Sudan University of Science and Technology
College of Graduate Studies

Estimation of Economic Efficiency of Sorghum and Sesame Crops Production in Habiella Agricultural Scheme in South Kordofan State- Sudan

تقدير الكفاءة الإقتصادية لإنتاج محصولي الذرة والسمسم في مشروع هبيلا بولاية جنوب كردفان- السودان

A thesis Submitted in Fulfillment for the Requirements of the Degree of Ph.D. in Agricultural Economics

By

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بسم الله الرحمن الرحيم

In the name of Allah the most and beneficial merciful

قال تعالى:

(هُوَ الَّذِي أَنزَلَ مِنَ السَّمَاء مَاء لَّكُم مِّنْهُ شَرَابٌ وَمِنْهُ شَجَرٌ فِيهِ تُسِيمُونَ (10) يُنبِتُ لَكُم بِهِ الزَّرْعَ وَالزَّيْتُونَ وَالنَّخِيلَ وَالأَعْنَابَ وَمِن كُلِّ الثَّمَرَاتِ إِنَّ فِي ذَلِكَ لآيَةً لِّقَوْمٍ يَتَفَكَّرُونَ (11)

صدق الله العظيم

سورة النحل الآيتان (10)، (11)

DEDICATION

To all:

My Allah prolongs their life and blesses them

,Amen,

My lovely parents

My Family dear (wife Entsar mum, son's Baha Alden- Ala Alden- Diea Alden, daughter Shima- Aliya)

My Relatives

My Friends everywhere, I offer this work

Khalid (2022)

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ABSTRACT

The study tackled the estimation of the economic efficiency for production of two crops sorghum and sesame in Habiella agricultural scheme, Habiella locality, in south kordofan state. This study aimed at estimation the economic efficiency for the two crops, sorghum and sesame in Habiella agricultural scheme, and determine the main factors affecting, that cause economic inefficiency both in two perspectives (Technical efficiency and Allocative), determine the lowest level of cost production obtainable so as to reach the high level of production in taking the umbrage of the best blend of using the actual available resource of production, knowing the products ideal returning either sesame and sorghum, knowledge of Socio-economic characteristics factors that affect the products, then on the economic efficiency of the producers (farmers). The study depended both primary and secondary data sources, primary data were collected from a survey conducted in 2019/2020, from (191 farmers) through structured simple random sampling technique. While the secondary data were collected from relevant sources, to the topic of the study such as books, researches, scientific papers, journals, periodicals, reports from Ministry of Production and Economic Resources. The analysis was done by using the statistical package for social sciences (SPSS), Excel programmed, from budget, computer programmed (Frontier version4.1), stochastic frontier production function, descriptive Statistics and linear programming. The most important results obtained were that most farmers were males with percent 99.5%, and their average age (53) years old which fall in the range of the productive active age (45-60) with percentage 39.9%, the mean of the family households members was (8) with 53.1%, the average of the family members those who work on the farm were only (2) persons per households with the percentage 46.6%, Most of the farmers 80.1% have attained some sort of education, the average of the experience was 16 years with percentage 36.4%, the average of the other economic secondary activity was 52.9%, and stochastic frontier production function model, the farmers economic efficiency showed 0.43%, 0.06% for the sorghum and sesame respectively, and the average of the farmers Technical efficiency was 0.99%, 0.54% for the sorghum and sesame respectively, the most production factors that affect the Technical efficiency significant, indication and the result of the linear programming showed the ideal returning and higher efficient profit for sesame crop. The study results also reached that farming budget was highest profit for farmers of the sesame crop compared to those of the sorghum crop. The study recommended the fowling: it is important to intensive extension programmers to improve the economic efficiency (Technical efficiency and Allocative) of farmers, revitalizing the special lows that concern farmers and herders, solving problems and obstacles that affect of the production of two crops (enough financing at suitable time, efficient agricultural machineries, integrated pest management and improved seeds), adoption of using technical package and full modern technologies that recommended by Agricultural Research center, and zero tillage programmed, to increase production and productivity and farmers income, lead to the optimum technical efficiency and economic efficiency.

