TECHNICAL EFFICIENCY OF WHEAT PRODUCTION
IN THE GEZIRA SCHEME
A CASE OF WAD ELMENSI GROUP

By

ELMOIZ ABD ALLA FADL ELMULA EL AGAB
B. Sc. (Honors, 2003), Agricultural Economics,
Faculty of Natural Resources & Environmental Studies,
University of Kordofan.

Supervisor
Dr. Mohammed Ahmed El Feel

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Department of Agricultural Economics
Faculty of Agriculture
University of Khartoum

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Dedication

To my Lovely Mother and my Father
To my brothers and sisters
To my relatives
To my friends
With best love

Elmoiz
Acknowledgement

Firstly I am fully thank to the Almighty Allah for the good health and live he gave me through the study and research. I am greatly indebted to my supervisor Dr. Mohammed Ahmed Elfeel for his valuable guidance, wise counsel, encouragement, and advice throughout this study. My thanks extended to Dr. Adam Elhaj for his valuable guidance. I would also like to thanks the staff members of the department of Agricultural Economics University of Khartoum for their unlimited helps and support. My thanks are also extended to all farmers in Wad El Mensi, colleagues, and friends.
ABSTRACT

This study was carried out in Wad-Elmansi block in Gezira Scheme covering the season 2007-2008. Presently people in the rural areas changing from a traditional local based consumption patterns an increased used of domestically produced and imported wheat products. The main purposes of the study are to measure technical efficiency of producing wheat, to determine main factors behind technical inefficiency, and to identify the socio-economic factors that affecting the level of efficiency of farmers.

The study used primary and secondary data. Primary data were collected using structured questionnaire for 100 farmers in Wad-Elmansi block, and it covers the socio-economics characteristics of farmers, and the different inputs quantities used in agricultural practices. Secondary data were collected from different sources, which include Ministry of Agriculture and Forests (MOAF), in addition to various documents, records, books, periodicals, reports and internet.

The Stochastic Production Frontier (SPF) analysis was used to estimate the technical efficiency of producing wheat in the scheme, and to determine the factors behind inefficiency such as gender, age educational level, marital status and family size. Also, descriptive statistics were used to analyze the socio-economic characteristics of farmers.

The result showed that most of the estimated β co-efficient of the stochastic frontier model for wheat production model have the expected signs, and significance. The mean technical efficiency is 73%. This means that the farmers can increase their wheat output by 27% through the better use of the farmers, available resources. The gender, the marital status and land tenure of farmers are significance in explaining technical inefficiency in Managil Extension, except the age, educational level and family size are not significance for wheat production.

Lastly, in order to improve technical efficiency for wheat production in the area, the study recommended that improvement in finance, irrigation and early land preparation.
أجريت هذه الدراسة بقسم ود المنسي بمشروع الجزيرة في الموسم الزراعي 2007-2008. في البداية الأخيرة اتجه السكان في المناطق الريفية إلى التغيير في أنماط الاستهلاك الغذائي من المنتجات التقليدية إلى القمح ومنتجات المنتج المحلي والمصورة. الهدف الأساسي من هذه الدراسة قياس الكفاءة الفنية لإنتاج محصول القمح، تحديد العوامل التي تؤثر على الكفاءة الفنية ومعرفة العوامل الاقتصادية والاجتماعية التي تؤثر على مستوى الكفاءة الإنتاجية للمزارعين.

اعتمدت الدراسة على المصادر الثانوية وال الأولية في جمع المعلومات. تم جمع المعلومات الأولية بواسطة الاستبيان، وتعزيز 100 استبيان شعاعي للمستهدفين وشمل الاستبيان الخصائص الاقتصادية والاجتماعية للمزارعين، وعوامل الإنتاج المختلفة والتي تستخدم في العمليات الزراعية والتي تؤثر على الكفاءة الفنية لمصدر القمح. أما المعلومات الثانوية تم جمعها من مصادر متغيرة متمثلة في وزارة الزراعة والثليجة، الكتب، البحوث العلمية، المجلات والإنترنت. اعتمدت الدراسة في التحليل على (SPF) لتقرير الكفاءة الفنية لإنتاج القمح، و العوامل التي تؤثر على الكفاءة متمثلة في (النوع، العمر، المستوى التعليمي، الحالة الاجتماعية، حجم الأسرة). كما استخدمت الدراسة الإحصاء الوصفي لتحليل الخصائص الاقتصادية والاجتماعية للمزارعين.

أوضحت الدراسة إن معظم عوامل الإنتاج التي تؤثر على الكفاءة الفنية ذات تأثير معنوي، وتأثر إيجابيا عند إنتاج محصول القمح. وأن متوسط الكفاءة الفنية 73% بيرهن على إمكانية وفرة المزارعين من زيادة إنتاج القمح بنسبة 27% عند نفس عوامل الإنتاج المتاحة و المتوفرة.

كما أوضحت نتائج الدراسة أن الخصائص الاجتماعية للمزارعين ممثلة في (النوع، الحالة الاجتماعية، نوع الملكية) ذات أثر معنوي في تفسير الكفاءة الفنية للمشروع. أما العمر والمستوى التعليمي وحجم الأسرة ليست ذات أثر معنوي في تفسير الكفاءة الفنية. أخيرا، بهدف تحسين الكفاءة الفنية وتطوير الإنتاج الزراعي، أوصت الدراسة بالاهتمام بالتمويل وإثارة التدريب المبكر حتى يشهد المشروع في زيادة الإنتاج و الإنتاجية والنتائج القومي الإجمالي في المستقبل القريب.
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INTRODUCTION

1.1 Background:

Sudan is situated in the north-eastern corner of the Africa and is the largest African country with total area of about 2.5 million Km². at the north-east it is boarded by the red sea and it shares common boarders with nine countries: Eritrea, Ethiopia in the east, Kenya, Uganda and Democratic Republic of Congo in the south, the central African Republic, Chad and Libya in the west and Egypt in the north (FAO, 1997).

The cultivable area is estimated as 105 million hectares, (42% of the total area). The cultivated land is 17million hectares, which is 16% of the cultivable area. Only about 3% is under permanent crops, while the remaining area is farmed with annual crops (FAO, 1997).

1.2 The Agricultural Sector:

Agriculture is Sudan’s most important economic sector in terms of its contribution to both GDP and employment. In 2006 agriculture directory accounted for 39.2 % of the GDP (bank of Sudan, 2006). The sector also provides about 80% of the country’s exports (excluding petroleum) and contributes to the livelihood of 80% of its population (EIU, 1998). The agriculture sector is the source of raw material for processing factories in the country including textiles, sugar, vegetable oil, soap factories, grain mills diaries, tanneries and saw mills that contributes about 17% of the GDP and some 20% foreign exchange earnings (Sudagric, 2002).

The agriculture in Sudan depends on two principle sources of water: direct rains and the river Nile and its tributaries. There are also flood irrigation schemes fed by seasonal rivers in the east of the country in "Gash" and "Tokar" deltas. There are five sub-sector of Sudanese agriculture: modern irrigated
farming, mechanized rain fed crop production, traditional rain fed farming, livestock and forestry sub-sector (Ahmed, 2004).

The irrigated sub-sector consists of 4 million feddans of cultivated land. The major components of this sub-sector are large-scale schemes, represented by Gezira, Rahad and New Halfa schemes. Among the main agriculture sectors, the irrigation sector contributes about 27% of agricultural GDP and it produces most of cotton, sugar cane, legumes and orchard crops grown in the Sudan. (Ahmed, 2004).

Wheat cultivation has been known in northern Sudan between latitudes 17° and 27° north for thousands of years. The area cultivated with wheat has never exceeded 15,000 ha up to the end of the fifties and the yield was enough to cover the consumption needs in northern Sudan and the main towns. The rest of the population depends on sorghum in central and eastern Sudan, dukhn in the west and cassava in the south. All these crops with the exception of wheat are produced under rains (Ministry of Agriculture and Forestry, 2007). However, wheat consumption in Sudan has been sharply increasing from about 220,000 tons in 1970/71 to over 800,000 tons in 1990/91 both due to population growth and rising per capita consumption (Solh, 1996). It reached 2,000,000 tons in 2007. However, in the following years of policy liberalization and issuing inflation the cost of production became prohibitive and wheat area was reduced to the 1989 prompting the country to import most of its wheat requirements. At present, the Gezira scheme produces more than 50% of total wheat production, and wheat is also produced in the northern and Nile states in addition to specified areas in Rahad and New Halfa schemes. However, plans are underway to construct Hamdab and Kajbar dams to facilities the expansion of wheat production area in the northern state, not only for attaining self-sufficiency but also for export. Moreover, heightening of Roseires dam will
avail adequate irrigation water to intensify wheat production in the irrigated scheme of central Sudan (Ministry of Agriculture and Forestry, 2007).

1.3 The Problems Statement:
The Sudan’s wheat situation is characterized by rapid growth in consumption, continuous and variable deficit between domestic needs and local production, uncertain estimates of actual wheat demand due to quota and price controls. Current average wheat yield are quite variable and are substantially lower than the potential. Space variability, induced by confounded effects of location, management and tenant preferences, calls for some level of specialization and vertical increase in production in contrast to the current area expansion strategies (Faki, 1996). Average yields are generally low as affected by many production and environmental factors. Many factors are known to affect the productivity of wheat in its main growing areas in sudan. Generally classified, these factors include weather cultivars and sowing dates, crop establishment practices, crop nutrition and irrigation, harvesting practices and biological factors (Solh, 1996).
Table (1.1): Wheat area, production and yield Gezira scheme for ten seasons.

