maintenance and replacement of assets, especially in the irrigated sector. Therefore, any improvement in macroeconomic policy will provide better incentives to the stakeholders in the irrigation systems.

From the recent national accounting estimates, irrigated crops contribute with about 58.8% of the total crop production, 34.2% of the agricultural GDP and 11.6% of total GDP. Under favourable conditions, their share in the annual growth rates is the highest compared with the product of other sub-sectors.

The relative importance of irrigated agriculture should be compared to other sectors that provide more stable levels of income and employment opportunities. The shift from cotton to food crops may not have unfavorable impact on income levels, but it disturbs the balance of employment levels.

When analyzing policy options in irrigated agriculture, the decisions to be taken on incentives to foster agricultural growth, and create the required impact on income generation and employment, should be emphasized. This will be followed by well targeted programs for implementation.

7.6.2 The Impact of the Crop Rotations in the Gezira

The crop rotations to be studied are the four course and five course rotations. The main parameters used for comparison are the impact on food self-sufficiency, foreign exchange earnings, and employment opportunities, with the following assumptions: (a) all the wheat, sorghum, fodder and cotton seed produce will be consumed locally; (b) all the cotton lint and the groundnut will be exported; and (c) fodder and sorghum will be treated as similar on the technical coefficients and value of produce. Based on these assumptions, the hypothetical example set for comparison is as follows:

Five Course Rotation	Four Course Rotation	Four Course
Cotton	420000	525000
Wheat	420000	525000
Sorghum/Groundnut	420000	262500
Fodder/Fallow	420000	262500
Fallow	420000	525000
Cropping intensity	70%	75%

Yield estimates relevant to this hypothetical example are as follows:

	5 Course Rotation	4 Course Rotation
Cotton lint	1.4 bale/feddan	1.2 bale/feddan
Cotton seed	0.5 m ton/feddan	0.5 m ton/feddan
Wheat	0.8 m ton/feddan	0.7 m ton/feddan
Groundnut	1.5 m ton/feddan	1.2 m ton/feddan
Sorghum	1.0 m ton/feddan	1.2 m ton/feddan

The expected output will be as follows:

	5 Course Rotation	4 Course Rotation
Cotton lint	588000 bales	630000 bales
Cotton seed	42800 ton	44600 ton
Wheat	336000 ton	367500 ton
Groundnut	315000 ton	315000 ton
Sorghum	420000 ton	315000 ton

A. The Impact on food self-sufficiency

The total human consumption of cereals is 3855000 m.tons and 11800 tons of vegetable oil based on a population of 2570000 (1993 census).

Per capita consumption of cereals is 150 kg (100 kg sorghum 40 kg wheat, 10 kg millet).

Per capita consumption of vegetable oil is 7 kg.

Therefore, the contribution of the Gezira Scheme will be:

	Cereals	Vegetable Oil
Five Course Rotation	19.6%	23.8
Four Course Rotation	17.7%	24.8

B. The Impact on Foreign Exchange Earnings

The gross export earnings from cotton and groundnut are based on the price of US$250 for a bale (average quality) and the same for a ton of groundnut. The expected earnings will be:

	Cotton	Groundnut	Total
Five Course Rotation	US$ 147,000,000	US$ 78,750,000	US$ 225,750,000
Four Course Rotation	US$ 157,500,000	US$ 78,750,000	US$ 236,250,000

The foreign exchange saving from producing wheat and sorghum and cotton seed are calculated as follows:

	Five Course Rotation (000 man-days)	Four Course Rotation (000 man-days)
Wheat	336000x140=47040000	367500x140=51540000
Sorghum	420000x100=42000000	315000x100=31500000
Cotton	42800x50=2,140,000	44600x50=2,230,000
Total US $	91,180,000	85,270,000

	Five Course Rotation (000 man-days)	Four Course Rotation (000 man-days)
Cotton	420000x67=28140000	52500x667=57750000
Wheat	420000x47.5=19950000	525000x47.5=24937500
Groundnut	210000x16.5=34650000	262500x16.5=4331250
Sorghum	4200000x23=9660000	262500x23=6037500
Total US $	61,215,000	70,481,250

Five Course Rotation 316,930,000 - 61,215,000 = US $ 255,715,000

Four Course Rotation 321,520,000 - 70,481,250 = US $ 251,038,750

C. *The Impact on Employment Opportunities*

	Five Course Rotation (000 man-days)	Four Course Rotation (000 man-days)
Cotton	420x65=273,000	525x65=43,125
Wheat	420x6.5=2,730	525x6.5=3,413
Groundnut	210x48.7=10,227	262.5x48.7=12,784
Sorghum	420x23.7=13,734	262.5x32.7=8,458
Total	53,991	58,775