الخلاصة

تناولت الدراسة تقدير الكفاءة الإقتصادية لإنتاج محصولي الذرة والسمسم في مشروع هبيلا الزراعي، محلية هبيلا، بولاية جنوب كردفان قي الفترة، 2019-2022م. الهدف الاساسي من الدراسة هو تقدير الكفاءة الإقتصادية لإنتاج محصولي الذرة والسمسم في مشروع هبيلا الزراعي، بالاضافة الى وتحديد العوامل التي تسبب في عدم الكفاءة الاقتصادية بشقيها (التقنية والتوظيفيه)، تحديد أدنى مستوى تكاليف الإنتاج للحصول على أعلى مستوى إنتاج في ظل التوليفة المثلى لموارد الإنتاج المتاحة فعلياً، معرفة عائد إنتاج المحصول الأمثل السمسم ام الذرة، ومعرفة العوامل الإجتماعية والإقتصادية التي تؤثر على الإنتاج وعلى مستوى الكفاءة الإقتصادية للمنتجين (الزّراع). إعتمدت الدراسة على البيانات الأولية والثانوية، تم جمع والبيانات الأولية من خلال المسح الميداني لعدد 191 مزارع في مزارع مشروع هبيلا الزراعي عن طريق العينة العشوائية البسيطة والمنتظمة بواسطة إستبيان، بيما تم جمع البيانات الثانوية من المصادر ذات الصلة بمضوع الدراسة كالكتب، البحوث والاراق العلمية، المجّلات العلمية، النشرات، المطبقات، والتقارير من وزارة الإنتاج والموارد الإقتصادية. وتم تحليل البيانات بواسة برناج الحزم الاحصائية للعلوم الاجتماعية (SPSS)، برنامج الحاسوب (Excel)، وميزانية المزرعة، برنامج الحاسوب (Frontier version4.1)، ودالة الانتاج المجال العشوائي، والبرمجة الخطية. توصلت الدراسة الى عدّة نتائج أهمها: أن أغلب المزارعين ذكور بنسبة 99.5% ، ومتوسط أعمارهم 53عام بنسبة 39.9%، وتقع هذه الأعمار في المدى العمري النشط (60-45)عام، متوسط عدد افراد الأسرة بلغ 8 افراد بنسبة 53.1%، متوسط افراد الأسرة الذين يعملون في الزراعة 2 فرد فقط بنسبة 46.6%، أغلب المزارعين نالوا مستويات تعليمية مختلفة بنسبة 80.1% ، متوسط الخبرة الزراعية بلغ 16عاماً بنسبة 36.4%، وبلغت نسبة الأنشطة الثانوية الاقتصادية الأخرى 52.9%، أظهرت نتائج دالة الإنتاج المجال العشوائي، بأن الكفاءة الإقتصادية للمزارعين 0.43% و0.06% لكل من مزارعي الذرة والسمسم على التوالي، وأن متوسط الكفاءة التقنية للمزارعين 0.99% و0.54% لكل من مزارعي الذرة والسمسم على التوالي. إن معظم عوامل الإنتاج التي تؤثر في الكفاءة الفنية ذات تأثيرمعنوي بمعنى،. واظهرت نتائج البرمجة الخطية ان العائد الأمثل وأعلى كفاءة ربحية كان لمحصول السمسم،. ومن نتائج الدراسة ايضاً أن الميزانية المزرعية كانت أعلى ربحية لمزارعي محصول السمسم مقارنة بمزارعي محصول الذرة. ومن أهم توصيات الدراسة: ضرورة تكثيف البرامج الإرشادية لتجويد وتحسين الكفاءة الاقتصادية (الإنتاجية والتوظيفية) للمزارعين، وتفيعل القوانين التي تضبط بين الزراعّ والرعاة، وحل المشكلات والمعوقات التي تؤثر على إنتاج المحصولين بمنطقة الدراسة (التمويل الكافي، وفي اوالوقت المناسب، الاليات الزراعية الفعّالة، المكافحة المتكاملة للأفات الزراعية، وتوقير التقاوي المحسنة التقاوي)، وتبنّي إسىتخدام الحزم التقنية والتقانات الحديثة الموصى بها من قبل هيئة البحوث الزراعية، وتبنّي برنامج اسىتخدام الميكنة الزراعية المتكاملة (تقانات الاليات الزراعية)، وتبنّي برنامج اسىتخدام الزراعة الصفرية، لزيادة الإنتاج الانتاجية وزيادة دخل المزارع، ولحصول على التوليفة المثلى والكفاة الانتاجية (الفنية)، والكفاءة الإقتصادية

TABLE OF CONTENTS

List of Tables

List OF Figures

ABBREVIATIONS

CBS	Central Bureau of Statistics
GDP	Gross Domestic Product
UNDP	Unite Nation Development Program
FAO	Food and Agriculture Organization
LP	Linear program
SPSS	Statistical Package for Social Sciences
SPF	stochastic production frontier
MPI	Malmquist Productivity Index
MFC	Mechanized Farming Corporation
DEA	Data Envelopment Analysis
UN	Unite Nation
TE	Technical Efficiency
AE	Allocative Efficiency
EE	Economic efficiency
PPF	Production possibilities frontier
SFPF	Stochastic Frontier Production Function
SKSIO	South Kordofan State International Organization
mm	millimeter
kg	Kilogram
ML	Maximum Likelihood
SDG	Sudanese Pound
Log	Logarithm
fed	Feddan(0.42ha)
ha	10000m²
feddan	4200m²

CHAPTER ONE
INTRODUCTION

1.1 Introduction:

Sudan is the largest between Arab and African countries and ninth largest in the world with an estimated area 250.6 million hectare extending between 40 and 22 north latitudes and 22 to 38 East latitudes (Khalid, 2010).

Sudan is the third largest in Africa and seconds in the Arab counties occupying an area of about 1,882,000Km2. It lies in the Northeast part of Africa between longitude 21° 49 and 38° 34 E latitude 8° 45 and 22° 8 N. the total population of country according to 2016 ensues is 39.60 million head with and annual growth rate of about 2.4% per year (CBS, 2017).

Agriculture in the Sudan represents the backbone of the Sudanese economy. Agriculture in the Sudan provides labor and livelihood for more than two thirds of the population, beside that agriculture contributes to GDP by more than one third of the total GDP of the Sudan. Despite of the fact that oil sector and industrial sector have contributed in 2009 to the GDP by 13.1% and 23.8% respectively, (Bank of Sudan, 2009) agriculture remains the most important sector in the Sudan because it produces 60% the raw materials needed by the manufacturing sector (Ibrahim, 2018).

These agricultural advantages did not make any addition to the agriculture, on the contrary, agriculture has witnessed complete neglecting, particularly, alter the extraction of the oil, and the result was sharp decrease in the production and productivity of both the irrigated and the rain fed sub-sector. It is worth mentioning That oil crops and their derivatives, remained for a period, with a crucial role in the Sudan’s economic. Nevertheless, this role is retreating now in the list of Sudan export.

The type of agriculture in South Kordofan is rain fed agriculture, which contributes in boosting the wheel of the country’s economy. Rain fall in this area ranges between 450-900 mm per year. The patterns of the agricultural production (animal and plant) are the most crucial economic activities in the area, with dearly seen domination of the traditional systems of cultivation. These agricultural characteristics represent factors of power and economic opportunities, which enable the area to flourish in producing set of products.

Sorghum is one of the important food, and sesame the important oil cash crop and edible-oils in the area. They contribute in raising income of the households, locality, and the country as a whole. Arms conflicts between the government and the rebel group and the disputes frequently occurred between the farmers and the animal breeders have resulted in the decline of both the area cropped with Sorghum and sesame and productivity of the both crops. This in turn, resulted in the deterioration of the living conditions of the Sorghum and sesame producers.

Habiella locality located far north of the South Kordofan State. It is famous in two crops Sorghum and sesame production, because soil is suitable for both crops. Some oil factories are constituted to use the available raw material of sesame. In the recent days, sesame production is facing many difficulties, which affected the size of production and the quality as well. So, and from what is said above, the question to be asked is that; what are the variables which affect economic efficiency (technical and a locative efficiencies) of producing sorghum and sesame?

