PCHAPTER FIVE

RESULTS AND DISCUSSION

In this chapter, resource allocation, linear programming and sensitivity analysis, and profitability analysis results are presented and discussed.

5.1 Resources availability and utilization in the Gezira scheme.

5.1.1 Farm labour

Farm labor is one of the most important inputs for agricultural production. Most of the cultural operations in the scheme are done manually, particularly for the summer crops, which need several cultural operations like thinning, weeding, watering, and harvesting …etc.

In the Gezira scheme, both family and hired labour are used by tenants for farm activity. Family labour depends on family size, age, composition, and domestic organization. Hired labour, on other hand, is governed by labor market institutions and tenant's operation capital availability. Hired labours are always used at the peak of high labour requirement. At this period, many operations with which the tenant is less familiar or need much effort take place, e.g. dura cutting and collecting, cotton picking, etc. The hired labour in the Gezira scheme comes from two sources, either local camps resident camps, near the Gezira scheme villages or migrant labour which comes from western Sudan tribes. The payment method for the hired labour varies in the Gezira scheme. In operation like sowing, resowing, weeding and threshing, the payment method is on piece basis. Also, some forms of daily wage and according to productivity payment method prevail for these operations. In cotton picking, the payment method is on per basket (1kantar = 9 baskets approximately). In season 2011, varied from SDG 6.5 to SDG 7 depending on the type of agreement between the tenants and the pickers.

For the purpose of the study, the standard man-day (m.d) was taken as a measurement for labor input, ignoring differences in labor quality. The standard man- day is defined as the effort extended by a healthy adult in the age of 15-64 years in a working day of eight hours. A one- day labor input was assumed to be 0.75 standard man-day for women and 0.5 for children and old persons (Babiker, 2006). Table (5.1) shows average labour used per feddan by crop in the Gezira scheme. As shown in the table, most of the labours used were devoted to the main cash crops, onion and cotton which received 23.5% and 19.26%, respectively of the total labour used, groundnut, chickpea, sorghum and wheat received 18.9%, 15.94%, 15.28%, and 7.12% of the total labour used, respectively.

Table (5.1): Average labour used (m.d) per feddan by crop an average in the Gezira scheme, season 2011/12.

Crops	Family labour		Hired labour		Total labour	
	Average	**%**	**Average**	**%**	**Average**	**%**
Cotton	16.81	19.27	27.08	19.25	43.89	19.26
Sorghum	13.37	15.32	21.45	15.25	34.82	15.28
Groundnut	15.25	17.49	27.81	19.77	43.06	18.90
Wheat	9.25	10.61	6.96	4.95	16.25	7.12
Chick pea	16.36	18.76	19.99	14.20	36.35	15.94
Onion	16.18	18.55	37.39	26.58	53.57	23.50
Total	87.22	100	140.68	100	227.94	100

Source: Field survey, season 2011/12

5.1.1.1 Cotton Labour

Table (5.2) shows the per feddan labour mandays for cotton crop distributed by month and crop activity in season 2011/12. This crop has two peaks of labour requirements. The first peak period coincides with sowing and weeding periods (July – September); which absorbed 57% of the total labour used in cotton production. The second period coincides with cotton picking or harvesting period (January- March), which absorbed about 22.33% of the total labour used in cotton production. As aggregate cotton used 43.89 mandays per feddan, of which family labour contributed only 16.81 mandays, while the hired labour contributed 27.08 mandays per feddan. Most of the hired labour used for cotton was used in operations like weeding, and harvesting (picking, cotton stalk pulling and collecting).

5.1.1.2 Sorghum Labour

Table (5.3) shows the per feddan labour mandays for sorghum crop distributed by month and crop activity in season 2011/12. Sorghum crop has two peaks of labour requirements. The first peak period coincides with sowing and weeding periods (June– September); which absorbed 70% of the total labour used in sorghum production. The second period coincides with sorghum cutting, collecting and threshing or harvesting period which absorbed about 30% of the total labour used in sorghum production. On average, the total labour used for sorghum crop were 34.82 mandays per feddan, of which family labour contributed only 13.37mandays, while the hired labour contributed 21.45 mandays per feddan.

Table (5.2): Labour used for cotton crop by month and by crop activity in (m.d) per feddan in the Gezira scheme, season 2011/12

Activity	Type of labour (m.d)			Months								
	FL	HL	TL	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan..Mar	Apr
Tegant raising	0.83	0.56	1.39	1.39								
Sowing	1.5	0.74	2.24		2.24							
Resowing	0.83	1.4	2.23		2.23							
Thinning	1.63	1.94	3.57			3.57						
Watering	6.95	6.5	13.45		1.7	1.7	1.7	3.4	3.4	1.7		
Weeding	4.64	6.59	11.23		3.7	3.7	3.7					
Fertilizer application	0.43	0.27	0.7		0.7							
Harvesting	0	9.08	9.08							8.1		1
Total	16.81	27.08	43.89	1.39	10.57	8.97	5.4	3.4	3.4	9.8		1

Source: Field survey, season 2011/12

Table (5.3): Labour used for sorghum crop by month and by crop activity in (m.d) per feddan in the Gezira scheme, season 2011/12

Activity	Type of labour (m.d)			Months						
	FL	HL	TL	Jun	Jul	Aug	Sep	Oct	Nov	Dec..May
Tegant raising	0.73	0.55	1.28	1.28						
Sowing	1.58	2.02	3.6	3.6						
Resowing	1.09	1.28	2.37	2.37						
Thinning	1.82	1.47	3.29		3.29					
Watering	3.54	3.75	7.29			1.82	1.82	1.82	1.82	
Weeding	4.27	5.34	9.61			4.81	4.81			
Fertilizer appli-	0.34	0.33	0.67			0.67				
Harvesting	0	6.71	6.71						6.71	
Total	13.37	21.45	34.82	7.25	3.29	7.3	6.63	1.82	8.53	

Source: Field survey, season 2011/12

5.1.1.3 Groundnut Labour

Table (5.4) shows the per feddan labour mandays for groundnut crop distributed by month and crop activity in season 2011/12. Groundnut crop has two peaks of labour requirements. The first peak period coincides with sowing and weeding periods (June– September); which absorbed 71% of the total labour used in groundnut production. The second peak period coincides with groundnut pulling, collecting and threshing or harvesting period which absorbed about 29% of the total labour used in groundnut production. On average, the total labour used for groundnut crop were 43.06 mandays per feddan, of which family labour contributed only 15.25 mandays, while the hired labour contributes 27.81 mandays per feddan.