<table>
<thead>
<tr>
<th>Season</th>
<th>Area (000 fed)</th>
<th>Production (000 tons)</th>
<th>Yield Kg/Fed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Planted</td>
<td>Harvested</td>
<td></td>
</tr>
<tr>
<td>94/95</td>
<td>393</td>
<td>383</td>
<td>230</td>
</tr>
<tr>
<td>95/96</td>
<td>400</td>
<td>391</td>
<td>254</td>
</tr>
<tr>
<td>96/97</td>
<td>390</td>
<td>385</td>
<td>270</td>
</tr>
<tr>
<td>97/98</td>
<td>320</td>
<td>301</td>
<td>261</td>
</tr>
<tr>
<td>98/99</td>
<td>176</td>
<td>125</td>
<td>34</td>
</tr>
<tr>
<td>99/2000</td>
<td>67</td>
<td>43</td>
<td>22</td>
</tr>
<tr>
<td>2000/2001</td>
<td>116</td>
<td>111</td>
<td>100</td>
</tr>
<tr>
<td>2001/2002</td>
<td>80</td>
<td>80</td>
<td>58</td>
</tr>
<tr>
<td>2002/2003</td>
<td>116</td>
<td>111</td>
<td>100</td>
</tr>
<tr>
<td>2003/2004</td>
<td>200</td>
<td>190</td>
<td>171</td>
</tr>
<tr>
<td>2004/2005</td>
<td>149</td>
<td>142</td>
<td>114</td>
</tr>
</tbody>
</table>

Source: Department of Agricultural Statistics, Ministry of Agriculture forestry (2006)

Table (1) shows that annual production growth for the period (1995/1996-2004/2005) decrease by 8% every year. The production decrease from 245000 ton metric in 1995/96 to 114000 ton metric in 2004/05, because of decreasing in planted area by 13% annually in spite of increasing in yield by 5%, that may due to vertical expansion. The growth rate for the first five years (1995/1996to 1999/2000) decrease for area, production and productivity by 44%, 70%and 26%, respectively. But the growth rate increase for the period
(2000/2001 to 2004/2005) by 57% as a result of expansion in area by 23% and productivity by 4% altogether (Osman, 2006).

Consequently "Gezira scheme have failed to attain the desired socio economic transformation and full involvement of the settlers. In addition most of the schemes have failed to cover their establishment objectives and even their operating costs, because there are multi problems confronting tenants and affecting production and productivity, such as:

1. Area fluctuation, which leads to fluctuation of output.
2. High costs of cultural operation which inforce tenants to rent their farm to rich tenants.
3. Irrigation problems in Managil extension, such as cyclical cleaning of channels and its capacity is not sufficient to irrigate the land.
4. Inverse environmental conditions and pests and diseases increase the production cost in some seasons
5. Low agricultural revenues accompanied with highly taxes made tenants leave agriculture and depend on other activities.
6. Insufficient finance and agricultural extension leading to low production and productivity.

1.4 Objectives of the Study:

The overall objective of this study is to measure and evaluate the economic efficiency of wheat production in Gezira and Managil extension.

The study aims to achieve the specific following objectives:

1. To measure and identify technical efficiency of wheat production in Managil extension.
2. To identify the major problems that faces tenants and affects the technical efficiency of crop production in Managil extension.
1.5 Hypotheses:

The study will test the following hypotheses:

1. Wheat productions fluctuations in the Gezira Scheme are due to numerous interrelated causes such as those related to wheat area, land preparation, irrigation problems and tenants income.

2. Wheat productivity differences among the tenant in Gezira scheme are assumed to be mainly due to the tenants' technical inefficiency.

3. Tenants' Age, Gender, experience, harvesting date, level of education, Land tenure, family size and marital status are the main factors assumed to be behind tenants' technical inefficiency.

1.6 Organization of Study:

This study consists of five chapters:

Chapter one contains an introduction to the agriculture, the importance of wheat to Sudan economy, the research problems, justification, hypotheses and the objectives of study.

The literature review which is related to efficiency was presented in chapter two. The study area and research methodology which include data collection and model specification are presented in chapter three. The empirical result are presented and discussed in chapter four. Lastly, chapter five presents the summary, conclusions and recommendations.
CHAPTER TWO  
LITERATURE REVIEW

2.1 Wheat:

2.1.1 Background:

On a world production and utilization basis, wheat is the world’s single most important food crop and wheat trade represents a significant component of the balance of trade of national economies (Henry and Kettlewell, 1996; Gooding and Davies, 1997).

Wheat is used and processed for many products because of the large quantity produced by people of diverse cultures and socioeconomic groups. The global success of wheat as a food crop not only derives from its geographical range of climate and soil tolerance, but also its adaptability for many different food products, thousands of which are produced worldwide (Faridi and Faubion, 1995).

2.1.2 Wheat Production in Sudan:

Wheat production in the Sudan started thousands of years ago on the fertile soil of the River Nile Banks in the area which now administratively falls in the Northern and Nile River states.

Since the early 1940s wheat production has moved southward and the crop is now cultivated in Khartoum, Gezira, White Nile, Gedaref, Kassala, Darfur state Suki, Rahad and New Halfa (Hassan 1996)

2.1.2.1 The Evolution of the Cultivated Areas with Wheat Crops, Its Production and Productivity in Period from 1984/85 – 2004/2005:

The production of wheat in Sudan remained concentrated in Northern region for along period of time, till its cultivation stated in Halfa scheme in season 1964/65. The Gezira scheme with the bingeeing of the intensification of crop rotation in season 1975/76. and in view to this expansion in cultivated areas in
different districts in the country, the importance of the comparative advantage of the northern region in wheat production was reduced the country witnessed remarkable evaluation in the cultivated areas, thus raised from 382 thousand feddan in 1985/86 to 1168 thousand feddan in season 1990/91, acquainted that the Gezira scheme contributed with great share from the total cultivated areas with wheat in Sudan

2.1.2.2. The Evolution of Cultivated Areas:

Table (2.1) show that the cultivated area with wheat reached 122 thousand feddan in season 1984/85 because the cultivated areas affected with agricultural policy of productivity in the irrigated schemes, where as cultivation in the Gezira scheme ceased completely in that season due to the orientation to encourage the cash crop and shortage in irrigation water. Cotton as a first one which have great effect in decrement the total cultivated areas with wheat. Its cultivation stopped, then after that increased in the country again till reached 417 thousand feddan in season 1988/89. This increment concentrated also in the Gezira scheme.

Execution to the expansion policy in wheat production and the contribution of the Gezira scheme reached about 70% from the total cultivated areas in that seasons.

The cultivated areas with wheat reached its maximum in season 1990/1991 with an area of 1168 thousands feddan. The share of the Gezira scheme reached 52% while the contribution of the northern region skipped to 13%.

The cultivated area started to decline again till reached its minimum of about 277 thousands feddan in season 2001/2002, where the participation of the northern region was about 53% from the total cultivated area with wheat.

Nevertheless, the share of the Gezira scheme about 29% from the total cultivated area. The two seasons 2002/2003 and 2003/2004 witnessed increasing
in cultivated area. Where the participation of the Gezira scheme was (36%, 44%), the northern region (40%, 32%) the Nile (17%, 15%). Afterwards the wheat cultivated areas in the country was decreased again to reached 407 thousands feddan in season 2004/2005. The general trend for cultivated areas with wheat in Sudan during the period 1984/1985 to 2003/2004 resulted in very weak rate of growth reflecting the increase in cultivated areas with about 13%.

2.1.2.3. The Average Production Of Feddan And It Is Evolution:

The productivity of the feddan ranged between 497-648 Kg/feddan (Table 2.1) till reached it is maximum in season 1991/1992 (the season of self-sufficient) as it reached about 1 ton/ feddan. The productivity started to fluctuate again due to change in the agricultural policy. In the later years 1999/2000 – 2004/2005 the productivity increased. Again as a result of the continued effect to increase the production vertically that by generalization of the computable types of the different areas and rehabilitation of the irrigation infrastructure and using the fertilization.

The general trend for the average productivity for feddan during the period grown from the weak changing rate about 2.98 % (Osman, 2006).
Table (2.1): Wheat area, production and yield in Sudan for the seasons (1984/85-2003/04)

<table>
<thead>
<tr>
<th>Season</th>
<th>Area (1000 Fed)</th>
<th>Production (000 Kg)</th>
<th>Yield (Kg/Fed)</th>
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<td>1984/85</td>
<td>122</td>
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<tr>
<td>2004/05</td>
<td>407</td>
<td>364</td>
<td>894</td>
</tr>
<tr>
<td>Growth Rate</td>
<td>0.13%</td>
<td>3.11%</td>
<td>2.98%</td>
</tr>
</tbody>
</table>

2.1.3 The Crop Description:

Wheat crop was cultivated in season of winter in period between 12 – 26 of November, and continue until the beginning of December, moreover, the crop needs temperature ranging between 10 – 25°C is the optimum soil for wheat growth is alluvial soil (Gureir) that distinct by good drainage and high organic matter content. Also it can grow in light clay soil. The soil ploughed deeply for eradicating weeds followed by harrowing and leveling to avoid water lodging in lower position and drought in upper sites.