1.2 Sudan Economy

Sudan has one of the highest growth rates amongst sub-Saharan African countries and a rapidly rising per capita income, with per capita GDP of US$1,500. Nonetheless, the country’s human development outcomes remain weak. Sudan ranks 171 out of 187 countries in the UNDP’ s Human Development Report 2013. However, the secession of the south in 2011, had gravelly affected the economy as more than 80% of Sudan’s oil fields existed in the southern part of the country. This decline in oil revenues caused major adjustment to the Sudan’s fiscal situation and prompting financial austerity measures. Historically, agriculture remained as the main source of income and employment in Sudan, hiring over 80% of Sudanese. Despite this strong agricultural orientation, oil production drove most of Sudan’s post-2000 growth. Real GDP growth was estimated at 4.1% in 2018. As a result of the oil loss, the growth of industrial sector fell into the negative in 2011and 2014but service sector increased about 47% in 2011-2014while only agricultural sector witnessed constant growth in both years. In the agricultural sector, the government has tried to diversify its cash crops; however cotton and gum Arabic remain its major agricultural exports. Grain sorghum (Dura) is the principal food crop, and wheat is grown for domestic consumption, sesame seeds and peanuts are cultivated for domestic consumption and export. Livestock production has vast potential, and many animals, particularly camels and sheep, are exported to Egypt, Saudi Arabia, and other Arab countries. Problems of irrigation and transportation remain the greatest constraints to a more dynamic agricultural economy. Sudan continues to strengthen links with key emerging country partners, especially China, Malaysia and India following the attraction of substantial "resource seeking" since the late 1990s. The government has already decided to make more credit available to agriculture as part of its future development plans. It continues efforts to engage in strategic partnerships with local and foreign private investors, particularly reared towards increasing agricultural exports and diversification of production to absorb the shock of the declining oil revenues. Sudan's economic growth is dominated by agriculture which estimated on average at 31.4% of gross domestic product (GDP) in 2015 (CBoS, 2016).Agricultural remains the main source of employment and household income in rural areas where 65% of population live. About 80% of the labor force employed in agriculture and related activities such as agro-industries (FAO, 2015). It provides livelihood to about 70% of the population (Ministry of Finance and National Economy, 2017). The agricultural sector provides most of the raw material required by local industries such as sugar, textile and vegetable oil(Bank of Sudan,2016), therefore, provision of food, fiber, foreign exchange earnings, labor employment, and sale of industrial goods in rural areas

1.3 Problem statement

In recent years, the operating efficiency and the production and productivity efficiency in rain fed area has deteriorated and the income of tenants has consequently declined. Habiella Scheme is no exception.

Sorghum and sesame production in the Sudan, in general, and Habiella locality in South Kordofan (in particular) is facing many difficulties such as economic, agriculture, climate, lack of extension services, lack of funding policies by the government, conflict between farmers and animal keeper, and image new type of grasses (bests) during animal movement difficulties.

These difficulties led sorghum productivity to decline, (10-12) sack/fed, which is considered the ideal productivity and optimum sesame productivity (3-4 kantar/fed). In addition, the cultivated area of Sorghum and sesame is reduced, beside, the quality of sorghum and sesame produced is the less than ever used to produce. The Habiella Scheme is considered one of the most important schemes in the South Kordofan State.

All these issues raise many questions, and of course, the main question is what are obstacles and the problems facing sorghum and sesame cultivation and hindered production economic efficiency in Habiella locality? In addition, sub- questions can be asked -:

- To what extent agricultural machines used in sorghum and sesame production are affecting the soil and the productivity?
- Is there any relationship between not applying the technical package recommended to sorghum and sesame producers in Habiella locality and the low efficiency of productivity?
- What are the effect fewness, fluctuation, and the distribution of the rainfall, on production and productivity of the sorghum and sesame?
- To what extent conflicts are affecting economic efficiency of the sorghum and sesame production in the area?
- Dose the weakness and absence of the finance in area consider one of the difficulties facing the economic efficiency of both crops?

1.4 Objectives of the study

1.4.1 Main Objective

The main Objective of the study is to estimate the economic efficiency of Sorghum and sesame corps production in Habiella Agricultural scheme, south Kordofan state.

1.4.2 The specific Objectives are to:

- Describe the Scio-economic characteristics of sorghum and sesame producers.
- Estimate the profitability of the two crops production in the study area.
- Determine the farmer's technical efficiency of producing sorghum and sesame in the study area.
- Investigate the inefficiency of a locative resources use in producing sorghum and sesame in study area.
- Determine the optimum crop combination that maximizes farmers' returns.

1.5 Methodology

1.5.1 Data collection

Both primary and secondary data were used, although primary data is the main data source. Primary data was collected by means of a well set (questionnaire) from 191 Sorghum and Sesame producers in Habiella Agricultural scheme, Habiella locality, North South Kordofan state using probability sampling techniques' (simple random sampling).

Relevant Secondary data were collected from various sources. These sources include information from related sources such as Ministry of Agriculture and Forests, Ministry of Production and Economic Resources, South Kordofan State, Agricultural Sector, books, Ministry of Finance and National planning, references, and other related institutions.

1.5.2 Analytical techniques:

- Descriptive statistics will be used to identify the socio-economic characteristics.
- Using statistical package for social sciences (SPSS), and Frontier 4.1version to measure the indictors of sorghum and sesame production and their technical efficiency.
- Partial budget analysis will be estimated to explore cost and profit of both crops production.
- Technical efficiency will be addressed to determine the factors affecting both crops production.
- Using linear programming to compute crop combination sorghum and sesame.

1.6 Organization of the study:

This study organized into five chapters; the first chapter includes introduction, problem statement, objectives, and research methodology. The second chapter contains the literature review related to the study, and conceptual frame work. The third chapter includes study area and research methodology. While the fourth chapter includes results and discussion; the last chapter is the summary, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAME WORK

This chapter focuses on the literature review and conceptual frame work, the theoretical background, estimation procedures and the empirical models of the stochastic production frontier (SPF), and linear programming (LP), and Budget analysis, used to test the study objectives.

2. 1 Introduction:

Efficiency of institutions using data envelopment analysis (DEA), (Cob-Douglas) method where these studies applied different models. These studies revealed a set of results that no doubt have contributed to clarify the researcher's vision to measure the efficiency of different decision making units. The study is concentrated on measuring the technical efficiency and productivity change for the Sudanese mechanized rain fed agricultural –sub sector, mainly in the south Kordofan and Gedaref states.