If we consider the total rural force in the Gezira State of 760,000 persons (27% of the country's rural labor force), and a level of agricultural force in the Gezira State estimated as 450,000 persons, then the contribution of the Gezira crop rotation is expressed as follows:

Five Course rotation = 53,911,000 ÷ 200 = 270,000 persons
Four Course rotation = 58,775 ÷ = 294,000 persons

The five course rotation will contribute to 50% of the Gezira State population and the four course rotation to 54%.

D. The Impact on Water Saving Opportunities

The total demand for water for the two sets of crop rotations is calculated as follows:

	Five Course Rotation (000 m^3)	Four Course Rotation (000 m^3)
Cotton	420x4500=1,890,000	525x4500=2,362,500
Wheat	420x2473=1,038,660	525x2473=1,298,325
Groundnut	210x4103=861,630	262.5x4103=1,077,038
Sorghum	420x3067=1,288,140	262.5x3067=805,088
Total	5,078,430	5,542,952

With the application of the amended five course rotation (70% cropping intensity), there is a chance of saving about 464.5 million m^3 of water than when applying the four course rotation (75% cropping intensity).

The general rating from the comparison of the impact of the two studied crop rotations is as follows:

	Five Course Rotation (A)	Four Course Rotation (B)	The Higher Score for
1. Food Self-sufficiency A.1 Cereal A.2 Veg Oil	 19.6% 23.8%	 17.7% 24.8%	 A B
2. Foreign Exchange earnings	US$ 256 Million	US$ 251 Million	A
3. Employment Opportunities	54.0 million man-days	58.8 million man-days	B
4. Water Saving Opportunities	5.08 milliard m^3	5.54 milliard m^3	A

The five course rotation is better, if the expected improvements in yield capabilities are maintained at the levels presented in the hypothetical example. The gap in the employment opportunities will be bridged if higher intensifications are realized according to the original design of the five course rotation (80% cropping intensity). This move towards realizing the 80% cropping intensity should only be taken with firm commitment to the crop sequence. This should be implemented without creating water management problems at any stage of each of the crop development programs.

7.7 SUMMARY AND CONCLUSIONS

The irrigated sector is a major contributor to economic growth in Sudan. The Gezira Scheme stands as its most important irrigation system. On the other hand, the economy regards agricultural growth as vital to generate income and create employment opportunities. To achieve agricultural growth, the macro-economic environment that encourages the use of production improvement technologies is necessary. This implies well-targeted crop development programs be implemented.

Within the Gezira crop rotations, various crop development options were tested during the studied period 1981/92 - 1993/94. Assessment of the macro-economic perspectives was the main theme of the study on the agricultural growth path in the Gezira.

The link of agricultural growth to the changes in area and yield of cotton, wheat, groundnut and sorghum, and the distribution related consequences of costs and benefits, were studied. Cotton was found to be the production possibility with the highest return.

The conclusion that can be derived is that there is still room for yield improvement opportunities, but this could only be structured under favourable macro-economic conditions with incentives to use improvement technologies for achieving higher income levels. At the same time, it was found justified to expand food crops in the irrigated sector at attractive yield levels, but this should always be weighed with other competing crops.

Within the contest of the Gezira crop rotation, the five course rotation at 70% cropping intensity (leaving 50% fallow in the fodder leg of the rotation) has better opportunities than the four course rotation to attain the overall objectives of the economic development strategy. Further increases in cropping intensity are recommended, with the condition that water management problems are avoidable.

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APPENDIX (1)

Agriculture in the Sudan

The situation of the Crops Sub-Sector—Season 1991/1992

	Irrigated *	Mechanized Rain-fed	Traditional	Total
CEREALS				
Sorghum	1394	11277	2130	14,801
Millet	7	183	5250	5,440
Wheat	898			898
Maize	53	4	3	60
Sub Total	2,352	11,464	7,383	21,199
OILSEEDS				
Groundnut	135		640	775
Sesame		1303	705	2,008
Sunflower		77		77
Sub Total	135	1,380	1,345	2,860
OTHER CROPS				
Cotton	351	87	5	443
Vegetables	175			175
Fodder	150			150
Fruits	118			118
Beans	102			102
Lentils	7			7
Sub Total	903	87	5	995
TOTAL	3,390	12,931	8,733	25,054

* Excluding the sugar plantations which represent about 6% of the irrigated farming.