The recommended quantity of seeds per feddan ranging between 50 – 60Kg. the recommended irrigation number ranged between (7 to 8) times with interval of 14 days. One feddan needs 400 m in any time of irrigation. Fertilization applied in two dozes from Urea (50Kg / feddan) and one douse from supper phosphate (40Kg / feddan). The Aphide insect was the only insect that attack wheat crop and controlled by using Okthin insecticides sprayed from 1 – 2 sprays.

The crop harvesting in period 4 weeks directly after maturity.(Osman, 2006)

2.1.4 Wheat in Northern State:

The idea of the program of wheat relocation in northern state has emerged in the year 1994 and focused on the materialization of autonomous sufficieny. The justification of his strategic policy is that the crop depend upon the relative advantage of its production in the state however, those advantage are:

1. The appropriate climate for production of wheat, particularly the temperature which is always between 6-30°C in winter season.
2. Availability of water resources.
3. Availability of fertile land.
4. The very long experience of the tenant in the state.

In 1999 they chaged the name of the project to the national project for wheat production, so the wheat become the main crop at the two state (North and River
states). The main objectives of this project is to meet the demand of Sudanese people from wheat through horizontal and vertical expansion (Ali 1999).

Until year 1994 production was confined to the north state (17-22n) whose inhabitants are traditional wheat consumers. Scarcity of land high cost of production in the northern state coupled with the increasing demand for the wheat consumption led to expansion of wheat growing area southward warmer southern regions and to the irrigated schemes in central and Eastern Sudan (13-15n).

Until 1988 Sudan imported 75% of its annual local needs estimated at 0.8 to 1.0 million tons. Since then, the government has launched and ambitious programs of food security that aimed at attaining self sufficiency in wheat by 1992. The program was successfully implemented by expanding wheat area and application of improved production technologies (Aageb, 1994).

2.1.5 Wheat in Gezira Scheme:

Wheat was introduced in Gezira scheme since 1940s during the World War II to provide the British army with wheat in an area of about 5000 ha at Wad-Kerri Messlimia group. No wheat was grown in the scheme during the period 1947/48- 1958/59, due to poor yield, high cost of production and competition of irrigation water and high harvesting labor with cotton, where was no combine harvesting as well as other crop were manually harvesting (Salih, 1983).

In the early 1960s the crop assumed to play its role as a vital and strategic commodity in the country due to increasing consumption resulting from increasing population, urbanization, low prices of imported wheat and changing food consumption behavior. This necessitated an expansion of the crop to warmer regions of the country. The Gezira Scheme was well suited to embrace the crop and, in fact, became the major contributor to wheat production in Sudan. In the Gezira, in the early 1960s, the crop started with relatively small
areas that increased gradually to reach more than 210,000 ha in the mid 1970’s in the following years the crop experienced a gradual decline due to poor planning, unavailability of inputs, inadequate pricing policies, dependency on food grants and foreign aid, from part of the government besides other problems such as inadequate seed bed preparation, poor seed and fertilizer distribution, irregular irrigation schedules and delayed harvest. All of these factors led to poor yields and area reduction (Abdalla et al., 1994).

Cotton represents the main competitor to wheat for irrigation water and inputs particularly during winter times. Its area, in turn, depends on the extent of cultivation of the summer crops (Groundnut and dura) which their competition arises when irrigation of these crop extends beyond October, the time when their irrigation should stop and water is released for wheat planting (Faki et al., 1994).

2.1.5.1 Wheat Productivity Constraints in Gezira Scheme:

Since independence, the successive government formulated many development plans. The target of self-sufficiency was considered as one of the major objectives which were emphasized by these plans. In Gezira wheat possessed an important advantage as the most suitable winter crop option in the cropping system. Wheat production is fully mechanized. For tenant to obtain high yields and make profits, machinery has to be efficiently used managed. Mechanization faces problems like unavailability of machinery, unskilled operators, and shortage of fuel and spare parts (Mamoun, 1996).

2.2 Efficiency

The concept of efficiency is at the core of economic theory. The theory of production economics is concerned with optimization implies efficiency (Baumol, 1977). Decision makers are presumed to be concerned with the maximization of some measure of achievement such as profit or utility. The analysis of efficiency, in general, focuses on the possibility of producing a
certain level of output at lowest cost or of producing optimal level of output from given resources. Therefore, efficiency measurements that show the scope for improved performance may be useful in the formulation and analysis of agricultural policy (Russel and Young 1983).

2.2.1 Economic Efficiency:

Despite the many earlier studies, the concept of economic efficiency is not unambiguous and its usefulness as a measure of economic performance has been questioned. Pasour (1981) argued that efficiency measures derived by assuming profit maximization are not appropriate standards to measure the performance of economic agents operating under imperfect information and whose objective functions involve elements other than profit. Analysis of economic efficiency are typically based on the assumptions that tenants strive to maximize profits given competitive input and output markets, and that they do so under certainty. However, considering the existence of imperfect information, and the socio-economic context within which tenants operate, the assumption of profit maximization is unsatisfactory. Consequently, more realistic behavioral assumptions should be made in modeling peasant behavior. Also, every farm is more or less a multi-input decision making unit and operates under technical, physical and socio-economic constraints. The farmer’s decision making problem may therefore be regarded as one of constrained utility optimization under uncertainty. (Torkomani and hardaker, 1996)

2.2.2. Efficiency Analysis:

Economic efficiency (EE) is the degree of ability of a tenant to produce a given level of output at least cost. EE may be divided into allocative and technical efficiencies (Farrel, 1957).
Allocative efficiency refers to the appropriate choice of input combinations. A farm is allocatively efficient if production inputs are allocated according to their relative prices. Consequently, price or allocative inefficiency results from suboptimal input combinations.

Technical efficiency refers to the proper choice of production function among all those actively in use by tenants. A farm is technically efficient if it produces the maximum obtainable level of output from a certain amount of input, given its technology. A farm is considered technically more efficient compared to other farms if it produces a larger output from the same quantities of inputs.

**2.3. Stochastic Production Frontier**

Stochastic frontier production functions have been the subject of considerable econometric research during the past two decades, originating with a general discussion of the nature of inefficiency in Farrell (1957). In traditional economic theory, efficiency is generally assumed as an outcome of price-taking, competitive behavior. In this context (and assuming no uncertainty), a production function shows the maximum level of output that can be obtained from given inputs and the prevailing technology. However, variations in maximum output can also occur either as a result of stochastic effects (e.g., good and bad weather states), or from the fact that firms in the industry may be operating at various levels of inefficiency due to mismanagement, poor incentive structures, less than perfectly competitive behavior or inappropriate input levels or combinations. The econometric technique developed by Battese and Coelli (1988), allows for a decomposition of these effects and a precise measure of technical inefficiency defined by the ratio of observed output to the corresponding (estimated) maximum output defined by the frontier production function, given inputs and stochastic variation.
The stochastic production frontier Aigner, Lovell, and Schmidt (1977), Battese and Corra (1977) and Meesusen and Van den Broeck (1977)] is motivated by the idea that deviations from the production frontier may not be entirely under the control of the production unit under study. These models allow for technical inefficiency, but they also acknowledge the fact that random shock outside the control of producers can affect output. They account for measurement error and other factors, such as effects of weather, luck, etc., on value of the output variable, together with the combined effects of unspecified input variables in the production function. The main virtue of stochastic frontier models is that at least in principle these effects can be separated from the contribution of variation in technical inefficiency (Kebede, 2001).

Rahman (2002) stated that several methods have been developed for the empirical estimation of the frontier models. These different methods to estimate the frontier efficiency models can be categorized according to:

(a) The way the frontier is specified; the frontier may be specified as parametric function of inputs or as deterministic nonparametric function;
(b) The frontier may be estimated either through programming techniques or through the explicit use of statistical procedures;
(c) The deviation from the frontier is interpreted; deviations may be interpreted simply as inefficiencies or they could be treated as mixtures of inefficiency and statistical noise; that is, frontier may be deterministic or stochastic;
(d) The frontier is optimized (dual approach); the frontier may be production frontier or cost frontier.

2.3.1. Conceptual Model Specification:

Ahmed (2004) cited that the measure of firm efficiency consist of two component: technical efficiency, which reflects the ability of a firm to obtain the maximal output from a given set of inputs, and the allocative efficiency, which
reflects the ability of the firm to use the inputs in optimal proportion, given their respective prices. These two measures combined to provide a measure of the total economic efficiency. The function can be estimated from sample data using non-parametric piece-wise-linear technique or a parametric function such as in the Cobb-Douglas form.

The model is defined by:

\[
\ln(y_i) = x_i \beta - u_i, \quad i = 1, 2, ..., N, \ldots
\]

\(\ln (y_i)\) is the logarithm of the (scalar) output of the i-th firm; 
\(x_i\) is a \((k+1)\) –row vector whose first element is “1” and the remaining elements are the logarithms of the K- input quantities used by the i-th firm; 
\(\beta = (\beta_0, \beta_1, ..., \beta_k)\), is a \((K+1)\)- column vector of unknown parameters to be estimated; and the \(u_i\) is a non–negative random variable, associated with the technical inefficiency in production of firms in the industry involved.