The measurement of productivity change is another important aspect to consider when dealing with efficiency and performance of different organizations banks, financial institutions public services…etc. Therefore technical efficiency and efficiency change should be measured .The other aspects of DEA is a Malmquist Productivity Index (MPI) especially when focusing on inefficiency aspects of non-parametric models. Malmquist Productivity Index is currently regarded as the most popular index due to the ability to handle a number of information dealing with panel data. Productivity growth can decompose into two important elements; technical change refers to the change of frontier level and efficiency change which refers to the individual productivity displacement with respect to the frontier.

This chapter reviews various studies, and relevant periodicals concerning technical efficiency and productivity change measurements. After a comprehensive survey to all available resources, the researcher found a number of studies related to measuring technical efficiency and productivity change. Other studies were found, but they were not directly focusing on the topic. In the following, 19 of these studies the researcher found that most of these studies have been used in Bank and financial institution efficiency literatures (Raphael, 2013; (Bereket & Lalitha, 2012; Walid, 2011; Mansouri & Akasha 2010; Loretta & fetal, 2003; Georg & H .Simih, 2003; Barry& Jan, 2002; Ana& Jean, 2000; BEREKET &LALITH, 2012; A. Maghyereh, 2003 ;)

2.2 Background of Agriculture in Sudan

The need for agriculture increased worldwide, due to increase in human population and subsequently the demand for more food. Sudan has a vast arable land reached. About 73.5 million hectare (after separation of the south Sudan (2011)) out of the total country area. Although it is a large area, but the actual cultivated land is only 12 million hectare .About 10 million hectare is rain fed land. The 2 million hectare is irrigated lands (Osman, 2011). About 70% of total good agricultural land in Sudan Not used, because of problem of technology, short of labor, and increasing costs of production (Gaafar, 2013, p1).

2.3 Mechanized rain fed corporation in Sudan

Mechanized rain fed sector in Sudan started in 1945 for large scale production of sorghum to meet the grain shortage after the second war (Hassan, 1991, p158).

2.4 The development of the Mechanized farming

The development of the Mechanized farming has passed through three phases; the first phase 1945 – 1953, was completely under the government control and the total area cropped was 13020 hectare. The second phase 1954 -1968, in this phase the private sector was allowed to invest in agriculture and the government role was to provide the necessary infrastructure including road, domestic water supply, pest control, extension service etc. and to run pilot farms to solve mechanized production problem. The third phase 1969-1985, this phase started with establishment of Mechanized Farming Corporation (MFC), as statutory body to be responsible for all mechanized farming activities in Sudan. In this phase, the government had made an agreement with the World Bank to finance the bush clearance operation, roads, supply domestic water and procurement of machinery for some projects which were planned on sound land use principle. In this phase, during the period (1970 – 1880) the MFC was more developed; the importation of machinery has been increased steadily with few fluctuation, the area reached one million hectare, and it managed to form for state in Agadi (at Damazine), Samsam (at Gadarif), Habiella (at Nuba Mounting), and Gozrom (at Rank). In 1985, state farms abandoned due to high cost of production and UN remunerative yields. In 1994, the MFC belonged to State Ministries of Agriculture, and their role was confined only in schemes demarcation, renting and storage services.

2.5 Production of Rained crops

2.5.1 Sorghum (Sorghum bicolor L. Moench)

Sorghum (Sorghum Bicolor L. Moench) is an important staple food in semi-arid zone of Africa, Asia and South America because of its drought resistance and its ability to survive (Hulse et al., 1980).

It grows with limited water and temperature stress and it offers great potential supplementing the world food resource (Hulse, 1980).

It is the world's fifth major cereal crop after wheat, rice and barely, in feeding human race (on Wueme and Sunha, 1999). It's the main staple food crop in Sudan. It is produced under wide range of soils and climatic conditions, covering at least one- third of the total cropped area, producing about 75% of food grains in the country.

Most of Sorghum lie in the central rain lands of the Sudan, in ablest between the 450mm and 600mm isohyets (Ali and, salih, 1972) provides, on average, about 66% of total sorghum production. It is grown as a dual-purpose crop, the grain being used for human consumption and the straw for animal feed.

The national cereal production for 2009-2010, including allow estimate for the 2010 wheat crop which has yet to be planed, was forecasted at 3.16 million tons (excluding the south country).

Many reasons have enforced the adoption of this policy; the most important is perhaps the drastic decline in yield and productivity for sorghum under rain fed condition. Sass reported by (Mohamed et al.2003, Ahmed and Naggar 2003 and Omer et al.2003):-

- Reduction (deterioration) of soil fertility due to the over-exploitation of the land coupled with an extensive farming without application of any sort of nutrients.
- Mono- cropping systems practiced with the absence of crop rotation programs.
- Erratic occurrence of rain-falls with spatial and temporal variability and uncertainty.
- High infestation of pests, diseases and weeds, particularly Buda (striga hermonthica) (Adil Eltom, 2013).

Sorghum is nutritionally equivalent to most cereals, and its protein content is quiet variable. Most literatures report several instance of levels ranging from 6 to 16% (Yousif, 1998 and Afripro, 2003. Mona, 2013). Sorghum is given various names in different places in the world (FAO, 1995). In western Africa, it is called great millet, kafir corn or guinea corn, which represents connection with corn or millet

(U.S. Grain council, 2005). Other names include Durra, Egyptian millet, federate, Guinea corn Grass, Jola, cholam, Jannalu, Great Millet, Dari, Mtama and solam (in Eastern Africa) (FAO, 1995).

In the United States, it is usually referred to as Milo or Milo-maize (kulamarva, 2005). Locally the crop is named Durra.

2-5-2. Sesame (Sesamum indium L)

Sesame is one of the oldest oil crops used by humans and is by- product among oil crops in world trade and its importance has decreased due to competition from other oil crops that are easy to produce and cheap. The world production of this crop has been almost constant since the mid- 1940s despite high demand for sesame oil in non- European country, especially African.

Sesame has prominent position in Sudanese agriculture, wih an important position in the Sudanese economy for domestic product and food consumption. Historical evidence points to the emergence of sesame in Ethiopia from which it was transported to India and China, and has become a common food in South Africa and South Asia. Its cultivation spread in many countries of the world from latitudes 40 degrees north and 40 degrees south.

Sesame was introduced to the United States in the 17th century and its cultivation has been significantly flourished in many Latin American countries, such as Mexico, Gutimayla, Nicago and Venezuela (Al khdeir ,1997). Sesame research didn’t get attention. But the UN world Food and Agriculture Organization (FAO) showed some interest in the crop in the 1980s. Sudan ranks first in sesame production among African countries and wellness. It is Sudan’s third crop after sorghum and millet and has especial position in the Sudanese and local consumption (FAO, 1991-1992).