5.1.1.4 Wheat Labour

Table (5.5) shows the per feddan labour mandays for wheat crop distributed by month and crop activity in season 2011/12. Wheat received low labour compared to other crops because the operations of this crop are done mechanically. Watering operation absorbed 76%, Tegant raising and canal cleaning absorbed 8.9% of the total labour used in wheat production. On average, the total labour used for wheat crop were 16.25 mandays per feddan, of which family labour contributed only 9.29 mandays, while the hired labour contributed 6.96 mandays per feddan.

Table (5.4): Labour used for groundnut crop by month and by crop activity in (m.d) per feddan in the Gezira scheme, season 2011/12

Activity	Type of labour (m.d)			Months							
	FL	HL	TL	Jun	Jul	Aug	Sep	Oct	Nov	Dec.Apr	May
Tegant raising	0.75	0.52	1.27								1.27
Sowing	2.75	3.09	5.84	5.84							
Resowing	0.75	1.1	1.85	1.85							
Watering	6	6.08	12.08	1.7	1.7	1.7	3.4	3.4			
Weeding	4	9.44	13.44	4.48	4.48	4.48					
Fertilizer application	1	0.2	1.2	1.2							
Harvesting	0	7.38	7.38						7.38		
Total	15.25	27.81	43.06	15.07	6.18	6.18	3.4	3.4	7.38		1.27

Source: Field survey, season 2011/12

Table (5.5): Labour used for wheat crop by month and by crop activity in (m.d) per feddan in the Gezira scheme, season 2011/12

Activity	Type of labour (m.d)			Months						
	FL	HL	TL	Jun..Sep	Oct	Nov	Dec	Jan	Feb	Mar
Tegant raising	0.83	0.59	1.42		1.42					
Resowing	0.71	0	0.71			0.71				
Watering	6.63	5.72	12.35			1.8	1.8	3.6	3.6	1.8
Fertilizer application	0.5	0.27	0.77				0.77			
Weeding	0.62	0.38	1				0.5	0.5		
Total	9.29	6.96	16.25		1.42	2.51	3.07	4.1	3.6	1.8

Source: Field survey, season 2011/12

5.1.1.5 Onion Labour

Table (5.6) shows the per feddan labour mandays for onion crop distributed by month and crop activity in season 2011/12. Onion crop has two peaks of labour requirements. The first peak period coincides with sowing and weeding period which absorbed 50% of the total labour used in onion production. The second peak period coincides with onion pulling, and harvesting period which absorbed about 18% the total labour used in onion production. On average, the total labour used for onion crop were 53.57 mandays per feddan, of which family labour contributed only 16.18 mandays, while the hired labour contributed 37.39 mandays per feddan. Onion crop used higher labour than other crops in the Gezira scheme.

5.1.1.6 Chickpea Labour

Table (5.7) shows the per feddan labour mandays for the chickpea crop distributed by month and crop activity in season 2011/12. Chickpea crop has two peaks of labour requirements. The first peak period coincides with sowing and weeding period which absorbed 44% of the total labour used in chickpea production. The second peak period coincides with chickpea pulling, collecting and threshing or harvesting period which absorbed about 21% the total labour used in chickpea production. On average, the total labour used for chickpea crop were 36.35 mandays per feddan, of which family labour contributed only 16.36 mandays, while the hired labour contributed 19.99 mandays per feddan.

Table (5.6): Labour used for onion crop by month and by crop activity in (m.d) per feddan in the Gezira scheme, season 2011/12

Activity	Type of labour (m.d)			Months						
	FL	HL	TL	Jun.Sep	Oct	Nov	Dec	Jan	Feb	Mar
Tegant raising	0.85	0.69	1.54		1.54					
Sowing	0	7.86	7.86			7.86				
Resowing	0	3.28	3.28			3.28				
Watering	8.01	6	14.01			1.5	3	3	3	3
Weeding	6.72	9	15.72				5.24	5.24	5.24	
Fertilizer application	0.6	0.64	1.24				1.24			
Harvesting	0	9.92	9.92							9.92
Total	16.18	37.39	53.57		1.54	12.64	9.48	8.24	8.24	12.92

Source: Field survey, season 2011/12

Table (5.7): Labour used for chickpea crop by month and by crop activity in (m.d) per feddan in the Gezira scheme, season 2011/12

Activity	Type of labour (m.d)			Months						
	FL	HL	TL	Jun..Sep	Nov	Dec	Jan	Feb	Mar	Apr
Tegant raising	0.63	0.57	1.2		1.2					
Sowing	1.38	2.44	3.82		3.82					
Resowing	1	1.13	2.13		2.13					
Watering	6.17	5.1	11.27		1.6	1.6	3.2	3.2	1.6	
Weeding	4	6.01	10.01			5	5			
Fertilizer application	0.18	0.12	0.3			0.3				
Harvesting	3	4.62	7.62							7.62
Total	16.36	19.99	36.35		8.75	6.9	8.2	3.2	1.6	7.62

Source: Field survey, season 2011/12

5.1.2 Farm operating capital

Operating capital is one of the important farm resources. As indicated earlier the Gezira scheme advances credit to tenants to cover the costs of agricultural activities for cotton and wheat crops. These advances are either in the form of cash or kind advances. The growing seasons of crops, produced in the Gezira scheme, overlap. Vegetables are harvested between August and December, groundnut and sorghum between December and January i.e. part of the proceeds of groundnut, vegetables and sorghum can be used to finance many operations of cotton and wheat activities. Likewise, cotton and wheat proceeds can be used to finance operations of cotton, groundnut, vegetables, and sorghum in the next season.