The ratio of the observed output for the i-th firm, relative to the potential output defined by the frontier function, given the input vector \(x_i\), is used to define the technical efficiency \((TE_i)\) of the i-th firm :

\[
TE_i = \frac{y_i}{\exp(x_i \beta)} = \frac{\exp(x_i \beta - u_i)}{\exp(x_i \beta)} = \exp(-u_i) \ldots
\]

Aigner, Lovell and Schmidt and Meeusen and van den Broeck (1977) Model proposed the stochastic frontier production function in which an additional random error, \(v_i\), is added to the non-negative random variable, \(u_i\), in equation (1) to provide:

\[
\ln(y_i) = x_i \beta + v_i - u_i \quad i = 1, 2, ..., N, \ldots
\]

The random error, \(v_i\), accounts for the measurement of error other random factors such as the effects of weather, strikes, luck, etc. and effects of
unspecified input variables in the production function on the value of the output variable.

ALS (1977) assumed that the vi’s were independently and identically distributed (i.i.d.) normal random variables with zero mean and constant variance, $\delta_v^2$, independent of the u_i’s, u_i’s were assumed to be (i.i.d). exponential or half-normal random variables. The model defined by equation (3) is called the stochastic frontier production function, because:

The output values are bounded by the stochastic (random) variable $\exp(x_i\beta + v_i)$. The random error, $v_i$, can be positive or negative.

The stochastic frontier output varies from the deterministic part of the frontier model, $\exp(x_i\beta)$.

ALS 1977 derived the log likelihood function for the model, defined by equation (3), in which the u_i’s are assumed to be i.i.d. N(0, $\delta^2$) random variables, independent of the vi’s, v_i’s are assumed to be N(0, $\delta_v^2$). They also expressed the likelihood function in terms of two variance parameters, $\sigma^2 = \sigma_v^2 + \sigma_u^2$. Battes&Corra. (1977) suggested the parameter $\gamma = \sigma_v^2 / \sigma_u^2$ be used because it has a value between zero and one, the parameter $\gamma$ could be of any non-negative value. A value of $\gamma$ of zero indicates that the deviations from the frontier are entirely due to noise or uncontrollable factors while a value of one would indicate that all deviations are due to the technical inefficiency.

The $\gamma$-parameterization has advantages in obtaining the Maximum Likelihood (ML) estimates because the parameter space for $\gamma$ can be searched by a suitable iterative maximization algorithm. The log-likelihood function, in terms of this parameterization is equal to
\[ \ln(L) = -\frac{N}{2} \ln\left(\frac{\pi}{2}\right) - \frac{N}{2} \log(\delta^2) + \sum_{i=1}^{N} \ln\left[1 - \Phi(Z_i)\right] - \frac{1}{2\delta^2} \sum_{i=1}^{N} (\ln y_i - x_i\beta)^2 \quad (4) \]

\[ Z = \frac{(\ln y_i - x_i\beta)}{\delta} \sqrt{\frac{\gamma}{1 - \gamma}} \]

Where:

\( \Phi(.) \) is the distribution function of the standard normal random variable.

The ML estimates of \( \beta, \delta^2 \) and \( \gamma \) are obtained by finding the maximum of the log-likelihood function (Ahmed, 2004).
CHAPTER THREE
3. STUDY AREA AND RESEARCH METHODOLOGY:

3.1 The Study Area

The triangle of land between the blue and the white Nile bounded in the Sudan by the railway line joining Sennar and Kosti is called the Gezira. The word “Gezira” is used to describe the irrigated scheme but it’s also applied to the original land area. The original irrigated land is called the “Gezira area” and the new extension is called the “Managil Extension” each with an area of about one million feddans (Affan, 1976).

The Gezira scheme is in the area that extend from the latitude 13°N to latitude 15°N. The scheme stretches over 300 kilometers and it is northern boundaries are south of Khartoum. For administration purpose the Gezira divided into eighteen groups covering the two areas the Gezira and the Managil, each comprises six to ten blocks. The block is smallest administrative unit (Euro Consult, 1990). Gezira scheme consists of two main parts: Gezira main with an area of 1.1 million feddans and Managil scheme extension of 1.0 million feddans. Elmansi group one of eighteen groups in the Gezira scheme, includes seven blocks, with total area of 125,616 Fed. and the total numbers of tenants is 8,485 tenants.

The climate of the Gezira Scheme is arid and continental characterized by a law average annual precipitation and considerable rainfall fluctuation 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 (world bank, 1990).

3.1.1 Economic Importance

Gezira scheme is the largest irrigated scheme under one management in the world. It represents about a quarter of the irrigated area in the Sudan and amounts to about 50 percent of the schemes irrigated from the Nile system. From Sudan current allocation of the Nile water, the scheme utilizes about 35 percent. One of the main objectives of the scheme since its establishment was the production of long staple cotton to feed the British colonial textile industry at Lancashire. However, the prevailing farming system in the scheme aim to produce food and high value export crops for self-sufficiency and for export, respectively. One of the scheme main objectives is to promote social development of the tenants as well as people residing in the scheme area through better schooling, medical care, creation of job opportunities and the sense of security though better settlement (Ahmed 1997).

The main crops produced in the Gezira scheme are cotton, groundnut, wheat and dura, in addition to minor crops such as vegetables. The main vegetable crops produced in the scheme are onion and tomato and they mainly consumed locally (Mirghani et al...2002). A considerable amount of livestock is raised in the scheme, involving cattle, sheep and goats.

The Sudan Gezira Board (SGB) employs about 1919 permanent staff and about 5917 permanent laborers in addition to around 350,000 seasonal staff and laborers employed in cotton picking and other manual jobs (Mirghani et al 2001). It is estimated that about 2.7 million people live in the Gezira scheme and depend on it for their livelihood as tenants, sharecroppers, agricultural laborers, traders or provider of various services. The main group of this
population is made up of about 114,000 tenants in the Gezira scheme with an associated population of about 798,000. The other main group is the migrant labor. These, live in about 1,000 camps with a population thought to be about 600,000 (World Bank, 2000).

3.1.2 Main Crops Calendar:

The climate and soil conditions in the Gezira scheme are suitable for year-round crop production, provided irrigation water is available (government of the democratic republic of the sudan, 1982). The main crops grown in the Gezira scheme are cotton, wheat, sorghum and groundnuts. Cotton is considered the main cash crop in the Gezira Scheme, and it is a hard currency earner for the national economy.

Cotton is grown in the Gezira scheme since the Scheme began as a pilot project for cotton production in 1911. In the Gezira scheme, cotton is grown in summer from 1st of July to 10th of August through different stages of crop development until it reaches the harvesting period from the end of December to April. Currently, two types of cotton varieties are grown in the Gezira scheme namely extra long staple cotton (Barakat) and medium staple cotton (Acala). The irrigation interval is 14 days and the recommended number of irrigation is 14 during the season. Thinning operation is performed one week after the first irrigation. The recommended amount of fertilizer is 80 kg of urea per feddan and the optimum time of application is 1 to 2 months from the effective sowing date (Yousif, 1997). the green ridging operation is always done after fertilizer application.

Sorghum (dura) is grown in the Gezira scheme for on-farm consumption it is considered as the main staple food for most of the tenants in the scheme and in the Sudan. Sorghum is produced in the three agricultural sub-sectors, namely, irrigated, mechanized-rainfed and the traditional rainfed sub-sector. The dura
produced in the scheme is mainly for local consumption and the excess amount is sold in the local markets. For sorghum cultivation the soil is prepared with disc harrow, leveling and riding. The optimum sowing date for dura is July 15th. Thinning operation is done after 2 to 3 weeks after the first irrigation. The recommended amount of nitrogen fertilizer is 80 kg per fedan. Dura requires about 7 to 8 irrigations during the growing season with 14 days irrigation intervals and is harvested during November and December. 

Wheat is grown in the Gezira scheme as an import substitute crop Until 1997 Gezira scheme produced more than 40 percent of the total amount of the wheat produced in the Sudan. Wheat is a winter crop in the Gezira scheme. The optimum sowing date is between 1st and 30th of November. The crop requires 80 kg of urea and 40 kg of triple super phosphate per feddan. Wheat requires 7 to 8 irrigations with 14 day irrigation intervals.

Groundnut is a summer crop. Land, for groundnut, sowing is prepared by riding followed by split riding. The optimum sowing date is June 15th. Herbicides are recommended to be applied 1 to 7 days after the effective sowing. The crop requires about 8 irrigation with 14 days watering intervals. A month after the effective sowing date green riding is recommended. GN reaches maturity in 130 to 140 days (Yousif, 1997)

3.1.3 Size of Tenancy:

The area of the Gezira scheme is divided into 114,000 tenancies. The standard tenancy size is 20 feddans in the Gezira main and 15 feddan in Managil extension. More than 50 percent of the tenants in the Gezira scheme own a tenancy of 20 feddans or more. However, there is a variation from this standard size of the tenancy in both Gezira main and Managil extension. This variation is mainly attributed to the tenancy fragmentation via inheritance. Inheritance represents the only formal way for the tenants to transfer the ownership of
tenancy. The land tenure system is clearly stated in the Gezira land ordinance of 1921. Each tenant possesses only one tenancy, the same is true for the tenant's son or wife, formally the onership of the tenancy can be transferred to another one by inheritance. The standard size of the tenancy is not allowed to be fragmented to less than half the standard tenancy size. The average size of the tenancy in the scheme is 18 feddans.

