CHAPTER THREE

STUDY AREA AND RESEARCH METHODOLOGY

The aim of this chapter is to describe geographical, demography, climatic characteristics, and the farming system in the Gezira scheme and its importance to the Sudanese economy. Also, the methodological approaches used in the study are presented.

3.1 Gezira scheme

3.1.1 Background

The first phase of the Gezira scheme called the Gezira main was established in the early twenties, while the second phase called the Managil extension was established in the early sixties of the last century. The Gezira scheme is the oldest and most important irrigated scheme in Sudan. Estimates of the total potential cultivable area under irrigation in Sudan within the Nile basin vary, between four to five million feddans. Hence, the Gezira scheme represents about a quarter of all irrigated area in the country and half the area of irrigation schemes drawing water from the Nile system. It uses about 35% of Sudan's current allocation of Nile water (World Bank, 2000). Gezira scheme has a gentle slop to the north and west of the Blue Nile, it is suitable for gravity irrigation. The irrigation system of the scheme is basically a gravity flow system where water is derived from Sennar Dam into the two main canals which supply main Gezira and Managil extension. These canals ramify into canals and sub-canals. From these sub-canals water flows through field outlet pipes into Abu XX and further to Abu VI (Adam, 1996).

3.1.2 Location of the Gezira scheme

The Gezira scheme is the area that extends from latitude 13° N to latitude 15° N between the Blue and White Niles. The scheme stretches over 115 kilometers south of Khartoum and north of the railway line between Sinnar and Kosti. It covers a net cultivable area of little less than one million hectares (about 2.1 million feddans). Gezira scheme consists of two main parts: Gezira main with an area of 1.1 million feddan and Managil extension of 1.0 million feddan (Adam, 1996).

3.1.3 Climate of the Gezira scheme

The climate of the Gezira Scheme is arid and continental characterized by a low average annual precipitation and considerable rainfall fluctuations between years in terms of intensity and distribution. The scheme has three seasons: rainy season from July to September, a cool dry winter season from November to February and a hot summer from April to June. The amount of the annual rainfall varies from 472 mm at head works in the southern part of the scheme near Sennar to about 160 mm in the northern part of the scheme near Khartoum state. The relative humidity fluctuates between 70% during the rainy season and 20% during the dry season. The temperature varies from below 20°C in December to over 40°C in May with an annual mean of about 28°C (World Bank, 1990).

3.1.4 Soil of the Gezira scheme

The soils of the Gezira area are classified as vertisols that consist mainly of sediments of the Blue Nile with a clay content of about 50% to 60%, and a high exchange capacity. The Gezira soils are also characterized by aeration, hence resulting in yield reduction (World Bank, 1990).

According to Eldaw (1985) and Faki (1992) the soils of Gezira suit the irrigation by gravity for the following reasons:

- The clay soils of the Gezira allow very little water loss through seepage, hence little investment in canal lining is required.
- The heavy cracking vertisols of the Gezira allow water to reach the plant roots as a result of the swelling and shrinking under wetting and drying.
- The gentle slope of about 15cm of the Gezira plain towards the north and the north-west allows suitable flow of irrigation water and little investment in leveling (Entesar, 2006).

3.1.5 Administrative structure of the Gezira scheme

3.1.5.1 Before Gezira Scheme Act of 2005

Gezira scheme was centrally managed. It had a board of directors. The top executive is the managing director. He is assisted by five heads of departments: agriculture, finance, engineering services, administration and lately three other departments were added, namely: planning, investment and irrigation.