5.1.3 Irrigation water available to the tenants

The irrigation net work consist two main canals one for the Gezira main and other for the Managil Extension, the irrigation water use in the scheme during season 2011/12 about 9348 million CM. Dividing the available irrigation water by the total number of tenants 114000 gives the averages amount of irrigation water per tenancy 82000 CM. Further dividing the irrigation water per tenancy by number of months in the growing season gives the monthly amount of available irrigation water 8200 CM.

5.2 Linear programming model analysis

5.2.1 Linear programming model's technical input-output coefficients

Linear programming model's technical input-output coefficients and resource endowments formulated into a matrix shown in table (5.8).

5.2.1.1 Activities set:

The activity set in the model includes the following:

1- Crop production activities.   2- Crop selling activities.

3- Sorghum consumption activities.   4- Sorghum buying activities.

5- Hired labor activities.   6- Capital borrowing activities.

7- Transfer capital activities.   8- Capital repayment activities.

1- Crop production activities:

This includes the production of cotton, sorghum, groundnuts, wheat, onion and chickpea (table 5.9).

The objective function coefficients for the production activities represent the total cost of production per feddan excluding the cost of hired labor.

This cost is subtracted from the operating capital streams in the months they are incurred. These production activities are linked with production balance equations and their respective yields per feddan are shown as negative figures in these equations. Table 5.8 represents portion of the LP matrix of the crop production activities in Gezira scheme.

2- Crop selling activities:

The selling activities include sales of crops. The objective function coefficients for the selling activities represent average price per unit of sale plus the value of crop residue (for sorghum and groundnuts). The objective function coefficients of selling activities also appear as supplying the operating capital stream in the month where selling takes place (Table 5.10).

3- Sorghum consumption activities:

The tenants usually consume part of their production from dura. The objective function coefficient is zero for these activities (no cost). This activity is linked to dura consumption constraint and dura production balance equation (Table 5.9).

Table 5.8 the linear matrix (a summary)

Variables		Crop production			Crop selling			Sorg Cons.	Sorg Buy.	Hired labor			Capital transfer			Borrowing Credit			Crop rep.	End cap.		
		crop1…..…..crop6			Crop1…….crop6					HL1…….……..HL12			CT1….……CT11			BC1…..….…..BC12						
Maximize		-SDG	…..	-SDG	SDG	….	SDG	0	-SDG	-SDG	……	-SDG	0	0	0	-SDG	…..	-SDG	0	0		
Const.	Unit																				Dir.	RHS
Tota. la.	Fed.	1	……	1																	<=	Bi
Cr1la.	,,	1																			>=	0
Cr…..	,,		……																		>=	0
Cr6la.	,,			1																	>=	0
FL.jun.	m.d.	C								-1											<=	Bi
FL….	,,		……								…….										<=	,,
FL.may	,,			C								-1									<=	,,
jun.OC.	SDG	C			-SDG					SDG			1			-1					<=	Bi
…cap.	,,		C			-SDG					SDG			-1+1			-1				<=	,,
May.OC.	,,			C			-SDG					SDG			-1			-1			<=	,,
Jun.Wat	CM	C																			<=	,,
…..	,,		C																		<=	,,
May Wat	,,			C																	<=	,,
Cr1prod.	Kantar	-C			1			1													<=	0
………	Sack		-C			1			-1												<=	0
Cr6prod.	Sack			-C			1														<=	0
Sorg.con.	Sack							1													=	Bi
Cap.rep.	Sdg															SDG	SDG	SDG	+1		<=	0
End cap	,,																			+1	>=	Bi

Not: Bi= resources levels, C =coefficients not equal to zero, one or minus one, SDG= monetary in Sudanese pound,

FL = Family Labour, OC = Operating Capital, Cr = Crop, La = land, Wat = Water, Prod = production, Sorg =Sorghum