The basic unit in Gezira is called [hawasha] which is a 4 or 3 feddans field under one crop, cultivated in rotation it is about 4 feddans in the Gezira main and 3 feddans in the Managil extension, where a five cours rotation is adopted. The tenants possess 5 hawasha, one hawasha each for cotton sorghum groundnut,wheat (or another winter crop) and a fallow. Crops are grown in a unit of 90 feddans known as number. Each number is divided in to 22-30 hawashas. Cotton, sorghum, groundnut, wheat (or another winter crop) and fallow, each is grown in a complete number.

3.1.4 Crop Rotation:

Since its inception till recent, Gezira scheme has adopted different type of crop rotation. The crop rotation in the Gezira scheme is dictated by scheme management Sudan Gezira Board (SGB), while limited freedom of area adjustment under crops other than cotton is exercised by the tenants. Table (3.1) summarizes the development of the crop rotation adopted in both parts of the scheme, Gezira main and Managil extension. The current crop rotation in the Gezira scheme is a five-course rotation. The main crops grown in the rotation are cotton, dura, groundnut and wheat (or another winter crops), in addition to a fallow. The main reason behind the sequence of the crops in the current rotation is that sorghum is a food crop for the tenant and his family. When planted after cotton the tenants have more incentives to clean the dura area as early as possible in order to make the cultural operations for dura at the right time.
Cotton crop comes after wheat and the resting season and this will results in increasing cotton productivity as cotton benefits from residual effect of the wheat fertilizer and the resting season in the improving the soil fertility (world bank, 2000).

**Table (3.1): Gezira Scheme: Development of the crop rotation**

<table>
<thead>
<tr>
<th>Season</th>
<th>Crop Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gezira Main</td>
<td>Cotton- sorghum/legume- fallow</td>
</tr>
<tr>
<td>1925-1930/31</td>
<td></td>
</tr>
<tr>
<td>1932/30-1932/33</td>
<td>Cotton- fallow- fallow</td>
</tr>
<tr>
<td>1933/34-1960/61</td>
<td>Cotton- fallow- fallow- cotton- fallow- sorghum- legume/fallow- fallow</td>
</tr>
<tr>
<td>1975/76-1985/86</td>
<td>Cotton- wheat groundnut/sorghum/vegetable- fallow</td>
</tr>
<tr>
<td>1986/87-1990/91</td>
<td>Cotton- wheat groundnut/sorghum/vegetable – fodder-fallow</td>
</tr>
<tr>
<td>1991/92-</td>
<td>Cotton- sorghum- groundnut- wheat(or other winter crops)- fallow</td>
</tr>
<tr>
<td>Managil</td>
<td></td>
</tr>
<tr>
<td>extension</td>
<td></td>
</tr>
<tr>
<td>1961/62-1974/75</td>
<td>Cotton- wheat- GN/sorghum</td>
</tr>
</tbody>
</table>
Sources: Fakki, 1982; Elhag et al., 1992; Adam, 1996; and world bank, 2000
3.1.5 Land and Irrigation Water:

Since its inspection in 1925 the Gezira irrigation network can support only 50% cropping intensity that is, 50% of the land can be irrigated at one time. By introducing wheat as a winter crop in the rotation, 75% cropping intensity was possible on the 0.9 million hectares comprising the Gezira and Managil extension schemes (Hassan, et al. 1994). However, bottlenecks occur when some crops grown in the rotation at one time creating an overlap on the demand of labor water and other inputs. Nevertheless, (20% of the land) remain idle, it represent a follow phase of the current cropping structure in Gezira. This indicate that area planted to wheat can easily be doubled in the capacity of the irrigation infrastructure on the scheme is increased. Insufficient irrigation water is therefore, the main limiting factor for horizontal area expansion in the scheme. While land is currently not a limiting factor for expanding wheat production in Gezira. However, wheat competes for irrigation water with the growing season crops that extend over the production cycle of wheat i.e cotton crop. The peak demand for water occurs between mid-October and mid-November, especially when the sorghum and groundnut harvest is delayed and overlaps with the first watering of wheat (Hassan, et al. 1994).

3.1.7 Production Management:

Production management in the Gezira Scheme is divided between government, scheme management Sudan Gezira Board (SGB) and the tenants. The government provides land and water. Gezira scheme board of directors is composed of the chairman and 12 members. Staff of the members is tenants while the others represent different governmental organizations. The scheme management (SGB) is highly decisive organization which makes the major production decisions in the scheme. SGB responsibilities include management
of the agricultural production system in the scheme, land preparation, cotton planting, distribution and application of fertilizers for cotton and to some extent for wheat, application of pesticides, seed propagation and distribution, harvesting of wheat and ginning of cotton. Moreover, SGB is responsible for management of the irrigation water from the minor canals to on-farm water operations (Mirghani, et al 2002).

Administratively the scheme is divided into 18 units called groups and each group in the scheme is headed by the group manager, assisted by a deputy. The group is subdivided further into small units called blocks which are each managed by a block inspector and 2 to 3 assistants. Blocks are further divided into 90 feddan fields called number within which the tenants cultivate individual plots called hawasha (Eltahir. 1990) the number is planted with only one crop. The responsibilities of the field inspectors are to supervise the work of the tenants in watering, growing and weeding of the crops, picking and bringing in the cotton and cleaning the land from the cotton residue at the end of the season (Yousif, 1997). At the block administration level, there is a block production council, village production council and Samad. The block production council consists of the member of the different village production councils. Its duties are mainly advisory. Before the beginning of season the block inspectors and their assistants hold meetings with the production councils to settle the required rates for private rented machinery as well as discussing problems concerning inputs transportation. The block production council is mostly involved in any decision concerning the tenants and farming practices. At each village there is a production council elected by the tenants. The responsibilities of the village production council include settling of water disputes among the tenants and touring the fields to see the progress of the crops to have a full idea in order to discuss sum arising matters at the block council meeting. At the number level
Sammad will be elected. Sammad is free tenants representative at the village council. His responsibilities are to organize the agricultural activities of his Numbers and communicate with the block inspector and pass on his commands and recommendations concerning the cropping and farming practices to the tenants (Eltahir, 1990).

The tenants carry out of the rest of the laborer operation such as sowing, weeding, irrigation, harvesting and cleaning field channels.

In 2005 a new low for Gezira Scheme was implemented. This low had five principles viz.,

1. The tenant is free in selection which crop to grow.
2. The land (Hawasha) belong to the tenant.
3. The tenant was given the right to dispose in his farm by selling mortgage and give up according to the role issued by Scheme board.
4. Establishment of water user’s associations for management, maintenance and operation of field channels in the Scheme.
5. The role of the Scheme board is conducting research, consultancy, Studies and planning agricultural policies.

3.2 Research Methodology

3.2.1 Data Analysis

Study objectives will be achieved through the estimation and analysis of Stochastic Frontier Production (SFP) model:

(SFB) model is method of estimating frontier function involving the use of econometric and there by measuring the efficiency of production. Economic efficiency is generally defined as the ability of a production organization to produce a well – specified output at the minimum cost.

Farrells (1957) proposed that economic efficiency of firm consist of two components: technical efficiency, which reflects the ability of a firm to obtain
maximum output from a given set of input and given technology, and allocative efficiency which reflect the ability of a firm to use the input in optimal proportion given respective prices. These two measures are combined together to provide a measure of the total economic efficiency. He also suggested that the function can be estimated from sample data using either a non-parametric piece-wise linear technique or a parametric technique such as in the Cobb-Douglas function using data from a sample of N firms.

3.2.1.1 FRONTIER:

The most commonly used package for estimation of stochastic production frontiers in the literature is FRONTIER 4.1 (Coelli, 1996a). This incorporates the maximum likelihood estimation of the parameters. The estimation process consists on three main steps. At the first step OLS is applied to estimate the production function. This provides unbiased estimators for the $\beta$'s (except for the intercept term and the variance estimate). The OLS estimates are used as starting values to estimate the final ML model. First, the value of the likelihood function is estimated for different values of $\gamma$ between 0 and 1 given the values for the $\beta$'s derived in the OLS. Finally an interative Davidon-Fletcher-Powell algorithm calculates the final parameter estimates, using the values of the $\beta$'s from the OLS and the value of $\gamma$ from the intermediate step as starting values. FRONTIER 4.1 has been created specifically for the estimation of production frontiers. As such, it is a relatively easy tool to use in estimating stochastic frontier models. It is flexible in the way that it can be used to estimate both production and cost functions, can estimate both time-varying and invariant efficiencies, or when panel data is available, and it can be used when the functional form have the dependent variable both in logged or in original units.
Frontier solves two general models. The error components model can be formulated as:

\[ Y_{it} = X_{it} \beta + (V_{it} - U_{it}) \]

Where \( Y_{it} \) is the (logged) output obtained by the i-th firm in the t-th time period; \( X_{it} \) is a \((k \times 1)\) vector of (transformation of the) input quantities of the i-th firm in the t-th time period; \( \beta \) is a \((k \times 1)\) vector of unknown parameters; and \( V_{it} \) are assumed to be iid \( N(0, \sigma_v^2) \) random errors, and \( U_{it} = U_i \exp (-\eta(t-T)) \), where \( U_i \) are assumed to be iid as truncations at zero of the \( N(\mu_i, \sigma_u^2) \).