Administratively the scheme is divided into 18 units called groups covering the two areas, Gezira and Managil. Each group is headed by the group manager, assisted by a deputy. The group is sub-divided further into small units called block (4 to 8 blocks) which are each managed by a block inspector and 2 to 3 assistants. His responsibilities are to supervise the work of the tenants in the field. There are 114 block inspector and about 200 field inspector. The management is top down, with instructions and orders relayed from Barakat headquarters to group managers, to block inspectors to field inspectors down to tenants. The reverse route is almost

blocked, with very little feedback from tenants, in spite of the fact that the tenant union was formed a long time ago

Figure (3.1) shows the map of the Gezira scheme, with boundaries of the 18 groups, the 114 blocks. Table (3.1) shows the names of the 114 blocks under the 18 groups in the Gezira scheme (Adam, 2005). Production management in the scheme was divided between government, scheme management (Sudan Gezira Board) and the tenants. The government provides land and water. The scheme management (SGB) responsibilities include management of the agricultural production system in the scheme and management of the irrigation water from the minor canals to on-farm water operation (Mirghani *et al*., 2002).

3.1.5.2 Current situation after Gezira Scheme Act of 2005

In 2005, a new Gezira Act was adopted by parliament and signed by the president in July 2005(Appendix 1).The act gives sweeping new responsibilities to water users associations (WUAs) and the private sector while significantly reducing the role of the public sector. It also guarantees free crop choice, transfers title and long-term lease deeds to farmers privatizes cost centers, and refocuses the (SGB) on agricultural research and technology transfer. The Act has major implications on marketing, credit, input supply, water management and maintenance of irrigation assets, the debt of the scheme and of the farmers, and, ultimately on agricultural productivity. After the Gezira Scheme Act of 2005, farmers are free to manage their productive and economic development and they have the right to participate in planning, management and management of irrigation channels at the level of the field by (WUAs).