Source: The Advisory Unit for Agricultural Corporations, Ministry of Agriculture Khartoum.

APPENDIX (2)

THE GEZIRA SCHEME

CROPPED AREA AND LAND-USE INTENSITIES

SEASON	COTTON	WHEAT	G/NUT	SORGHUM	VEG	FODDER	SUN FLOWER	TOTAL GROWN	%
81/82	435314	267863	264245	343899	35811			1,347,132	63
82/83	484315	155538	148182	320940	28774			1,137,749	54
83/84	497729	265824	136611	410791	35689			1,346,644	63
84/85	464792	0	212859	420068	25566			1,123,285	53
85/86	400528	242497	102535	578758	30050			1,354,368	64
86/87	415074	179869	151050	448005	36136			1,230,134	58
87/88	383037	252313	159562	390295	40849			1,226,056	58
88/89	404506	274247	110814	426810	45787			1,262,164	59
89/90	357984	392297	79580	440953	55889			1,326,703	62
90/91	251047	613305	39860	506577	61138			1,471,927	69
91/92	215504	532813	35452	709640	45194	29556	21181	1,589,340	75
92/93	174701	514093	163814	621736	49245	733	2100	1,526,422	72
93/94	151815	522817	187146	547329	43000	5333	655	1,458,095	69

Source: Socio-economic Research Unit, SGB.

APPENDIX (3)

GEZIRA SCHEME

COTTON AREA YIELD & PRODUCTION

AREA	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94
ACALA	55425	104955	151120							82377	104483	64726	57174
BARKAT	379889	379360	364609	345298	376109	328443	237992	223281	254876	116364	52946	86438	43791
SHMBAT					24419	56639	145045	181224	103109	52306	58075	23538	50850
TOTAL	415314	484315	515729	464792	400528	415082	383037	404505	357985	251047	215504	174702	151815
YIELD													
ACALA	4.5	509	6.4	7.2						4.1	5.8	3.9	4.2
BARKAT	3.8	4.3	4.3	4.4	3.4	4.7	3.9	4.1	3.7	2.9	5.0	4.4	3.7
SHMBAT					5.4	5.5	5.7	6.5	5.1	5.0	5.8	4.1	3.6
TOTAL	4.9	4.7	4.8	5.1	3.5	4.9	4.6	5.2	4.1	3.7	5.6	4.1	3.9
PRODUCTION													
ACALA	242887	645402	974118							336923	610178	249194	240131
BARKAT	1442634	1611974	1474568	1506894	1271248	1533190	920096	920993	936055	332776	262402	378859	161396
SHMBAT					131863	476515	830383	1176762	522610	263099	337999	96743	183060
TOTAL	1685521	2257376	2448686	2372217	1403111	2147097	2014709	2097755	1458665	932798	1210579	724796	584587

APPENDIX (4)

THE GEZIRA SCHEME

WHEAT: AREA (FED), YIELD (T/FED) & PRODUCTION (TON)

SEASON	AREA	PRODUCTION	YIELD
81/82	267863	87483	0.327
82/83	155760	92969	0.597
83/84	265864.5	103100	0.388
84/85			
85/86	242497.5	97388	0.402
86/87	179869	79918	0.444
87/88	252314	119568	0.474
88/89	274247	154127	0.562
89/90	392297	256955	0.655
90/91	613305.5	269854	0.440
91/92	526814	494152	0.938
92/93	514033.5	269868	0.525
93/94	522817	261408	0.500 (Est)

Source: Socio-Economic Research Unit, SGB.

APPENDIX (5)

THE GEZIRA SCHEME

GROUNDNUT: AREA (FED), YIELD (T/FED) & PRODUCTION (TON)

SEASON	AREA	PRODUCTION	YIELD
81/82	264245	97771	0.37
82/83	148182	60755	0.41
83/84	136611	91529	0.67
84/85	212859	108558	0.51
85/86	102535	55882	0.55
86/87	151050.5	91083	0.60
87/88	158728.25	958978	0.60
88/89	110864	66518	0.60
89/90	79580	42973	0.54
90/91	39860.25	29018	0.73
91/92	35452	28362	0.80
92/93	163418	116027	0.71
93/94	187146	153460	0.82

Source: Socio-Economic Research Unit, SGB.