This is the Battese and Coelli (1992) model. However some other models can be summarized as special cases of this one and can also be solved using FRONTIER. Setting \( \eta=0 \), the time invariant model of Battese, et al (1989) is obtained. The Battese and Coelli (1988) model results from the previous one for the particular case of problems in which balanced data is available. If we add \( \mu=0 \) to the aforementioned assumptions, the Pitt and Lee (1981) model results. And if we finally set \( T=1 \) in the Pitt and Lee model, we obtain the original cross-sectional data model of Aigner, et al (1977).

If \( \eta>0 \), the inefficiency term, \( U_{it} \), is always decreasing with time, whereas \( \eta<0 \) implies that \( U_{it} \) is always increasing with time. That could be one of the main problems when using this model, technical efficiency is forced to be a monotonous function of time.

The second model included in the FRONTIER package is the Technical Efficiency (TE) effects model (Battese and Coelli 1995). It can be expressed as \( Y_{it} = X_{it} \beta + (V_{it} - U_{it}) \), where \( Y_{it}, X_{it}, \beta \) and \( V_{it} \) are as defined earlier and \( U_{it} \)
\[ \sim N(m_{it}, \sigma_u^2), \] where \( m_{it} = Z_{it}\delta, \) \( Z_{it} \) is the vector of firm-specific variables which may influence the firms' efficiency. FRONTIER offers also the solution of the model of Stevenson (1980) which is a particular case of the previous model that can be obtained for the cases in which \( T \) is equal to 1 (for cross-sectional data).

There are two approaches to estimating the inefficiency models. These may be estimated with either a one step or a two step process. For the two-step procedure the production frontier is first estimated and the technical efficiency of each firm is derived. These are subsequently regressed against a set of variables, \( Z_{it}, \) which are hypothesised to influence the firms' efficiency. A problem with the two-stage procedure is the inconsistency in the assumptions about the distribution of the inefficiencies. In the first stage, the inefficiencies are assumed to be independently and identically distributed (iid) in order to estimate their values. However, in the second stage, the estimated inefficiencies are assumed to be a function of a number of firm specific factors, and hence are not identically distributed unless all the coefficients of the factors are simultaneously equal to zero (Coelli, et al 1998). Frontier uses the ideas of Kumbhakar, et al (1991) and Reifsneider and Stevenson (1991) and estimates all of the parameters in one step to overcome this inconsistency. The inefficiency effects are defined as a function of the firm specific factors (as in the two-stage approach) but they are then incorporated directly into the MLE. This is something that should be taken into consideration when programming in some of the general statistical packages.

FRONTIER offers a wide variety of tests on the different functional forms of the models that can be conducted easily by placing restrictions on the models and testing the significance of the restrictions using the likelihood ratio test. The
FRONTIER program is easy to use. A brief instruction file and a data file have to be created. The executable file and the start-up file can be downloaded from the Internet free of charge at the CEPA (University of New England) http://www.uq.edu.au/economics/cepa/frontier.htm

3.2.1.2 Efficiency Model:
This model includes the factors influencing the tenant technical efficiency for wheat production. SFP model of the Cobb-Douglas form will be used. The model is specified as follows:

\[ \ln y_i = \beta_0 + \beta_1 D_1 x_{i1} + \sum_{j=2}^{8} \beta_j x_{ij} + v_i - u_i \]

Where:
- \( \ln \) = the natural logarithm;
- \( y_i \) = yield of wheat in sack/feddan;
- \( x_1 \) = wheat area (Feddan);
- \( D_1 x_{i2} \) = dummy variable for sowing which has value of one if the sowing is done at the optimum time and two, otherwise;
- \( x_3 \) = number of plowing;
- \( D_1 x_{i4} \) = pest and weed control dummy variable with a value of one if tenancy is severely infested or zero, otherwise;
- \( x_5 \) = insufficient irrigations;
- \( x_6 \) = Agricultural income used in agriculture during the season;
- \( x_7 \) = Tenants experience;
- \( x_8 \) = off farm income used in agriculture during the season;
- \( \beta_1 \) and \( \beta_j \) are unknown parameters to be estimated for the dummy and continuous 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, associated with the tenants technical inefficiency in production and assumed to be independently distributed. For the technical inefficiency effect for the \( i^{th} \) tenants, it will be obtained by truncation (at zero) of the normal distribution with mean, \( \mu_i \) and variance \( \sigma^2 \).

**3.2.1.3 Inefficiency Effect Model:**

As mentioned above in the tenants model, \( u_i \) in the SFP model is anon 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, \( \mu_i \) and variance, \( \delta^2 \), such that

\[
\mu_i = \delta_0 + \sum \delta_s Z_s
\]

where:

\( Z_{1i} = \text{Gender: with value of one if the tenant is Male, or two if the tenant is Female;} \)
\( Z_{2i} = \text{Age;} \)
\( Z_{3i} = \text{Marital status with value of one if the tenant is single, two if the tenant is married or three divorced;} \)
\( Z_{4i} = \text{level of education with value of one if the tenant is illiterate, two if he has khalwa education, three has primary education, four has secondary, or five if he has university and post graduate level;} \)
\( Z_{5i} = \text{Family size;} \)
\( Z_{6i} = \text{Land tenure one if the tenant own the land or two for rent;} \)
\( Z_{7i} = \text{Harvesting date, which has value of one if the sowing is done at the optimum time and zero, otherwise;} \)
\( Z_{8i} \) = land preparation date, which has value of two if land preparation is done at the optimum time and one, otherwise;
\( Z_{9i} \) = farm location;

\( \delta_s \) and \( \delta_s^2 \) are unknown parameters to be estimated;

An important result is that the variance ratio parameters \( \gamma \) is large and significant. The result expresses that percentage value of \( \gamma \) for wheat output deviation is caused by differences in tenant’s level of technical efficiency as opposite to the conventional random variability. The significant estimates of \( \gamma \) and \( \sigma^2 \) imply that the assumed distribution of \( ui \) and \( vi \) is accepted.

3.2.1.4. Test of The Hypotheses:

The coefficients of farm-specific variables on the technical inefficiency effect models using the generalized likelihood-ratio statistic, LR were tested. Coelli (1995) suggested that the one-sided generalized likelihood-ratio test should be performed when ML estimation is involved because this test has the correct size (i.e. probability of a type I error). We were interested in testing the null hypothesis that the inefficiency effects were not present. In other words, the null hypothesis is that there are no technical inefficiency effects in the model. That is the:
\[ H_0: \gamma=\delta_0=\delta_1=\ldots=\delta_5=0. \]

3.2.2 Data Collection:

Data 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 the education and training of the field investigation. Primary and secondary data were collect to test the stated hypothesis and to fulfill the objectives of the study.
3.2.2.1 Primary Data:

Primary data were collected by using structural questionnaire using random sampling techniques due to socio-economic characteristic and homogeneity of Gezira scheme population, 100 respondents were selected. The primary data include basic information about the socio-economic characteristics of scheme population such as age, educational level, family size, farm income, off-farm income, crops yield and crops production.

3.2.2.2 Secondary Data:

Secondary data were collected form the relevant institutional sources, which include Ministry of agriculture and Forests, in addition to different document, records, books, paper, journals, periodicals and reports.
CHAPTER FOUR

4. RESULTS AND DISCUSSION

This chapter presents the empirical results of study. Namely the socio-economics characteristics of the tenants, stochastic production frontier and inefficiency model using the data of growing season 2006/07.

4.1 Socio-economic Characteristics:

4.1.1 Gender, Age, Marital Status, Educational Level and Family Size:

World Bank (2001) stated that the gender refers to socially constructed roles and socially learned behaviors and expectations associated with females and males’. It can be defined as more than biological differences between men and women. It includes the ways in which those differences, whether real or perceived, have been valued, used and relied upon to classify women and men and to assign roles and expectations to them (Mwanza, 1996).

Table (4.1) shows that most of the tenants are male with 95% of total respondent’s distribution in the Gezira scheme with efficiency of 70%.

Age structure is one of the factors that are used to distinguish the farming systems. Siddig (1999) cited that a tenant’s age is one of his demographic characteristic which influences the quality of his decision and his attitude toward accepting new ideas. Table (4.2) showed that the highest percentage of the tenants in the sample found in the non-productive age (over 60 year) with mean efficiency of 69% which is the lowest average of efficiency. Where the lowest percentage was in productive age with the highest average of efficiency of 87% (20-30) year.

Education in general can be defined as accumulation of knowledge and experience to prepare an individual for life (Ahmed, 1996 and Siddig, 1999). Education stimulates people to realize their needs to understand the problems
of their immediate environments and their rights and duties as citizens, (Malik, 1974).

Table (4.3) show distribution of the tenants according to their educational level, 29.0% illiterate, 14.0% khalwa, 28.0% primary, 20.0% secondary and 9.0% university. This means that the efficiency increase with the education level, but the respondents with university and post-graduate have lower level of efficiency than secondary level that may due to their main occupation is not the agriculture.

Table (4.4) illustrates that the majority of sample respondents 88% are married, 8% single, and 4% is divorce. It is important to emphasize that the survey comprised mainly of household head it took responsibility because the majority of respondents were married, additionally some of those single took responsibility.