Figure (3.1): Map of the Gezira Scheme

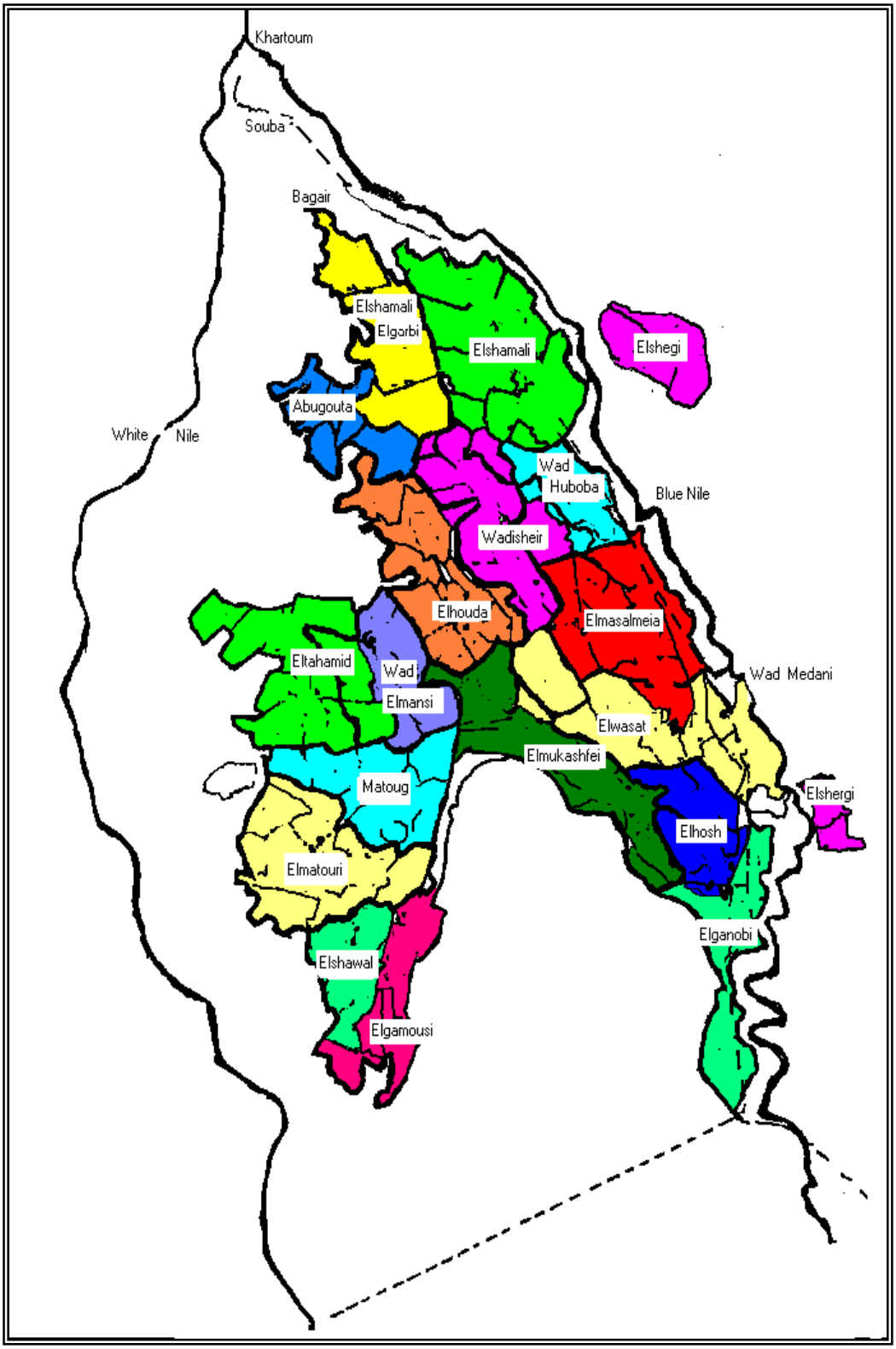

Table (3.1): Distribution of Gezira Scheme by groups and blocks

South	Hosh	Center	Massallamia	Wad Habouba
1 Hag Abdalla	4 Wadno*man	8 Hamadalnil	16 Tayba	25 Wad sulfab
2 Ghubshan	R Hosh	9 Nur Elhuda	17 Seleimi	26 Dogla
3 Ghubashan	6 Remeitab	10 Barakat	18 Tibub	27 Istarihna
95 Wadalhaddad	7 Wad alataya	11 Dirwish	19 Wad Elbur	28 Elrukun
108 Gundal		12 Kumur	20 Abdelgalil	
		13 Radam	21 Sa*adalla	
		14 Abdelhakam	22 Abdelrahman	
		15 Medina	23 Wad Hussein	
		109 Wad El nau	24 Nidiana	
		111 Wad Hilal		
Wad Shaeer	**North**	**Northwest**	**Abu Gouta**	**Eastern**
29 Neulla	35 Umdagarsi	41 Abu Gin	45 Abu Ideina	104 Haddaf
30 Feteis	36 Debeiba	42 Elguez	46 Bagiga	105 Wad Elfadl
31 Amarakasir	37 Turabi	43 Sideira	94 Wad Elkreil	106 Hurga
32 Keteir	38 Meilig	44 Elfaragin	98 Abu Gouta	107 Nur Eddin
33 Turis	39 Ka Elgidad	110 Alirayek	103 Abdelmagid	
34 Fawar	40 Laota			
112 Rayan	92 Ruweina			
114 Wadelbaseer	113 Sahwah			
Managil				
Mikashfi	**Huda**	**Wad El Mansi**	**Tahameed**	**Ma*toug**
47 Hamadnalla	50 Wadelzin	53 El Gelei*	57 Shakir	62 Maturab
48 Abu Digin	1\51 Elmalan	54 Ras Elfil	60 Beida	63 El Nur
49 Murad	52 Shendi	55 El N*ima	61 El Tarfa	64 Abu hawa
84 Wad Abid	90 Freijab	56 Mabrouk	86 Sheweirif	65Kartoub
85 Tunsa	91 Surhan	58 El Gadid	87 Um Shadida	66 El Hashaba
96 Elkarateeb	93 Goz Elreheid	59 El Tayif	88 Meheila	67 Um Hegliega
97 Elnasieh		83 Elkremet	89 El Nala	71 Affan
				72 El Hegeirat
Maturi	**Gamousi**	**Shawal**		
68 Agoba	78 El Radi	99 Kuwait		
69 El Tamad	79 Gabouga	100 Kageillah		
70 Elzafir	80 Abulkeilik	101 Sagadi		
73 El Nayer	81 Rangoub	102 Elwaha		
74 Eljebel	82 Tuweimat			
75 Rahama				
76 Umseneita				
77 Disheinat				