In South kordofan state, sesame is grown as a major crop in Habeilla rain- growing in the Nuba Mountains in large areas such as cash in the first frame work and consumption as cultivated in small areas in traditional agriculture and Jabariks in localities around administrative units, cities and villages for the same purpose.

There is continuing deterioration in the productivity of the sesame crop in the region, where the production of the single feddan sesame crop of the Habeilla Agricultural Scheme for the agricultural season (1990- 1991) ranged between three (3) sacks to ⅕ sack per feddan, agricultural season (2006- 2007) ⅕ sack sesame per feddan.

(Office of rain Agriculture, Dalang, 2008)

2.6. The tm parlance (Significance) of sesame crop in Sudan

To achieve sustainable and balanced economic and social development and the well-being of the Sudanese citizen and contribute to securing food requirements by exploiting the productive capacities available in the field of vegetable oils production in Sudan, and providing the agricultural manufacture by its require ements. However, it can participate in sustainable, and strengthen the Sudanese gross domestic product (GDP). In addition, to that it can realize achieving food security for the Sudanese compatriots, maximize the added value of agricultural production bay linking with industry and reducing poverty and creating jobs.

Sesame varieties in Sudan: Municipal varieties and cultivation prevails in the traditional sector, such as early-mature silk, medium-maturity, municipal and mountain medium maturity. Improved varieties: such as agriculture1, cultivation3, cultivation7 and its seeds are white and freedom39 seed brown. Licensed vaunts: such as Bromo, khader, Um shagra, Giza32, Toshki and schindwell3. Early maturity varieties such as kanana2, and kanana4 Aboa (Bromo) and al-shagra. Local varieties such as A-jabali, Hariri, Abu-Qaner, Jabrock, A-baladi, Abdul Razeg Red and white, Red and white mountains. Types of resistance to disease and wilting such as Shadwell3, Toshki and Giza32 (Koody, 2015).

2.7 Agriculture in South Kordofan State

The total area of agriculture is 13370000 km^2, equivalent to 3017200 feddan, and roughly 4% of the Sudan.

Arable area in South Kordofan State is 24.5 million fed.

The independent Agricultural mechanical area of 5371000 fed, types of crops grown are sorghum, sesame, groundnut, cotton, millet, hibiscus (karkady), hap of melons and beans.

The traditionally independent Agricultural area is 2088000 fed, and the varieties of crops planted are sorghum, sesame, groundnut, cotton, and millet, and hibiscus (karkady), hap of melons, beans, shaman corn, vegetables, and others.

Table (2.1): Types of sorghum grown in area of South Kordofan State

Item	Agriculture area (locality)
Wood Ahmed, Tabat, krorw, Arfa gadamak	All over the state
Gdamblia flower, Korgi, Safra, Zidan, Umbenin	All over the state
Gadm alhmam	All over the state

Aros alremal, Arosha, Gashish, Astifan, krmka, Korgi, Safra	Aldalanj
Gashish, Astifan, krmka, Nylon, Zabady, Titron, Kassby	Aldalanj
Callum, A jack, Ras algred, Gashish, Hagen, Batania	Abwgebiha
A jack, Arosha, Agab Sidow,	Alabasia
Ras algred, Titron, kassby, Batania, Gashish, Astifan,	Alrshad
Kassby, Titron, Agab Sidow	Altirtar
Wood Ahmed, Tabat, krorw	Habiella
krmka, Nylon, Zabady	Kadogli

Sources: (Ministry of Production and Economic Resources, South kordofan State-Agricultural Sector, 2019)

Table (2.2): Total number planned areas /fed in South kordofan state according to Clusters

Clusters	Area / locality	planned area/fed
First	Habiella	713840
Second	Elabasia	350000
Third	Altdamon	546000
Fourth	Abwgebiha	1048000
Fifth	Talody	215000
Sixth	Kalogiy	339500
Seventh	Aleiry	100000
Eighth	Kadugli	159950
Ninth	Abu kroshola	24354
Total		**371536**

Sources: General Administration of Rain fed Agricultural Machinery, Dalang - South kordofan state 2020.

2.8 The Mechanized Agriculture in South kordofan state

The mechanized Agriculture of South kordofan began in the agricultural season in 1968 after the success of field trials in the Angargo area of Dalang locality or district, where the projects were planned in the District of Habiella and followed by extension in the area of Fiu south Habiella and the area of kurtala east of

Habiella, and then expanded the horizontal mechanical Agriculture to include planned area (Umlobia, Al-Mutimir, Elabasia, Al-Tartar, Kadugli, Abu korshola and Aumbramita). The oriental and European stooges (locality of Kadugli) (120.000 feddan). Elabasia Tagli (locality Alrshad) (251.000 fed) Abu krshola and Umperpita (locality Alrshad) (255.000 fed). Al-Mutamir area (locality Abwgebiha) (280.000 fed). Wide area (locality Abwgebiha) (045.000 fed), Atiter and walkers (locality Abwgebiha) (270.000 fed), Al-Tiara area (locality Abwgebiha) (450.000 fed), Angel area (locality Abwgebiha) (160.000 fed) , Albida area (locality Abwgebiha) (224.000 feddan). The total planted area in the state was 2.831.500 feddan). There is an area of about 450.000 feddan, which is known as the automated sector outside the planning.

Source: Ministry of Production and economic resource, South Kordofdn State.

Department Planning and Statistics. Unit: Food Security.

Table (2.3): cultivated area and crops composition and rain feed for the agricultural season 2019-2020 in South kordofan state

Locality	Cultivated area/fed				Rain/mm
	Sorghum	Sesame	other	Total	
Kadugli	06388	02282	-	8670	671
Alrify Alshrgi	34182	18026	700	52908	1198
Abu krshola	31000	35500	200	68500	672
Elabasia	184290	122905	1640	308835	824
Gadeir	63225	40184	16035	119444	636
Aleiry	11578	1520	-	13098	1050
Talody	11147	1783	36	12966	883
Altdamoun	208852	181928	-	390780	372
Dlami	58187	66232	5586	130005	-
Habiella	227906	138152	-	366058	685
Abugebiha	638011	322930	3745	964686	977
Total	1.474.766	931.442	2942	2.435.950	

Source: Ministry of Production and economic resource, South Kordofdn State.