Table (5.9): Crop production activities in the Gezira scheme Season, 2011/12

Activities	unit	cotton	dura	groundnuts	wheat	onion	chickpea	Dir	RHS
Objective fun		-936.7	-683.5	-1020.5	-1045.9	-1982.5	-787.7		
Constraints									
Total land	Fed	1	1	1	1	1	1	<=	20
Cotton	" "	1						>=	0
Sorghum	" "		1					>=	0
Groundnuts	" "			1				>=	0
Wheat	" "				1			>=	0
Onion	" "					1		>=	0
Kabkaba	" "						1	>=	0
Jun labour	m.d/fed	1.39	7.25	15.07	0	0	0	<=	36
Jull labour	" "	10.57	3.29	6.18	0	0	0	<=	36
Aug labour	" "	8.97	7.3	6.18	0	0	0	<=	36
Sep labour	" "	5.4	6.63	3.4	0	0	0	<=	36
Oct labour	" "	3.4	1.82	3.4	1.42	1.54	0	<=	36
Nov labour	" "	3.4	8.53	7.38	2.52	12.64	8.75	<=	36
Dec labour	" "	8.8	0	0	3.07	9.48	6.9	<=	36
Jan labour	" "	0	0	0	4.1	8.24	8.2	<=	36
Feb labour	" "	0	0	0	3.6	8.24	3.2	<=	36
Mar labour	" "	2	0	0	1.8	12.92	1.6	<=	36
Apr labour	" "	0	0	0	0	0	7.62	<=	36
May labour	" "	0	0	1.27	0	0	0	<=	36
Jun water	CM/fed	0	0	373	0	0	0	<=	8200
Jull water	" "	292	0	731	0	0	0	<=	8200
Aug water	" "	547	145	846	0	0	0	<=	8200
Sep water	" "	877	575	646	0	0	0	<=	8200
Oct water	" "	990	877	0	0	0	0	<=	8200
Nov water	" "	788	666	0	320	511	292	<=	8200
Dec water	" "	183	0	0	800	701	768	<=	8200
Jan water	" "	0	0	0	864	593	718	<=	8200
Feb water	" "	0	0	0	570	323	282	<=	8200
Mar water	" "	0	0	0	0	244	163	<=	8200
Apr water	" "	0	0	0	0	0	0	<=	8200
May water	" "	0	0	0	0	0	0	<=	8200
OC Jun	SDG/fed	225	221.5	160.5	0	0	0	<=	17400
OC Jull	" "	123.3	93.6	277.5	0	0	0	<=	0
OC Aug	" "	224.8	122	36.4	0	0	0	<=	0
OC Sep	" "	44.7	36	0	0	454	0	<=	0
OC Oct	" "	0	0	337.2	242.1	94.7	200	<=	0
OC Nov	" "	0	210.1	0	279	314.8	133.3	<=	0
OC Dec	" "	120.6	0	0	229.1	56	120.3	<=	0
OC Jan	" "	75	0	0	39.3	56	56	<=	0
OC Feb	" "	0	0	0	0	1007	0	<=	0
OC Mar	" "	121.5	0	0	54.1	0	31	<=	0
OC Apr	" "	0	0	0	202.3	0	247.2	<=	0
OC May	" "	0	0	208.9	0	0	0	<=	0
Cotton prod	Kantar/fed	-5.2						<=	0
Sorghum prod	Sack/fed		-7.8					<=	0
Ground prod	Sack/fed			-14.7				<=	0
Wheat prod	Sack/fed				-8			<=	0
Onion prod	Sack/fed					-80.5		<=	0
Chickpea prod	Sack/fed						-6	<=	0
Sorghum consu	Sack							=	12.5

Source: Constructed from survey data

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4- Sorghum buying activities:

The buying activities are permitted to allow households to satisfy dura consumption constraint in case model production could not satisfy this constraint. The objective function value for this buying activity represents the average price household pays for purchased dura (Table 5.10).The purchase price is higher than the average selling price because purchase occurs at periods long after harvest.

5- Hired labor activities:

The Gezira scheme farmers use both family labor (F.L.) and hired labor (H.L.) in conducting their field crop production activities. Table (5.11) shows the portions of the matrix representing H.L. activities. The labor hiring activities were introduced in the models to supplement the family labor on monthly basis. The unit of the activity is one manday (8 hours of work per day). A standard manday was taken as the effort exerted by a healthy adult in the age of 15-65 years in working day. A one day labor input was assumed to be 0.75 standard manday for women and 0.5 for children and old person (Abdel-Aziz, 1999). The objective function coefficient of each of the hired labor activities represents average monthly wage rates estimated from the field survey. The coefficients carry negative sign since they draw from the value of the objective function.

Table (5.10): Crops selling, consumption and buying activities in the Gezira scheme, season 2011/12

activities	unit	Cotton selling	Sorghum selling	G.N selling	Wheat selling	Onion selling	Chickpea selling	Sorghum cons	Sorghum buying	Dir	RHS
Obj.function		475	164	102.2	155	48.5	235	0	-170		
constraints											
OC Jun	SDG/fed									<=	17400
OC Jull	" "									<=	0
OC Aug	" "									<=	0
OC Sep	" "									<=	0
OC Oct	" "		-164							<=	0
OC Nov	" "			-102.4						<=	0
OC Dec	" "									<=	0
OC Jan	" "									<=	0
OC Feb	" "									<=	0
OC Mar	" "					-48.5				<=	0
OC Apr	" "	-475			-155		-235			<=	0
OC May	" "									<=	0
Cotton prod	Kantar/fed	1								<=	0
Sorghum prod	Sack/fed		1					1	-1	<=	0
Groundnut prod	Sack/fed			1						<=	0
Wheat prod	Sack/fed				1					<=	0
Onion prod	Sack/fed					1				<=	0
chickpea prod	Sack/fed						1			<=	0
Sorgh consu	Sack							1		=	12.5

Source: Constructed from survey data

Table (5.11): Labour hiring activities in the Gezira scheme, season 2011/12

Activities constraints	Objective function			HL 1 -15	HL 2 -15	HL 3 -15	HL 4 -15	HL 5 -15	HL 6 -15	HL 7 -15	HL 8 -15	HL 9 -15	HL 10 -15	HL 11 -15	HL 12 -15
	sign	unit	RHS												
Jun labour	<=	M.D	36	-1											
Jull labour	<=	" "	36		-1										
Aug labour	<=	" "	36			-1									
Sep labour	<=	" "	36				-1								
Oct labour	<=	" "	36					-1							
Nov labour	<=	" "	36						-1						
Dec labour	<=	" "	36							-1					
Jan labour	<=	" "	36								-1				
Feb labour	<=	" "	36									-1			
Mar labour	<=	" "	36										-1		
Apr labour	<=	" "	36											-1	
May labour	<=	" "	36												-1
OC Jun	<=	SDG	17400	15											
OC Jull	<=	" "	0		15										
OC Aug	<=	" "	0			15									
OC Sep	<=	" "	0				15								
OC Oct	<=	" "	0					15							
OC Nov	<=	" "	0						15						
OC Dec	<=	" "	0							15					
OC Jan	<=	" "	0								15				
OC Feb	<=	" "	0									15			
OC Mar	<=	" "	0										15		
OC Apr	<=	" "	0											15	
OC May		" "	0												15

Source: Constructed from survey data

6- Capital borrowing activities:

In practice, Gezira scheme advances credit to tenants for cotton crop. Table (5.12) shows the portions of the matrix representing borrowing activities. Borrowing activities are used to supplement the amount of cash owned by the farmers, and include formal sources of finance mainly the Agricultural Bank of Sudan (ABS). The bank lending terms depend on Morabaha system, where the Morabaha margin for the year 2011 was 12%. This rate appeared as a negative coefficient in the objective function.