Source: Adam, 2005

3.1.6 The economic importance of Gezira scheme

Gezira scheme is the largest irrigated scheme under one management in the world. The prevailing farming systems in the scheme aim to produce food and high value export crops for self-sufficiency and for export, respectively. One of the scheme's main objective is to promote social development of the tenant as well as people residing in the scheme area through better schooling, medical care, and creation of job opportunities and the sense of security through better settlement (Ahmed, 1997).

Gezira scheme is the most important component of the agricultural sector in Sudan. According to Ahmed (2004), its importance to the economic growth can be demonstrated by the following:

* It constitutes about quarter of irrigated area in the Sudan and amounts to about 50 percent of the scheme irrigated from the Nile system.
* It produces 58% and 23% of the country main export crops, cotton and groundnut, respectively and as such it is a leading source of foreign exchange earnings and raw materials for local industries.
* It produces 46% and 12% of the country's wheat and sorghum respectively, as well as considerable amount of vegetables.
* It is a source of labor employment and income for both skilled and unskilled manpower.

It is estimated that over 2.7 million people live in and adjacent to the Gezira scheme and depend on it for their livelihood either as tenants, agricultural laborers, as sharecroppers, traders or providers of various services. The scheme is framed by about 120.000 tenants (World Bank Report, 2000).

The Gezira scheme is not only boosting the national economy at the area of production and labor, but also at other indirect areas such as custom duties on imported machineries, fertilizers, insecticides and all other materials needed for the process of production. It also activates both public and private sector, in areas of transportation, power, telecommunications and commercial banks.

3.1.7 Farming activities

3.1.7.1 Tenancy size

In the Gezira scheme, the whole tenancy size ranged between 10 and 40 feddans. The standard tenancy size is 20 feddan in the Gezira main and 15 feddan in Managil extension. The average tenancy size of the sampled farmers is 19.7 feddans which approximately equal to the standard tenancy size of the scheme. The basic unit is "hawasha" which is four feddans in the Gezira main and three feddans in the Managil extension.

3.1.7.2 Crop rotation

Gezira scheme has adopted different types of crop rotations since its establishment and changes in crop rotation are dictated by scheme management (SGB). Table (3.2) shows the change of the rotation in the Gezira scheme and Managil extension during the period (1925-2005). After the Gezira Scheme Act for the year 2005, farmers are not restricted by a certain crop rotation, where the Act has insured that farmers are free to manage productive and economic determinants in the context of art and the use of technology to upgrade the productivity and maximize their profitability.

Table 3.2: Change of rotations in the Gezira scheme

Period	Details of rotations
1925-1930	(3 course rotation) Cotton – Fallow – Fallow
1931-1933	(4 course rotation) Cotton – Sorghum – Fallow – Fallow (Introduced Dura as a food crop)
1934-1960	(8 course rotation) Cotton – Sorghum – Fallow – Fallow Fallow – Sorghum – Lubia or Fallow – Fallow
1961-1974	Managil (6 course rotation) Cotton – Wheat – Fallow – Cotton – groundnut / Sorghum – Fallow Gezira (8 course rotation) Cotton – Wheat – Fallow – Cotton – Lubia- groundnut / Sorghum – Fallow – fallow (introduce wheat as winter crop and groundnut as a summer crop, initiated of intensification and diversification
1975-1979	Managil (3 course rotation Cotton – Wheat – Sorghum / groundnut Gezira (4 course) rotation) Cotton –Wheat – Sorghum / groundnut – Fallow
1980-1986	Managil (4 course rotation) Cotton – Wheat – Sorghum / groundnut – Fallow
1986-1993	Gezira (4 course rotation) Cotton – Wheat – Sorghum / groundnut – Fallow
-1999	Gezira and Managil (5 course rotation) Cotton –Wheat - groundnut /Vegetable- Sorghum – Fallow+Fodder
1999-2000	Gezira and Managil (5 course rotation) Cotton – Sorghum – groundnut –Wheat –Fallow
2000-2005	Gezira and Managil (5 course rotation) Cotton – Wheat – groundnut /Vegetable + Fodder – Sorghum Dura – Fallow