Depart meant Planning and Statistics.

Unit: Food security.

Table (2.4): Agricultural machinery and gasoline in South kordofan State, Season 2019/20

Locality	Agricultural machinery						Gasoline/ (gallon)
	Tractor	Disk	Planter	Machine gum	Sorghum harvester	Sesame harvester	
Akogli	12	12	-	1	3	-	8670
Alrify Alshrgi	115	115	-	6	29	5	49302
Abu krshola	187	97	-	-	31	27	75200
Elabasia	-		-				220000
Gadeir	137	137	-	7	18	1	53440
Aleiry	32	32	-		5	-	24000
Talody	31	31	-	-	-		12997
Altdamoun	640	633	12	294	240	235	224600
Delami	172	172	-	49	35	60	130000
Habiella	204	204	9	120	117	45	365000
Abu gebiha	989	973	9	349	249	159	580940
Total	2509	2396	30	826	727	532	1.744.149

Sources: Ministry of Production and Economic Resources, South kordofan state-Agricultural Sector (2019-2020)

2.9 Technical Packages

2.9.1 Sowing date

The best time for planting is after enough rain has fallen to block the soil cracks, and it often occurs 15 days after the rains. This early cultivation means the extermination of weeds from the crop, and this means that the cost of production will increase and be compensated for by increasing productivity. As for late planting, it leads to exposing the seedlings to heavy rains, and thus their death or weakness, and exposing plant to shortage of water required. Delaying planting also leads to plowing and cultivating the land, which is very soft, which prevents the preparation of a soft bed for seeds. The land must be cleaned of weeds before planting and the first cleaning must be done two weeks after the date of planting.

2.9.2 Varieties

That must be grown in the rain mechanized cultivated areas:

1. Improved varieties with high genetic potential.
2. Varieties are quick to ripen so as not to be affected by shortage of water during the formation of the spike, flowering (urticaria) and the fullness of the grains.
3. Varieties with a high harvest factor where the weight of the grains is equal to the weight of the reeds and can also be harvest automatically.
4. Varieties with high efficiency in making use of the water available to them in the soil.

2.9.3 Plant density

Refers to the number of plants per feddan. Each row has a recommended plant density and it is affected by the amount of rain and is proportional to it directly, and the main goal of this ratio is to maximize the amount of available moisture in the soil, the more this density increases within the available moisture limits, the higher the productivity.

Table (2.5): Plant density the number of plants Sorghum and Sesame per feddan

Varieties	Quaintly plants/ fed	Rain fed/ mm
Sorghum	70000	600-800
Sesame	93000	500-700

Sources: Ministry of Production and Economic Resources, South kordofan state-Agricultural Sector (2019-2020)

2.9.4 Agricultural cycle

Means the succession of crops on the ground and the duration of cultivation.

The goals of agricultural cycle:

Maintain soil fertility as much as possible.

Resistance of weeds and diseases that parasitize the plant hosts.

Sorghum crop: Sorghum is considered one of the most soils -exhausting crops and affects the next crop in the season.

Sesame crop: it is not destructive to the soil and does not affect the next crop. It has deep roots and it is abroad-leaf plant.

Types of agricultural rotations:

Double cycle: you can use Sorghum in a dual cycle

Tables (2.6): Agricultural cycle

Sorghum	Anon-grass crop

Triple course (cycle):

Sorghum	Bohr	Sesame

Quadruple course (cycle):

Sorghum	Sesame	Bohr	Legume crop

Source: Agriculture Expert Groups Office of rain-fed agriculture al Dalang (2019)

2.9.5 Agricultural engineering

It is related to the plant density of the crop, which is the planting distances between plants within a single row, between one row, and between rows and the depth of planting.

2.9.6 Weed control: weeds cause poor yield, compete with basic plants in food, expose the crop to insects and diseases, and reduce the amount of production and productivity.

Weed control is the following:

- Use of chemical pesticides.
- Conducting the first clearance or the first polish.
- Follow the agricultural cycle.
- Plowing fallow after weed growth and before seed planting.

2.9.7 Fertilization

It is the addition of fertilizer to the crop and to ensure its viability, the following work is recommended:

- Early cultivation
- Cultivation of the early-leaching varieties.
- High plant density
- Ground humidity.

Source: agricultural Expert Groups Office Dalang rain-fed agriculture (2019)

2.10 Total number planed area/ feddan in South Kordofan State according to **clusters, nine Clusters in South kordofan state as follow**

Table (2.7) Cluster first: (Habiella Agricultural scheme) locality Habiella

No	Area	Planned area/ fed	Year of planning	Number of farmers	Farmers % in the state	Farmers % out of the slate
1	Old Habiella	211500	1970	425	94	6
2	Habiella private	178500	1973-1976	393	93	7
3	Kurtala	203740	1983	235	65	35
4	Alsifaifeer	70100	2000	280	80	20
5	North Habiella	50000	1984	2000	97	3
Total		713840		3332		

Source: Agriculture Expert Groups Office of rain-fed agriculture al Dalang (2019)

Tables (2.8): Cluster Second: Elabasia locality

Area / locality	Year/ planned	planned area/fed	Number of farmers	the Farmers	
				From the state%	Out of the state%
Abodom (a)	1984	110000	185	30	70
Abodom (b)	1984	40000	Cooperative societies	100	
South Abodom	1998	32000	400	100	
Al khashkhash and al atshan	1998	106000	744	50	50
Al morat	1995	48000	169	25	75
Imtdat al morat	1998	15000	49	20	80
Total		**350000**			

Source: Agriculture Expert Groups Office of rain-fed agriculture al Dalang (2019

Table (2.9): Cluster three: Altdamoun locality

Area / locality	Year/ planned	planned area/fed	Number of farmers	The Farmers	
				From the state %	Out of the state%
Algrada	1984	55000	57	55	45
Alhano	1984	42000	64	35	65
Bangial altartar	1998	74000	146	90	10
Siniynat	1984	110000	138	75	25
Okara	2011	300000	138	100	
Total		**546000**			