7- Transfer capital activities:

Eleven transfer capital activities were included in the model to permit the transformation of capital from one month to another. The coefficients of capital transfer in the objective function carry zero values since it does not involve money transactions. Table (5.13) depicts the proportion of the matrix representing transfer of capital activities.

8- Capital repayment activities:
This is composed of two types of repayment:-

(1) Repayment of Gezira scheme advances which appeared as operating capital for the tenants in the model, it required that the total of the repayments should be paid back at the end of the season.

(2) Repayment of the borrowed capital.

These two have a zero objective function coefficient and they are linked to their respective constraints (Table 5.12).

Table (5.12) Borrowing capital activities in the Gezira scheme, season 2011/12

Activities constraints	Objective function			Bc1 -.12	Bc2 -.12	Bc3 -.12	Bc4 -.12	Bc5 -.12	Bc6 -.12	Bc7 -.12	Bc8 -.12	Bc9 -.12	Bc10 -.12	B11 -.12	B12 -.12	Cap rep	End cap
	sign	unit	RHS														
OC Jun	<=	SDG	17400	-1													
OC Jull	<=	" "	0		-1												
OC Aug	<=	" "	0			-1											
OC Sep	<=	" "	0				-1										
OC Oct	<=	" "	0					-1									
OC Nov	<=	" "	0						-1								
OC Dec	<=	" "	0							-1							
OC Jan	<=	" "	0								-1						
OC Feb	<=	" "	0									-1					
OC Mar	<=	" "	0										-1				
OC Apr	<=	" "	0											-1			
OC May	<=	" "	0												-1		
Cap rep	<=	" "	0	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1	
End cap	=	" "	17400														1

Source: Constructed from survey data

Table (5.13) Transfer capital activities in the Gezira scheme, season 2011/12

constraint	Activities			Tc 1/2	Tc 2/3	Tc 3/4	Tc 4/5	Tc 5/6	Tc 6/7	Tc 7/8	Tc 8/9	Tc 9/10	Tc 10/11	Tc 11/12
	Objective function			0	0	0	0	0	0	0	0	0	0	0
	sign	unit	RHS											
OC Jun	<=	SDG	17400	1										
OC Jull	<=	" "	0	-1	1									
OC Aug	<=	" "	0		-1	1								
OC Sep	<=	" "	0			-1	1							
OC Oct	<=	" "	0				-1	1						
OC Nov	<=	" "	0					-1	1					
OC Dec	<=	" "	0						-1	1				
OC Jan	<=	" "	0							-1	1			
OC Feb	<=	" "	0								-1	1		
OC Mar	<=	" "	0									-1	1	
OC Apr	<=	" "	0										-1	1
OC May	<=	" "	0											-1

Source: Constructed from survey data

5.2.1.2 Constraints set:

The constraints set of the model includes the following:

1- Land.

2- Labour.

3- Irrigation.

4- Operating capital and credit constraint.

5- Sorghum Consumption.

6- The crop balance constraint.

7- Capital repayment

1- Land:

The average tenancy is 20 feddan in main Gezira scheme. The total land in the model is restricted as equal to or less than 20 feddans. After Act 2005, the farmers are free to choice crops to grow that means no fixed rotation, the field survey found that the average area cultivated was 4, 4, 2, 3, 4 and 3 feddan for cotton, sorghum, groundnut, wheat, onion and chickpea, respectively.

2- Labour:

In this study, the minimum available monthly labour (in mandays) to the household was estimated by the survey to be 36 mandays. The assumptions put forward in this calculation were:-

- One principal tenant is a mature male who was given eight hours per day.
- The other principal tenant is a woman who was assigned six hours per day.
- The rest were children and assigned four hours a day per individual.

3- Irrigation:

Irrigation was expressed in amount of irrigation water available to the tenant on a monthly basis. The available irrigation water in the Gezira scheme

during the growing season was 8200 CM. This amount of irrigation water available represents the right hand side of irrigation constraint, table (5.12).

4- Operating capital and credit constraint:

In this study, the Gezira scheme advances for cotton are used as operating capital. Additional operating capital was obtained from borrowing, off farm income and crops sales.

5- Sorghum consumption:

Sorghum consumption was estimated from field survey by 12.5 sacks per household per year.

6- Production balance equation:

This refers to the fact that the crop produced is used through sales and/ or consumption.

7- Capital repayment:

Borrowing capital in the model was restricted to be paid back at the end of the season with a 12 percent Morabaha margin.

5.2.2 Linear programming model, results and discussion

This part gives the results of the linear programming model discussing the basic solution and presents the different scenarios by changing the parameters of the basic model in the sensitivity analysis. The results of the basic model were compared to the actual situation. The information obtained from linear programming analysis included the objective function value, the optimal crops combination, resources use and their respective marginal productivities. Analysis focused on the optimal cropping pattern, resources use and the optimal production plan as shown in table (5.14).

5.2.2.1 Optimal production plan

5.2.2.1.1 Cropping pattern

From table (5.14), it is clear that most of the land is allocated to onion crop which was 8.68 feddans, followed by cotton crop which is 6.88 feddans, while sorghum and groundnuts entered in the optimal plan with small areas 1.74, and 0.92 feddans respectively, wheat and chickpea did not enter in the optimal plan. In the real situation cotton, sorghum, and onion occupied about the same area (4 feddan), followed by wheat and chickpea, (3 feddan), and then groundnuts (2 feddan). From table (5.14), it is clear that cotton crop increased from 4 to 6.88 feddans by 72% compared to actual land allocated while onion crop increased from 4 to 8.68 feddans by 117%.