Source: Suleiman, 2007

3.1.7.3 Crop production

The main crops grown in the Gezira scheme are cotton, wheat, sorghum and groundnut. Cotton is considered the main cash crop in the scheme. It is grown in summer from 1st of July to 10th of August; the harvesting period of cotton is from the end of December to April. There

are two varieties of cotton grown in the scheme which are Barakat and Acala. The recommended numbers of irrigation is 14 during the season and the irrigation interval is 14 days. The recommended amount of fertilizer is 8 kg of urea per feddan. Weeding operation is always done after fertilizer application (Ahmed, 2004).

Sorghum is the major cereal crop and considered as main pillar of food security in the country. It is grown in the Gezira scheme for on farm consumption, and the excess amount is sold in the local market. The optimum sowing date 15th July, the recommended amount of nitrogen fertilizer is 80 kg per feddan. It requires about 7-8 irrigation during the growing season with 14 days irrigation interval and harvested during November and December.

Wheat is the second most important cereal after sorghum in the Sudanese diet. It is grown in the Gezira scheme as an import substitute. It is a winter crop in the Gezira scheme, the optimum sowing date is between 1st and 30th of November. It requires about 80kg of urea and 40 kg of triple super phosphate per feddan. It requires 7-8 irrigations with 14 day irrigation interval (Ahmed, 2004).

Groundnut is summer crop in the Gezira scheme. Land for groundnut sowing is prepared by ridging followed by spit ridging. The optimum sowing date is June 15th. Herbicides are recommended to be applied 1 to 7 days after the effective sowing. It requires about 8 irrigations with 14 days watering interval. A month after the effective sowing date, weeding is recommended. It reaches maturity in 130 to 140 days (Ahmed, 2004).

In addition to the main crops which are mentioned above, minor crops such as vegetables, fodder and legumes are also grown in the scheme. The main vegetable crops produced in the scheme are onion and tomato which

account for 60 percent of the total area under vegetables and are mainly consumed locally. Moreover, there is a considerable amount of livestock in the scheme (Ahmed, 2004).

3.1.7.4 Credit

The agricultural credit is needed to pay for the cost of the different agricultural operations and inputs that the farmers are unable to pay for in right time. Two main sources of credit are reported in the Gezira scheme. The first is the formal source which represented by Agricultural bank of Sudan (ABS) through Sudan Gezira Board. The second is the informal source which provided by money lenders (merchants) to the farmers as "shail". The crops produced in the Gezira scheme may be categorized into those, which are partially financed by (ABS), and those which are fully financed by the tenants themselves. The first category includes cotton and wheat, for these two crops the loan is given in kind in form of agricultural inputs and the repayment is in kind. The amount of repayment is tied, through a formula, to the market price of the crop at harvest. The second category which is financed by the tenants includes sorghum, groundnut, vegetables and legumes. When the farmers are enabling to finance those crops from their own sources, they resort to the informal credit sources to meet their financing needs through "shail". In the "shail" method, money lenders advance loans to farmers who pledge the delivery of a specific quantity of output equivalent to the value of the loan at the time of harvest. The shail could be in cash or in kind, but repayment is usually in kind at lender-set price that are significantly lower than harvest prices.