Source: Agriculture Expert Groups Office of rain-fed agriculture al Dalang (2019

Table: (2.10): Cluster four: Abwgebiha locality

Area / locality	planned area/fed	Year/ planed	Number of farmers	The Farmers	
				From the state %	Out of the state%
Jdied almotier	1984	253000	………	80	20
Ariad	2001	45000	………		
Jandail	2001	40000			
Altaiara	1984	450000	475	20	80
Banjal alsragia	1998	160000	22	60	40
Alphaw (kaw and narw)	2009	100000	Sharkt tawr	100	
Total		**1048000**			

Source: Agriculture Expert Groups Office of rain-fed agriculture al Dalang (2019

Table: (2.11): Cluster five: Talody locality

Area / locality	Year/ planned	planned area/fed	Number of farmers	the Farmers	
				From the state %	Out of the state%
Elbiada	1976	199000	240	90	10
Carandal	1970	16000	32	100	
Total		**215000**			

Source: Agriculture Expert Groups Office of rain-fed agriculture al Dalang (2019

Table: (2.12): Cluster six: kalogiy (Gadeir) locality

Area / locality	Year/ planned	planned area/fed	Number of farmers	the Farmers	
				For the state %	Out of the state%
South kalogiy	2010	72000	232	95	5
Alsherik	2009	84000	152	85	15
Towsy	1970	9000	21	100	
Grdod twro	2013	15000		100	
Gadeir	2013	76000		97	3
Hager aldom	2013	59500		97	3
Um Hassan	2013	24000		100	
Total		**339500**			

Source: Agriculture Expert Groups Office of rain-fed agriculture al Dalang (2019

Table: (2.13): Cluster seven: Aleiry locality

Area / locality	Year/ planned	planned area/fed	Number of farmers	the Farmers	
				For the	Out of the

				state %	state%
Algogana (a)	2011	30000	Almogtrbin	100	
Algogana (b)	2011	20000	Africa combine		100
Algogana (c)	2011	50000	Local community	100	
Total		**100000**			

Source: Agriculture Expert Groups Office of rain-fed agriculture al Dalang (2019

Table: (2.14): Cluster eight: kadogli locality

Area / locality	Year/ planned	planned area/fed	Number of farmers	Farmers	
				For the state %	Out of the state%
Azlitaia	2001	51950	467	100	
Albardab	2001	60000	311	100	
Krongo abdllh	2001	18000	Local community	100	
Alboram	2001	30000	Hoy fatg combine china		100
Total		**159950**			

Source: Agriculture Expert Groups Office of rain-fed agriculture al Dalang (2019

Table: (2.15): Cluster nine: Abw krshola locality

Area / locality	Year/ planned	planned area/fed	Number of farmers	the Farmers	
				For the state %	Out of the state%
Um lobeia	1970	140000	342	75	25
Abw krshola	1998	59574	150	90	10
Um prempita	1998	44000	917	100	
Total		**243574**			

Source: Agriculture Expert Groups Office of rain-fed agriculture A Dalang (2019)

2.11 Definition and measures of Efficiency

2.11.1 Economic efficiency concept

When measuring any phenomenon as phenomenon of efficiency must be preceded by the identification of what is meant by that phenomenon in order to have meaning to clarify the concept productive Efficiency in the light of economic theory through economic decisions mode at the level of production unite that may be correct on both sides or in one. (Khalid, 2014).

2.11.2 Efficiency Concepts

Efficiency is very loose term indeed; to an engineer efficiency may mean the ratio of output/ input or output/ theoretical capacity, percent. While the cost account uses the ratio standard cost /actual cost, percent, or it’s inverse to measure the productive efficiency of a firm. The economist, when he refers to the efficiency of affirm generally means one of two ratios, the first concerns the firm's success in producing as large as possible an output from a given set of inputs; or what amount to the same thing, producing given output with least inputs; this is called productivity, or technical efficiency (Amey;1969).

2.11.3 Economic efficiency

Is the product of technical and allocative efficiencies, Thus, if a firm has achieved both technical and allocative efficient levels of production, efficient and new investment streams may be critical for any new development (Alene and Hassan, 2003).

2.11.4 Production Efficiency

Production efficiency refers to a firm's costs of production and can be applied both to the short and long run; it is achieved when the output is produced at minimum average total cost. For instance, we might consider whether a business is producing close to the low point of its long run average total cost curve. When this happens the firm is exploiting most of the available economies of scale.

Productive efficiency exists when producers minimize the wastage of resources in their production processes (Tutor2u, 2006)

Rahman, 2002 cited that productive efficiency has two components. The purely technical, or physical, component refers to the ability to avoid waste by producing as much output as input usage allows, or by using little input as output production allows.

Rahman, 2002, stated that production efficiency is one of the three conditions necessary for an economy to be economically efficient is that it be on its production -possibilities frontier. If it is not on the production- possibilities frontier, more could be produced with given resources and technology. Because greater production would increase value, any position below the production-possibilities frontier is inefficient. Notice that a great many points satisfy this condition of production efficiency every point on the production- possibilities frontier is production efficient.

To be on production possibilities frontier, all resources must be used. Unemployed resources indicate that more goods and services could be produced, which means that the economy was not on the frontier initially. In addition, resources must be used properly.

Economic efficiency is achieved by meeting the flowing:

- Full use of economic resources. - Efficient utilization of resources.
- Achieving productive Efficiency

2.11.5 Deification Economic efficiency

Is the amount reduction in the production cost achieved by using the ideal allocation of rescores for low level costs? Ferrell in 1957 proposed his idea that the economic efficiency of a farm consisted of two components:

Technical efficiency: - recorded as possibility to achieve on the maximum of production with potential input of production.

The technical efficiency: - is the possibility to obtaining the maximum of production by using a specified amount of production inputs from Technical Point of view and the reduced range from (0-1).

Allocative efficiency: - the possibility to obtain an ideal or less expensive mixtures of production inputs used in production with certain quality of production and the values range from (0-1).

This, incorporative these measurements (TE and AE) in order to obtain the "economic efficiency" EE.

Economic efficiency:

Is the possibility to obtain the lowest cost mix from inputs production to achieving the maximum production it is possible by any specific amount of inputs of production and their values range from (0-1).

Thus: TE% * AE% = EE%

To the institutions or farms

For instance: Institution **A is** more efficient than institution **B** if it can produce a high level with the same amount of costs.

The production regards more (AE) (price) if it using the resources by the way which achieved more profit?