5.2.2.1.2 Resources use

The levels of resource use are shown in Table (5.14). It is clear that there is difference between the actual total land allocated and optimal total land, which was 20 and 18.22 feddans, respectively. It also noticed that the total labor mandays required for the basic solutions were 360 mandays and the actual mandays utilized

in the Gezira scheme were 382mandays. In the basic solution, about 83.33% of available family labour was utilized in the Gezira scheme compared to 91.65% in the actual situation. 83.32% of the available hired labour was utilized in the Gezira scheme compared to 86.76% in the actual situation. Percentage of the hired labor out of the total labour in the basic solution was 61.74% as compared to 61.74% in the actual situation. About 83.33% of the total labour available was utilized in the basic solution compared to 88.42% in the actual situation. The total quantity of water required for the basic solutions were 59125.6 C.M and the actual cubic meter utilized in the Gezira scheme are 57982 C.M. In the basic solution, about 60.09% of available water was utilized in the Gezira scheme compared to 58.9% in the actual situation.

Table (5.16), shows the monthly water required in the basic optimal plan model of the Gezira scheme in comparison with the actual situation. October, November, and December months had no surplus of water.

Table (5.14): Optimum solutions of the basic model of the Gezira scheme in comparison with the actual situation.

Item	Model	Actual
Total land	18.22	20
Cotton land	6.88	4
Sorghum land	1.74	4
Groundnuts land	0.92	2
Wheat land	0	3
Onion land	8.68	4
chickpea land	0	3
Total labour	360	382
Family labour	137.74	146.15
Hire labour	222.26	235.85
% of F.L/ Total F.L	83.33%	91.65%
% of H.L/ Total H.L	83.32%	86.76%
% of utilized H.L/T.L.	61.74%	61.74%
% of utilized T.L/T.L.	83.33%	88.42%
Total quantity of water requirement C.M	59125.6	57982
%of utilized of water/ water available C.M	60.09%	58.9%
Net farm income SDG	18697.24	11735.86

Source: Program computed

5.2.2.1.3 Optimum net returns

Comparison of the optimal and actual net farm income shows a difference. The actual net return was about SDG 11735.86 while the optimal plan's returns was SDG18697.24 which was more than actual one by 59.3%.

5.2.2.1.4 Credit use of the basic model

The result of the basic model in table (5.17) shows that, there was no cash problem cash except in March and April months. In March and April months there was a shortage in cash to meet harvesting operations.

Table (5.15): The optimum utilized and surplus labour in the basic model in comparison with the actual situation.

Month	Model		Actual	
	Utilized	**Surplus**	**Utilized**	**Surplus**
June	36	0	36	0
July	36	0	36	0
August	36	0	36	0
September	36	0	36	0
October	36	0	36	0
November	36	0	36	0
December	36	0	36	0
January	36	0	36	0
February	36	0	36	0
March	36	0	36	0
April	0	36	22.86	13.14
May	0	36	0	36

Source: Compiled by the author

Table (5.16): The monthly water utilized and surplus in the basic model in comparison with the actual situation.

Month	Model		Actual	
	Utilized	**Surplus**	**Utilized**	**Surplus**
June	341.55	7858.45	746	7454
July	2931.87	5268.13	3210	4990
August	5541.64	2658.36	6180	2020
September	8064.59	135.41	8108	92
October	8200	0	7116	1084
November	8200	0	6292	1908
December	8200	0	8132	68
January	6940	1259.60	8192	8
February	5500.27	2699.37	6646	1554
March	5205.30	2994.70	3360	4840
April	0	8200	0	8200
May	0	8200	0	8200

Source: Compiled by the author

Table (5.17): Marginal value of product of credit (SDG/unit) in the basic model of the Gezira Scheme.

Month	Model
June	0
July	0
August	0
September	0
October	0
November	0
December	0
January	0
February	0
March	0.12
April	0.12
May	0

Source: Compiled by the author

5.2.2.2 Sensitivity analysis

Sensitivity analysis is the investigation that deals with changes in the optimal solution due to changes in the data (Gass, 1985). The basic solutions of the LP models were developed by changing their parameters to present different policy analysis scenarios. These scenarios examined the impact of productivities, cost of production and prices on the crop mix and net farm income of the basic solutions. Table (5.18) depicts different scenarios of crops combination in the Gezira scheme.

5.2.2.2.1 Impact of crops productivities:

Sc1- Increase of productivity of all crops by 25%

Increase of productivity of all crops by25% in the basic model changed net farm income and crops mix. Net farm income increased from 18697.24 SDG to 32411.96 SDG (by 73.4%). Groundnuts area increased from 0.92 feddan to 3.96 feddan, while the areas of cotton, and onion did not change, sorghum, wheat, and chickpea did not enter the plan, (table 5.18).

Sc2- Increase of productivity of cotton and sorghum crops by 25%

Cotton crop gains foreign currency and dura crop considered the crop which meets food security in the Gezira scheme area, Gezira scheme administration and Gezira Research Situation seek to increase the yield of these crops. Increase of productivity of cotton and sorghum crops by 25% in the basic model change net farm income and crops mix. Net farm income increased from 18697.24 SDG to 23411.96 SDG (by 25.2%). Sorghum area increased from 1.7 feddan to 2.08 feddan, while cotton, and onion did not change in areas, groundnuts, wheat, and chickpea did not enter the plan.

Sc3- Increase of productivity of chickpea crop by 50%

Chickpea is a promising cash crop for farmers in the scheme increasing farm income. Increase of productivity of chickpea crop by 50% in the basic model change net farm income and crops mix. Net farm income increased from 18697.24 SDG to 18987.3 SDG (by 1.6%). The cotton, groundnuts, and onion areas decreased from 6.88, 0.92, and 8.68 to 6.48, 0.62, and 5.22 feddan, respectively, while sorghum and chickpea increased from 1.7 and zero to 2.44 and 4.72 feddan, respectively, wheat crop did not change in area.