APPENDIX (6)

THE GEZIRA SCHEME

SORGHUM: AREA (FED), YIELD (T/FED) & PRODUCTION (TON)

SEASON	AREA	PRODUCTION	YIELD
81/82	343899	89414	0.260
82/83	320940	125167	0.390
83/84	410791	216076	0.526
84/85	420068	147024	0.350
85/86	578753.5	318315	0.550
86/87	448005	179202	0.400
87/88	394456.5	141287	0.358
88/89	426810	215112	0.504
89/90	440953.25	216067	0.490
90/91	506577.25	267979	0.529
91/92	725306	477977	0.659
92/93	621736	480602	0.773
93/94	547329	437863	0.800

Source: Socio-Economic Research Unit, SGB.

APPENDIX (7)

INPUT REQUIREMENTS AND 1992/93 PRICE

(FOR THE GEZIRA COTTON AND WHEAT PROGRAM)

	UNIT PRICE US $	UNIT / FEDDAN
A. COTTON		
Fertilizer	200/m ton	80 kg
Insecticides	1.5 per feddan	5 sprays
Herbicides	10.0 per feddan	All area
Land Preparation	10.0 per feddan	All area
Sacks and B. hoops	18.6 per feddan	All area
B. WHEAT		
Fertilizer	200/m ton	100 kg
Insecticides	12.5 one spray	2 sprays
Herbicides	5.3 per feddan	All area
Land Preparation	6.8 per feddan	All area
Sacks and B. hoops	3.0 per feddan	All area

Source: Advisory Unit for Agricultural Corporations, Ministry of Agriculture, Khartoum.

APPENDIX (8)

THE GEZIRA SCHEME

CROP WATER REQUIREMENTS

CROP	M^3/FEDDAN
E1S-Cotton	4887
MS-Cotton	4100
Wheat	2473
G/Nut (Ashpord)	4103
Sorghum	3067
Fodder	6486
Vegetable	9661

Source: ARC -Wad Medani.

APPENDIX (9)

ANNUAL WATER RELEASED FROM SENNAR DAN FOR THE GEZIRA SCHEME (Mm^3)

	Annual Releases[1]	Adjusted at Conveyance Efficiency of 87%	Average
1981/82	6164	5363]	
1982/83	6157	5357}	5388
1983/84	6258	5444]	
1984/85	6086	5295]	
1985/86	5714	4971}	5061
1986/87	5153	4918]	
1987/88	5659	4923]	
1988/89	5752	5004}	5118
1989/90	6244	5432]	
1990/91	6483	5623]	
1991/92	6165	5364]	5390
1992/93	6050	5264]	
1993/94	6102	5309]	

(1) Adjusted from annual releases calendar basis to crop season basis

Source: MOI, Wad Medani.

APPENDIX (10a)

THE GEZIRA SCHEME

COST OF PRODUCTION DATA 1992/93 (LS/FEDDAN)

CROP ITEM	COTTON	WHEAT	GROUNDNUT	SORGHUM
Land Preparation	1562.64	828	728	650
Agric Operations	1239.64	635	1608	1280
Materials Used:				
Seeds	446.4	870	745	100
Fertilizer	1990.1	2300	-	660
Pesticides	9166.27	800	-	-
Sacks	690.29	345	907	490
Sub-total	12293.06	4365	1652	1250
Harvesting & Post harvest	1294.83	1067	2044	1540
Land & Water charge	1400	960	900	9000
Transport	1000.22	790	297	280
Others	109.87	55	-	-
TOTAL	18900.26	8640	7228	5900

Source: Socio-Economic Research Unit, SGB

APPENDIX (10b)

THE GEZIRA SCHEME

THE FARM BUSINESS COEFFICIENTS

A. LABOR

Cotton	65 man-days/feedan
Wheat	6.5 man-days/feedan
G/Nut	48.7 man-days/feedan
Sorghum	32.7 man-days/feedan

B. FARM GATE PRICES (1992/93)

Cotton	L.S. 6500/Kantar seed cotton
Wheat	L.S. 25000/M. Ton
G/Nut	L.S. 16784/M. Ton
Sorghum	L.S. 12000/M. Ton

C. COST OF PRODUCTION (From Appendix 10a) (1992/93)

Cotton	L.S. 18900/Feedan
Wheat	L.S. 8600/Feedan
G/Nut	L.S. 7228/Feedan
Sorghum	L.S. 5900/Feedan

Source: SGB - Barakat.