Family can be defined as all members living within a household having a blood relationship and who are supported by an income known as the family income (Siddig, 1999). Beside, that, family plays a vital role in the agricultural economic and development. Table (4.5) show that the family size ranged between (1 and 15) members and the largest family size 87% ranged between 5 and 10 members with the highest level of efficiency.
Table (4.1): Distribution of Sample Tenants According to Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Percentage</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>95%</td>
<td>70%</td>
</tr>
<tr>
<td>Female</td>
<td>71%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Table (4.2): Distribution of Sample Tenants According to Age

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Percentage</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–30</td>
<td>5%</td>
<td>87%</td>
</tr>
<tr>
<td>30–40</td>
<td>19%</td>
<td>74%</td>
</tr>
<tr>
<td>40–50</td>
<td>20%</td>
<td>78%</td>
</tr>
<tr>
<td>50–60</td>
<td>25%</td>
<td>72%</td>
</tr>
<tr>
<td>60 and up</td>
<td>31%</td>
<td>69%</td>
</tr>
</tbody>
</table>

Table (4.3): Distribution of Sample Tenants According to Education

<table>
<thead>
<tr>
<th>Educational Level</th>
<th>Percentage</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illiterate</td>
<td>29%</td>
<td>73%</td>
</tr>
<tr>
<td>Khalwa</td>
<td>14%</td>
<td>66%</td>
</tr>
<tr>
<td>Primary</td>
<td>28%</td>
<td>74%</td>
</tr>
<tr>
<td>Secondary</td>
<td>20%</td>
<td>81%</td>
</tr>
<tr>
<td>University and post graduate</td>
<td>9%</td>
<td>75%</td>
</tr>
</tbody>
</table>
Table (4.4): Distribution of sample tenants according to marital status

<table>
<thead>
<tr>
<th>Marital Status</th>
<th>Percentage</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marriage</td>
<td>88%</td>
<td>72%</td>
</tr>
<tr>
<td>Single</td>
<td>84%</td>
<td>8%</td>
</tr>
<tr>
<td>Divorced</td>
<td>82%</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table (4.5): Distribution of Sample Tenants according family size

<table>
<thead>
<tr>
<th>Family Size</th>
<th>Percentage</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>8%</td>
<td>66%</td>
</tr>
<tr>
<td>5-10</td>
<td>87%</td>
<td>75%</td>
</tr>
<tr>
<td>10-15</td>
<td>5%</td>
<td>64%</td>
</tr>
</tbody>
</table>
4.2 Frequency Distribution of Tenants Technical Efficiency

The tenants in Managil extension have wide range of technical efficiency ranging from 20 percent up to 98 percent for wheat production. The frequency distribution of the efficiency estimates obtained from the stochastic frontier for wheat production Figure (4.1) shows that 20 percent of the tenants operate with efficiency ranged above 60-70 level of efficiency for wheat. This implies that on average, the tenants producing wheat in Managil extension achieved 73 percent of the potential stochastic frontier wheat production level given their current level of production inputs and technology used. 20 percent of the tenants in Managil extension operated below 60 percent of the maximum wheat production, obtained by the fully efficient and 60 percent operated above the 70 percent level of technical efficiency.
The efficiency score of wheat is shown in the bar graph. The percentage distribution is as follows:

- 20-50: 12%
- 50-60: 8%
- 60-70: 20%
- 70-80: 19%
- 80-90: 19%
- Above 90: 22%

The graph indicates that the highest percentage of wheat has an efficiency score above 90.
4.3. Hypotheses Test of Wheat Production Model:

**Table (4.6):** Test of hypothesis for the parameters of stochastic frontier production function of wheat.

<table>
<thead>
<tr>
<th>Wheat Production Model</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0: \gamma = \mu = 0$</td>
<td>62.3***</td>
</tr>
<tr>
<td>LR $H_0$: No technical inefficiency</td>
<td>71.3***</td>
</tr>
</tbody>
</table>

*** asterisks on the value of the parameters indicate it is significance at 1, 5 and 10 percent level respectively.

As shown in Table (4.6) the test of hypothesis of wheat likelihood ratio test (LR), which tests the null hypothesis for the technical inefficiency effect for wheat production in Gezira scheme is rejected. The value of the test is calculated as:

$$LR = -2\left\{\ln[L(H_0) / L(H_1)]\right\} = -2\left\{\ln[L(H_0)] - \ln[L(H_1)]\right\}$$

Where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null hypothesis and alternative hypothesis, respectively (Rahman, 2002 & Ahmed, 2004).

Table (4.6) reveals that there are significant technical inefficiency effects in wheat production, because the null hypotheses $H_0$ are fully efficient given the specification of (SPF) in Cobb-Douglas form. Then the ($H_0: \gamma = \mu =0$): null hypothesis are rejected.

4.4 Stochastic Frontier Production Function Analysis:

Stochastic Frontier version 4.1 program (Coelli, 1996) was used to estimate the level of technical efficiency for Wheat production.

4.4.1 Wheat Production Efficiency:

As shown in Table (4.7), the mean technical efficiency of Wheat production function is 0.73 in the Gezira scheme, with minimum efficiency of
20%, and maximum efficiency 97% (Table 4.6). The average technical efficiency of Wheat means that the scheme produced 73 percent of Wheat at best practice, at the current level of production inputs and technology. This means that the respondents can increase their wheat output by 27 percent from a given mix of production inputs if the tenant’s are technically efficient.

Table (4.7): Summary Statistics of Efficiency Estimate from the Stochastic Frontier Model of Wheat:

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Wheat Efficiency score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.73</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.20</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.97</td>
</tr>
</tbody>
</table>
The maximum likelihood (MLE) estimate of Cobb-Douglas stochastic production frontier model with the assumption of half-normal for wheat production efficiency, and technical in-efficiency were presented in Tables (4.8) and (4.9).

Table (4.8): Maximum-likelihood Estimate for the Parameters of the Stochastic Frontier Production Function.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameters</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>$B_0$</td>
<td>2.808</td>
</tr>
<tr>
<td>Wheat area ($X_1$)</td>
<td>$B_1$</td>
<td>0.124*</td>
</tr>
<tr>
<td>Sowing date ($X_2$)</td>
<td>$B_2$</td>
<td>-0.100</td>
</tr>
<tr>
<td>Number of plowing ($X_3$)</td>
<td>$B_3$</td>
<td>0.016</td>
</tr>
<tr>
<td>Degree of infection ($X_4$)</td>
<td>$B_4$</td>
<td>-0.049*</td>
</tr>
<tr>
<td>insufficient irrigations ($X_5$)</td>
<td>$B_5$</td>
<td>-0.234***</td>
</tr>
<tr>
<td>agricultural income ($X_6$)</td>
<td>$B_6$</td>
<td>-0.130</td>
</tr>
<tr>
<td>Tenant experience($X_7$)</td>
<td>$B_7$</td>
<td>0.153***</td>
</tr>
<tr>
<td>Off farm income ($X_8$)</td>
<td>$B_8$</td>
<td>-0.016*</td>
</tr>
<tr>
<td>$\sigma^2_s = \sigma^2_v + \sigma^2$</td>
<td>$\sigma^2_s = \sigma^2_v + \sigma^2_s$</td>
<td>0.797***</td>
</tr>
<tr>
<td>$\gamma = \sigma^2_v / \sigma^2_s$</td>
<td>$\gamma = \sigma^2_v / \sigma^2_s$</td>
<td>0.977***</td>
</tr>
<tr>
<td>Mean efficiency</td>
<td></td>
<td>0.733</td>
</tr>
<tr>
<td>Log likelihood function</td>
<td></td>
<td>39.283</td>
</tr>
</tbody>
</table>

**Source:** calculated, 2008 by the author

***, ** and * asterisks on the value of the parameters indicate its significant at 1, 5, and 10 percent level of significance respectively.

The estimated standard errors are presented in parenthesis bellow the corresponding parameter estimate.
An important result is that the variance ratio parameters $\gamma$ is large and significant and has a value of 0.97. The result expresses that about 97 percent of wheat output deviation is caused by differences in tenant’s level of technical efficiency as opposite to the conventional random variability. The significant estimates of $\gamma$ and $\sigma^2$ imply that the assumed distribution of $u_i$ and $v_i$ is accepted (Tables 4.8).

Table (4.8) presents estimates of wheat stochastic frontiers for Wheat production in Gezira Scheme.

Most of the estimated $\beta$ co-efficient of the stochastic frontier model for wheat production model have the expected sign.

Wheat area has a positive sign and significant at 1 percent level of significance. The reason is that the increase of area increases the efficiency, this result may come from the fact that rich tenants can rent extra areas and they have enough money to apply the practices timely in case of credit delay.

Under the climatic conditions of Sudan, characterized high temperatures during the short growing season, a better definition of time of planting for wheat, will probably have a big effect on grain yield. Earlier studies in Sudan showed that sowing date was the most important factor affecting yield (Heipko, 1966).

Wheat sowing date has a negative sign and significance at 10 percent level of significance. The negative sign reflects the effects of late sowing on wheat production level.

The basic purpose of tillage is to provide a favorable soil environment for the germination and growth of the crop. Tillage usually affects four soil physical properties, aeration, moisture-holding capacity, temperature and mechanical impedance. Primary tillage is usually done to break the soil compaction, while
secondary tillage include weed control and turning under crop residues for best control for easier cultivation (Dawl and Beit, 1996).

The coefficient of number of plowing has a positive sign and not significance. This result means that the efficiency increases with the increase in number of plowing.