Sc4- Restricting sorghum area to the level required to meet consumption:

By restricting sorghum area in the Gezira scheme model to 2 feddans in order to produce 12.5 sacks, which is equal to the amount consumed by family during the year. The net farm income decreased from 18697.24 SDG to 18677.84 SDG (by 0.1%). Sorghum increased from 1.74 to 2 feddan, while groundnuts decreased from 0.92 to 0.22 feddan, and other crops did not change in areas.

5.2.2.2.2 The impact of prices:

Sc5- Increased of cotton price by 25%

 Cotton price depends on world marketing price, increase demand for cotton in world market lead to increasing cotton prices. Increase price of cotton crop by 25% in the basic model did not change crops mix. It only increased the net farm income from 18697.24 SDG to 22947.5 SDG (by 22.7%).

Sc6- Increased of chickpea price by 50%

 The chickpea crop was used in many processed foods and sweets, meaning that its demand increased in the market leading to increasing prices. Increase of price of chickpea crop by 50% in the basic model changed net farm income and crops mix. Net farm income increased from 18697.24 SDG to 18987.3 SDG (by 1.6%). Cotton, groundnuts, and onion areas decreased from 6.88, 0.92, and 8.68 to 6.5, 0.62, and 5.22 feddan, respectively, while sorghum and chickpea increased from 1.74 and zero to 2.44 and 4.72 feddan, respectively, wheat crop did not change in area.

Sc7- Decrease of cotton and onion price by 25%

Decrease of prices of cotton and onion crops by 25% in the basic model changed net farm income and crops mix. Net farm income decreased from 18697.24 SDG to 6572.3 SDG (by 64.8%). Cotton, groundnuts, and onion areas decreased from 6.88, 0.92, and 8.68 to 6.3, 0.41, and 5.26 feddans, respectively, while sorghum and chickpea increased from 1.74 and zero to 2.8 and 4.72 feddan, respectively, wheat crop did not change in area.

Sc8- Decrease of onion price by 25%

Decrease of prices of onion crop by 25% in the basic model changed net farm income and crops mix. Net farm income decreased from 18697.24 SDG to 11050.6 SDG (by 40.9%). Cotton, groundnuts, and chickpea areas increased from 6.88, 0.92, and zero to 7.67, 1.52, and 4.3 feddans, respectively, while sorghum and onion decreased from 1.74 and 8.68 to 0.34 and 2.7 feddan, respectively, wheat crop did not change in area.

5.2.2.2.3 The impact of production cost:

All the cost coefficients used in the study are relevant costs as they are directly reflected in the coefficients of objective function. Resource cost is a relevant cost if the amount paid for it is dependent upon the amount of the resource used by the decision variable (Loucks, 2003). With existing technology in the Gezira scheme, monthly family labor and irrigation water coefficients of the crops produced are not expected to change considerably. However, input prices, machinery cost, labor wages, water charge and transport costs are highly variable (Ahmed, 2004). If there is a body (scheme management, farmer union …etc) supply or provide the inputs (seeds, fertilizers, pesticides and sack) at lower marginal cost price, this will reduce production cost of all crops change scenarios used.

Sc9- Lowering cost of all crops by 25%

Scheme management supply or provide the inputs (seeds, fertilizers, pesticides and sack) at lower marginal cost price, this will reduce production cost of all crops change, lowering costs of all crops by 25% in the basic model changed net farm income and crops mix. Net farm income increased from 18697.24 SDG to 25156.8 SDG (by 34.5%). The groundnuts increased from 0.92 to 1.53 feddan, sorghum decreased from 1.74 to 1.52 feddan, while other crops did not change in areas.

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Sc10- Lowering cost of cotton and wheat by 25%

Lowering costs of cotton and wheat by 25% in the basic model did not change crops mix. It only increased the net farm income from 18697.24 SDG to 20288.6 SDG (by 8.5%).

Sc11- Lowering cost of cotton and wheat by 50%

Lowering costs of cotton and wheat by 50% in the basic model did not change crops mix. It only increased the net farm income from 18697.24 SDG to 21920.6 SDG (by 15.6%).

Table (5.18): Different scenarios of crops combination (in feddan).

Scenarios	Cotton	Sorghum	Groundnuts	Wheat	Onion	Chickpea	Net farm income/SDG
Sc0	6.88	1.74	0.92	0	8.68	0	18697.24
Sc1	6.88	0	3.96	0	8.68	0	32411.96
Sc2	6.88	2.08	0	0	8.68	0	23594.12
Sc3	6.48	2.44	0.62	0	5.22	4.72	18987.3
Sc4	6.88	2	0.22	0	8.68	0	18677.84
Sc5	6.88	1.74	0.92	0	8.68	0	22947.5
Sc6	6.5	2.44	0.62	0	5.22	4.72	18987.3
Sc7	6.3	2.8	0.41	0	5.26	4.72	6572.3
Sc8	7.67	0.34	1.52	0	2.7	4.3	11050.6
Sc9	6.88	1.52	1.53	0	8.68	0	25156.8
Sc10	6.88	1.74	0.92	0	6.68	0	20288.6
Sc11	6.88	1.74	0.92	0	6.68	0	21920.6

Source: Compiled by the author

5.3 Profitability analysis (Gross margin)

5.3.1 Cost of production

The cost of producing a certain crop refers to the expenses incurred in producing a certain quantity of that crop in a particular time period. Table (5.19) shows the average costs per feddan of cotton, sorghum, groundnut, onion, chickpea, and wheat in the Gezira scheme. The following items should be considered in calculating the costs of production:-

5.3.1.1 Cost of land preparation

As shown in table (5.19), the average costs of land preparation per feddan for cotton, sorghum, groundnut, onion, chickpea, and wheat were found to be SDG 82.8, 76.3, 75.8, 94.47, 85.9 and 81.5, respectively.

5.3.1.2 Cost of agricultural inputs

Agricultural inputs include seeds, fertilizers, pesticides, sacks and string. As shown in table (5.19), the average costs of agricultural inputs were found to be SDG 430.6, 227.6, 518.9, 1167.9, 254.7, and 478.7 per feddan for cotton, sorghum, groundnut, onion, chickpea, and wheat, respectively.