3.2. RESEARCH METHODOLOGY

3.2.1 Data collection

Date collection is an important step of the sampling procedure and the results of any study depend on the accuracy and reliability of data. The accuracy and reliability of data are mostly dependent on the method of data collection, and education and training of the filed investigation. Primary and secondary data were collected to test the stated hypotheses and fulfill the objectives of the study.

3.2.1.1 Primary Data

Primary data were collected by using a structured questionnaire using stratified random sampling techniques through direct personal interviewing. The primary data were collected during the period (April – May 2012), for the cropping season 2011/12. The primary data include basic information about the socio-economic characteristics of farmers such as age, education level, occupation, family size, marital status, experience in farming, farm and off farm income, animal ownership, crops yield, crops production cost and prices of output(appendix 2). The Gezira scheme is divided into 18 administrative units called groups, each of which is subdivided into further blocks, resulting in 114 blocks in total, no significant differences within the farming system regarding farmers' decisions on crop mix, yield and production is shown. Therefore a multistage stratified random sampling procedure was applied. From the 18 groups, three are selected namely the North, Central, and Hosh. Then two blocks were randomly selected from each group (6 blocks) and from each block 25 tenants were randomly selected. So the total sample size was 150 tenants out of a total farmers population of 120,000 tenants.

Table (3.3) shows the distribution of tenants sample by group, and block. The survey was conducted by the researcher himself.

Table (3.3): The selected Groups and Blocks in Gezira scheme

Group	Block	No. of farmers chosen
Northern	Umdagarsi	25
	Meilig	25
Central	Dirwish	25
	Kumur	25
Hosh	Remeitab	25
	Wad alataya	25
Total	6	150

Source: Compiled by the author

3.2.1.2 Secondary Data

In addition to the primary data, other important sources were consulted as a secondary data were collected from the relevant institutional sources, which include Planning and Socio-economic Research Administration (PSERA) of the Gezira schemes, Ministry of Agriculture and Forests, Administration of Agricultural Statistics (AAS); Ministry of Irrigation, Gezira State, Central Bank of Sudan, in addition to different documents, records, books, internet, paper, journals, and reports.

3.2.2 Analytical techniques:

To meet the objectives of the study a number of analytical techniques were used. Tabular as well as general descriptive statistics were used throughout the study to describe socio- economic characteristics of the farmers. Gross margin analysis. Estimates of marginal value products of different factors of production were calculatedly, stochastic frontier production function and Linear programming models were used in the analysis.

In order to estimate the level of technical efficiency in a manner consistent with the theory of production function a Cobb-Douglas type stochastic frontier production function was specified. The Cobb-Douglas of production function has some well-known properties that justify its wide application in economic literature (Rahman, 2002).

Linear programming technique was used to determine the optimum plan or course of action, among many which are possible, for the production of the crops in the scheme in a way that maximizes farmers' income and satisfies domestic consumption.

3.2.3 Specification of Stochastic Production Frontier Model:

The model included the tenant's factors influencing the farmer technical efficiency. Stochastic Production Frontier Model of the Cobb-Douglas form was used to find out the tenants' technical efficiency for crops production in Gezira scheme. In total 14 parameters were estimated in the stochastic production frontier model including nine parameters in the stochastic production frontier model except wheat included eight parameters (number weeding were excluded) and four parameters in the inefficiency model except cotton included five parameters (credit).

3.2.3.1 Technical Efficiency of cotton, sorghum and groundnut.

The model is written as follows:

$$\mathbf{lnyi} = \boldsymbol{\beta 0} + \sum_{\mathbf{j=1}}^{\mathbf{9}} \boldsymbol{\beta j}\, \mathbf{lnXij} + \mathbf{Vi} - \mathbf{Ui} \qquad (\mathbf{3.1})$$

Where:

ln = the natural logarithm

y_i = yield of cotton, sorghum and groundnut (kantar, sack/ Faddan);

X_1 = Tenancy location (1 when location at the head of the canal, 2 when location at the middle and 3 when location at the tail);