Wheat has been cultivated for hundreds of years in northern Sudan. No serious losses due to absence of pest that justify control measures. However, wheat production in the new areas south of Khartoum (Gezira, Rahad, New Halfa, White Nile and Blue Nile) has been faced with a number of pest problems. Important wheat pests in Sudan include aphids termites, stem borers and leaf miners (Sharaf Eldin, 1993). The coefficient of degree of infection has a negative sign and significance at 10 percent level of significance. This result indicates that the wheat production increase with decrease in degree of infection.

Since its inspection in 1925 the Gezira irrigation network can support only 50% cropping intensity that is, 50% of the land can be irrigated at one time. By introducing wheat as a winter crop in the rotation, 75% cropping intensity was possible on the 0.9 million hectares comprising the Gezira and Managil extension schemes (Hassan, et al. 1994).

However, bottle necks occur when some crops grown in the rotation at one time creating an overlap on the demand of labor, water and other inputs. Nevertheless, (20% of the land) remain idle, it represent a follow phase of the current cropping structure in Gezira. This indicate that area planted to wheat can easily be doubled in the capacity of the irrigation infrastructure on the scheme is increased. Insufficient irrigation water is therefore, the main limiting factor for horizontal area expansion in the scheme. While land is currently not a limiting factor for expanding wheat production in Gezira. However, wheat competes for
irrigation water with the growing season crops that extend over the production cycle of wheat i.e. cotton crop. The peak demand for water occurs between mid-October and mid-November, especially when the sorghum and groundnut harvest is delayed and overlaps with the first watering of wheat (Hassan, et al. 1994).

The coefficient of insufficient irrigations has a negative sign and significance at 1 percent level of significance. The negative sign indicates that the wheat production decrease with the increase in insufficient irrigations.

The coefficient of agricultural income has a negative sign and not significance. This result means that this income may be used in other crops rather than wheat production.

The coefficient of tenants’ experience has a positive sign and, 1 percent level of significance. This result means that the expert tenants will get high production than newer ones in wheat production.

The coefficient of off-farm income has a negative and significance at 10 percent. A possible explanation of this result is that a major of off-farm income is not used in wheat production. This result means that tenants who have off-farm income have less time to look after wheat and hence have lower yields.
### 4.4.2 Inefficiency Model for wheat

#### Table (4.9): Inefficiency for wheat Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameters</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant ($Z_0$)</td>
<td>$\delta_0$</td>
<td>1.737</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.756)</td>
</tr>
<tr>
<td>gender; ($Z_1$)</td>
<td>$\delta_1$</td>
<td>-1.331**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.514)</td>
</tr>
<tr>
<td>Age ($Z_2$)</td>
<td>$\delta_2$</td>
<td>-0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.006)</td>
</tr>
<tr>
<td>marital status ($Z_3$)</td>
<td>$\delta_3$</td>
<td>0.435**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.219)</td>
</tr>
<tr>
<td>Educational level ($Z_4$)</td>
<td>$\delta_4$</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.048)</td>
</tr>
<tr>
<td>Family size ($Z_5$)</td>
<td>$\delta_5$</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.037)</td>
</tr>
<tr>
<td>Land tenure ($Z_6$)</td>
<td>$\delta_6$</td>
<td>-1.128***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.323)</td>
</tr>
<tr>
<td>Harvesting date ($Z_7$)</td>
<td>$\delta_7$</td>
<td>-0.062</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.146)</td>
</tr>
<tr>
<td>land preparation date ($Z_8$)</td>
<td>$\delta_8$</td>
<td>-0.523***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.135)</td>
</tr>
<tr>
<td>Farm location ($Z_9$)</td>
<td>$\delta_9$</td>
<td>0.126*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.076)</td>
</tr>
</tbody>
</table>

**Source:** calculated, 2008 by the author

***,** and * asterisks on the value of the parameters indicate its significant at 1, 5, and 10 percent level of significance respectively. The estimated standard errors are presented in parenthesis below the corresponding parameter estimate.
As shown in Table (4.9), for wheat inefficiency, the estimated $\delta$ coefficient associated with explanatory variable in the model for inefficiency effects. The tenant’s sex has a negative sign and has a significance effect upon the inefficiency model for wheat crop. The age of tenants has a negative sign and not significance. Negative sign means that the inefficiency effects decrease with the increase in age of tenant’s operator. The result is that elder tenants are more efficient than younger ones.

The marital status has positive sign and high significant at 1 percent. Positively sign means that the decreasing of number of tenants who married reduces inefficiency by statistically significant amount.

The coefficient of educational levels of tenants has negative sign and not significant. Negatively significant parameter of education means that technical inefficiency decreases with the increase in education of farm operators. The reasons is that level of education of tenants are indicators of the tenants’ awareness and their abilities of taking decisions on how and what to produce, approaching credit, allocating their available resources and adopting new agricultural technologies. The coefficient of family size of tenants in model for inefficiency effects is estimated to be of positive sign and not significance. Positive sign indicates that tenants with large family size tend to have bigger inefficiency effects than tenants with smaller one. That because of the fact that wheat doesn’t need large amount of labor. The coefficient of land tenure has a negative sign and significance at 1 percent level of significance. In the scheme there are two types of land tenure the first one the tenant own his land an the second type is rent; the negative sign
indicates that tenants who rent land has higher efficiency, because the tenant who rent gives more attention to his crop.

However, harvesting date was positively correlated with sowing date (Al-Amin, 1996). Wheat is harvested in the large irrigation projects using combine harvesters. Total harvesting losses could be divided into pre-harvest, header, and processing losses. Pre-harvest losses caused by wind, bird, rats and rain, or by the movement of people in the fields. Header losses include dropped heads, shattered seeds and missed heads, which happens as a combine header passes over the wheat plants. Header losses are usually due to operational factors such as combine speed. Processing losses include cylinder loss, separation losses, and cleaning losses. Processing losses are mainly due to machine adjustment. Combine harvesters depend mainly on machine and need few number of labors, capital intensive operation while the manual harvest needs many number of labors then it compete for labor between a manual harvesting of wheat and harvesting of cotton crop. Moreover, combine harvester harvest at the optimum time, while manual harvester spends more time which leads to pre-harvest losses.

The coefficient of harvesting has a positive sign and not significant. The positive sign means that the optimum harvesting time increase wheat production.

Zahalan (1986) reported that the land quality is assumed to be one of the most important classical inputs that have an influence on the output of different crops grown. The quality of the land is also important because the land is different in quality from one side to another. Accordingly, land is expected to explain most of the variation in the output for the main crops grown in the traditional area.
The coefficient of land preparation date has a negative sign and significant at 1 percent level of significance. The result means that the late in preparations date increase inefficiency.

The coefficient of farm location has a positive sign and significant at 10 percent level of significance. The result is that farms located at the tail of the canal are more inefficient than thus at the head of the canal.
CHAPTER FIVE

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

In this chapter summary of the results, conclusion and recommendations were presented.

5.1 Summary

Agricultural productivity varies due to differences in production technology, and differences in the efficiency of the production process. The main objective of this study is to measure and evaluate the technical efficiency of wheat production which is practiced in the Managil extension. The specific objective are to identify the main factors behind the tenants technical inefficiency, to identify the socio-economic factors affecting the level of efficiency of tenants, to develop specification and estimations of stochastic frontier econometric models for producing wheat and to draw policy recommendations.

In this study primary and secondary data were used. The primary data were collected from a field survey by using structural questionnaire for 100 respondents distributed randomly, in addition to secondary data, which were collected from relevant sources.

The methodology used in this study, econometrics stochastic frontier models were estimated under the specification of the Cobb-Douglas production function model.

The study results showed that the mean technical efficiency is 73% for wheat was achieved by farms in the study area. This result indicates that there is a scope for increasing wheat production by 27% with present technology.

An analysis of the determinants of technical efficiency indicated that the area under wheat, degree of infection, insufficient irrigation, farm experience and off
farm income for producing wheat are both significant variable for improving technical efficiency. Also most of the estimated $\delta$ variables such as gender, marital status, and land tenure and land preparation date are significant variable. The family size, age, harvesting date, sowing date, number of plowing and agricultural income not significant. The descriptive statistic of socio-economics characteristic result showed that most tenants in the study are male 95% with efficiency level of 70%, their age distribution ranged between (20-70) years and most 31% of tenants their age distributed between (60-70) with the lowest efficiency level 69 and the efficient tenants age ranged between (20-30) years their efficiency level is 87% and 88% of tenants are married.
5.2 Conclusions:

The conclusions of this study based on the results of stochastic production frontier for wheat, are. Tenants in Managil extension are technically efficient; the average technical efficiency is 73%. This indicates that tenant’s can increase output by 27 % under existing inputs level and technology. In this study Gender of tenant’s, land tenure and land preparation date are found to have a negative significant impact on production in Managil extension. The study found that age, education level and harvesting date have no significant impact in wheat production. Marital status has significant effect on efficiency. Degrees of infection, insufficient irrigation and off-farm income have a significant influence for efficiency. The wheat area has a significant influence for wheat production technical efficiency. Sowing date, agricultural income and number of plowing have no significant effects
5.3 Recommendations

This study examined the technical efficiency of producing wheat in Managil extension. The study recommended that improving technical efficiency of wheat production of the tenant’s through:

1- Pest control must be done.
2- Provide water for irrigation in time and clean the irrigation channel.
3- Early land preparation.
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