5.3.1.3 Cost of land and water charges

Land and water charges for cotton, sorghum, groundnut, onion, chickpea, and wheat were found to be SDG 301.2, 266.5, 273.9, 354.82, 297.9 and 307.1, respectively. The costs of land and water charges for onion gained the highest because the onion land charges were higher than the other crops.

5.3.1.4 Cost of cultural practices

Farm labour was used for conducting the cultural practices namely sowing, resowing, thinning, fertilizing, weeding, watering, and harvesting. The agricultural operations which use done by the family labour were included in the costs of production of different crops. It included as an opportunity cost of this family labour (i.e. equivalent to wage as if they performed these operations for somebody else). In table (5.19), the costs of cultural practices per feddan for cotton, dura, groundnut, onion, chickpea, and wheat were found to be SDG 908.2, 681.5, 757, 1233.4, 667.55 and 542.4, respectively. Onion also had the highest costs of cultural practices; the costs of cultural practices for wheat crop were low compared to other crops because the operations of this crop were done mechanically and not by labour.

5.3.1.5 Other costs

The other costs of production included transportation, zakat, and insurance premium … etc. The average of the other costs of production per feddan for cotton, sorghum, groundnut, onion, chickpea, and wheat were found to be SDG 111.7, 73.1, 91.9, 365.2, 71.6 and 78.2, respectively (Table 4.15).

5.3.1.6 Total costs of production

As shown in table (4.15), the average total costs of production for cotton, sorghum, groundnut, onion, chickpea, and wheat per feddan were found to be SDG1533.3, 1058.5, 1443.6, 2861.14, 1079.9, and 1180.8, respectively. Onion crop recorded the highest total costs of production per feddan because cost of cultural practices and inputs were higher than other crops and given more care by farmers. Onion is very important cash crop in the Gezira scheme.

Table (5.19): The average cost items per feddan by crop for cotton, sorghum, groundnut, onion, chickpea, and wheat in the Gezira scheme, Season 2011/12

Cost items	Crop					
	Cotton	sorghum	Groundnut	Onion	Chickpea	Wheat
Land preparation	82.8	76.3	75.8	94.67	85.9	81.5
Seeds	40.5	17.3	84.7	199.4	47.43	156.2
Fertilizers	224.8	122	277.5	314.83	120.25	229.1
Pesticides	44.7	36	36.4	111.84	55.98	39.3
Sacks	120.6	52.3	120.3	541.79	31	54.1
Water &Land fees	301.2	266.5	273.9	354.82	297.9	307.1
Sowing	27	30.7	35.4	127.26	41.25	21.1
Resowing	15.8	15	18.3	32.5	12.5	18.3
Thinning	17.5	18.2	10	25	0	0
Tegant raising	17.2	18.8	21	19.55	19.7	18.7
Weeding	116	98.7	145	148.48	102.75	0
Watering	89.2	49.9	85	112.76	95.1	91.6
Fertilizers application	8.7	8.6	10	16.59	6.5	11.7
Pesticides application	10.5	13.4	13.5	23.12	14.2	14.8
Harvesting	305.1	161.7	144.9	373.36	77.65	59.1
Others	111.7	73.1	91.9	365.17	71.58	78.2
Total	1533.3	1058.5	1443.6	2861.14	1079.9	1180.8

Source: Field survey, season 2011/12

5.3.2 Crop returns

5.3.2.1 Yields

On average, the yield per feddan were found to be 5.2 kantar for cotton crop, 7.8, 17, 80.5, 6 and 8 sacks for sorghum, groundnut, onion, chickpea, and wheat crops, respectively, (Table 5.20).

5.3.2.2 Prices

Farmers usually sell crops at very low prices after harvesting due to their pressing needs for cash to meet different consumptions items; further more they need facilities for marketing storage. The crop prices used in this study were the average prices per unit received by tenants for cotton, sorghum, groundnut, onion, chickpea, and wheat crops per feddan were found to be SDG 475, 138.3, 90, 48.5, 235 and 155, respectively, (Table 5.20).

5.3.2.3 Gross returns

The yield and prices reported in previous subsection were used to calculate the returns per feddan. For dura and groundnuts crops, the crops residues value per feddan were also included in the gross returns. As shown in table (5.20), the average returns per feddan for cotton, sorghum, groundnut, onion, chickpea, and wheat crops per feddan were found to be SDG 2470, 1279.7, 1712, 3904.3, 1410 and 1240, respectively.

5.3.2.4 Gross margins

The gross margin of a crop is the difference between its gross returns and its total variable costs of production. As depicted in table (5.20), the average gross margins per feddan for cotton, sorghum, groundnut, onion, chickpea, and wheat crops per

feddan were found to be SDG 936.7, 221.2, 268.4, 1043.2, 330.1 and 59.2, respectively. Onion crop yielded a higher gross margin per feddan followed by cotton, chickpea, groundnuts, sorghum and wheat, respectively, (Table 5.20).

Table (5.20): The average crop budget per feddan for cotton, sorghum, groundnut, onion, chickpea, and wheat in the Gezira scheme, season 2011/12

Variable	Unit	Crop					
		Cotton	sorghum	Groundnut	Onion	Chickpea	Wheat
Yield	Kantar/Sack	5.2	7.8	17	80.5	6	8
Price /unit	SDG	475	138.3	90	48.5	235	155
Crop return	SDG	2470	1078.7	1530	3904.3	1410	1240
Crop residue value	SDG	-	201	182	-	-	-
Gross return	SDG	2470	1279.7	1712	3904.3	1410	1240
Total costs	SDG	1533.3	1058.5	1443.6	2861.1	1079.9	1180.8
Gross margin	SDG	936.7	221.2	268.4	1043.2	330.1	59.2

Source: Field survey, season 2011/12