X_2 = Age (years of interviewed tenant);

X_3= Education (schooling years of interviewed tenant);

X_4= Sowing date (dummy variable which receives one when at the optimum time and zero, otherwise);

X_5= Farm income (SDG);

X_6 = off- farm income (SDG);

X_7 = Number of irrigations;

X_8= Number of weedings;

X_9= Total labour (number of labor in mandays);

B_0 and β_j are unknown parameters to be estimated for the variables, respectively.

v_i represent the statistical error and the other factors which are beyond the tenants control such as weather, topography and other factors which are not included and may be either positive, negative or zero. u_i is non negative random variable.

3.2.3.2 Technical Efficiency of wheat.

The model is written as follows:

$$\mathbf{lnyi = \beta 0 + \sum_{j=1}^{8} \beta j\, lnXij + Vi - Ui} \qquad (3.2)$$

Where:

ln = the natural logarithm

y_i = yield of wheat (sack/ Faddan);

X_1 = Tenancy location (1 when location at the head of the canal, 2 when location at the middle and 3 when location at the tail).

X_2 = Age (years of interviewed tenant);

X_3= Education (schooling years of interviewed tenant);

X_4= Sowing date (dummy variable which receives one when at the optimum time and zero, otherwise);

X_5= Farm income (SDG);

X_6 = off- farm income (SDG);

X_7 = Number of irrigations;

X_8= Total labour (number of labor in mandays);

B_0, β_j, v_i and u_i as previously defined in equation (3.1).

3.2.3.3 Inefficiency Effect Model:

The u_i in the stochastic production frontier model is a non-negative random variable, associated with the tenants' technical inefficiency in production and assumed to be independently distributed, such that the technical inefficiency effect

for the i^{th} tenant, $u_{i,}$ will be obtained by truncating at zero of the normal distribution with mean, μ_i, and variance, δ^2, such that

$$\mathbf{Ui = \delta 0 + \sum_{s=1}^{4} \delta s Zsi \quad (3.3)}$$

Where:

Z_{1i} = Education level (0 when illiterate, 1when khalwa, 2 when primary, 3 when intermediate, 4 when secondary, 5 when university);

Z_{2i} = Tenants experience (number of years spent as a tenant);

Z_{3i} = Family size (1when (1-5), 2 when (6-10), 3 when (> 10);

Z_{4i} = Marital status (dummy variable which has the value one married and zero, otherwise);

Z_{5i} = Credit (dummy variable which has the value one if the tenant is not constraint by credit and zero, otherwise) (cotton)

δ_0 and δ_s coefficients are unknown parameters to be estimated; together with the variance parameters which are expressed in terms of

$\sigma^2 = \sigma_u^2 + \sigma^2 v$ and $\gamma = \sigma u^2 / \sigma^2$

Where the γ parameters has value between zero and one. The parameters of the stochastic frontier production function model are estimated by the method of maximum likelihood, using the computer program, FRONTIER Version 4.1.

3.2.4 Empirical Specification of the Linear Programming Model

3.2.4.1 Structure of the LP technique:

The objective function of the representative farm model maximizes net farm income after satisfying family requirements from the main food crops which are sorghum. The mathematical form of the model used is as follows:

$$\textbf{Max Z} = \sum_{t=1}^{n} \textbf{CjXj}$$

$$\textbf{Subject to} = \sum_{t=1}^{n} \textbf{aijXj} \leq \textbf{bi}$$

And

Xj>=0, all j=1 to n

Where:

Z= objective function value.

Cj= gross margin per feddan of the jth farm activity i.e. input/outpu

Xj= the level of the jth farm activity.

aij= the quantity of the ith resource required to produce one unit of the jth activity i.e. input/output coefficients.

bi= vector of resource availability.

The above structure was then formulated into a matrix that gives the model's technical input-output coefficients and resource endowments as shown in table (5.11) in chapter five.