Ferrell set several of assumptions to measures and analyses the technical efficiency and allocative and economic efficiency as represented below:

- Production process using only to element, farm, the element of labor and capital.
- Production process is homogenous and linear from the first class represented by the quant curve is one unit of output.
- All the production units the form or industry encounter the same element price to the prevailing production in the market.
- The homogonous to all output production. Is clear in the figure (1-2) iso - quant carve of production identify as the termer which works with high efficiency as the result to allocate the resources used fall on this carve.

There are three phases to estimate the efficiency, the phases and criteria are found in function as follows:-

- First phase: It is small squares method (OLS), it is distinguished by all criteria a count which is unbiased only is the part which be biased.

- Second phase: it is depending on (OLS) with (COLS) to obtain linear programming milestones unbiased.

With equation (Cobb-Douglas) with ability by previous, it takes following formula

$Yi = Bxi - ui$

Where is

Yi = farm production.

Xi = A vector for farm output.

B= the vector estimated mismatch parameters.

Ui= A random accomplishment, related to the technical inefficiency of the farm.

The technical efficiency is defined in this case by the percent of the actual production to the expected production which take values rage (1-2) to one elements.

Third phase: from the research, we will the results of second phase as primary values in the production measure recharge to achieve a high profit as implication before the economic efficiency including Both (TE x PE) in allotting to Locative price efficiency.

There are several sources to bridelain to productive efficiency:

- Not to use the optimal blearily rations (optimal combination output production).
- Insufficient capacity available from production inputs.

- Weak production (elasticity or flexibility) supply particular in agriculture which linkers for from in wide production, past encaush to pursuit the change economics (demand) .
- Anticipated risks and unanticipated also uncertain in agricultural production.
- Man aogerat capabilities provide to tram which has grater ols in raise or low. (Osuman, 2010)

2.12 Production possibilities frontier

The Production possibilities frontier (PPF) shows the maximal combination of two goods that can be produced during a specific time period given fixed resources and technology and making full and efficient use of available factor resources. APPF is normally drawn as concave to the origin because the extra output resulting from allocating more resources to one particular good may fall. This is known as the law of diminishing returns and can occur because factor resources are not perfectly mobile between different uses, for example, re-allocating capital and labour resources from one industry to another may require re-training, added to a cost in terms of time and also the financial cost of moving resources to their new use.

To be on the production-possibilities frontier, all resources must be used. Unemployed resources indicate that more goods and services could be produced, which means that the economy was not on the frontier initially. In addition, resources must be used properly. If society randomly assigns people to jobs on the basis of political reliability, it will not produce as much as it could.It will require some people with little strength and endurance to perform jobs that demand much strength and endurance. If switching people among jobs can increase output, the original situation was not on the production- possibilities frontier and thus not economically efficient (Rahman, 2002).

2.13 Technical Efficiency

Technical efficiency is just one component of overall economic efficiency. However, in order to be economically efficient, a firm must first be technically efficient. Profit maximization requires a firm to produce the maximum output given the level of inputs employed (i.e.be technically efficient) (Kumbhakr and Lovell 2000).These concepts can be illustrated graphically using a simple example of a two input(x_1,x_2) and two output(y_1,y_2)production process(Figure 3.1).Efficiency can be considered in terms of the optimal combination of inputs to archive a given level of output (an input-orientation), or the optimal output that could be produced given a set of inputs (an output orientation).

In figure 3.2(b), the firm is producing at a given level of output(y_1^*,y_2^*) using an input combination defined by point A. The same level of output could have been produced by radially contracting the use of both inputs back to point B, which lies on the isoquant associated with the minimum level of inputs required to produce (y_1^*, y_2^*) (i.e. Iso (y_1^*, y_2^*)). The input –oriented level of technical efficiency (TE_1(y,y)) is defined by 0B/0A.

The production possibility frontier for a given set of inputs is illustrated in Figure 1(b) (i.e. an output-orientation). If the inputs employed by the firm were used efficiently, the output of the firm, producing at point A, can be expanded radically to point B. Hence, the output oriented measure of technical efficiency (TE_0(y,x)), can be given by 0A/0B.This only equivalent to the input –oriented measure of technical efficiency under condition of constant return to scale. While point B is technical efficient, in the sense that it lies on the production possibility frontier (Kumbhaker and Lovell, 2000).

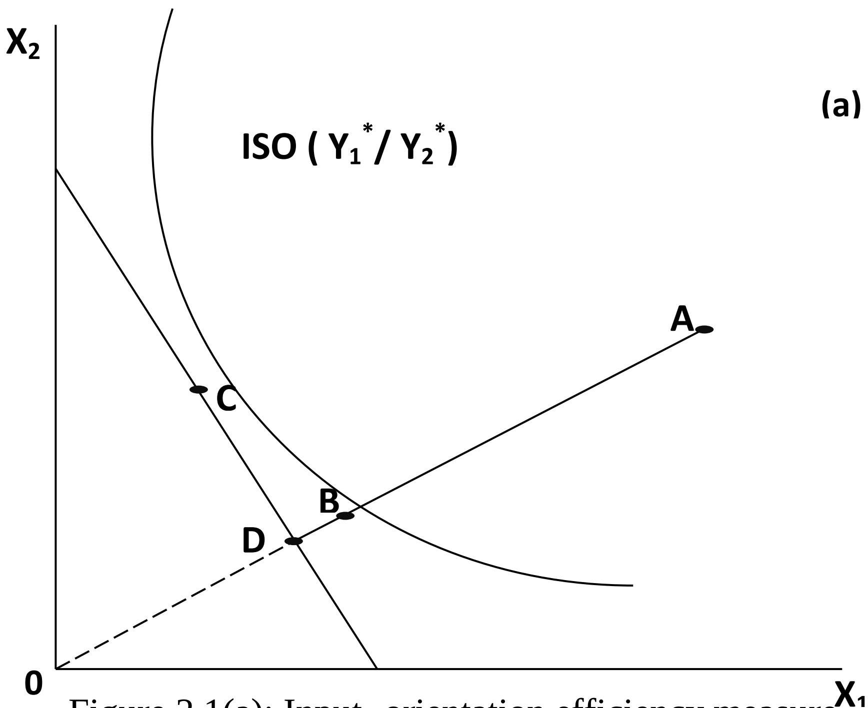


Figure 2.1(a): Input -orientation efficiency measure

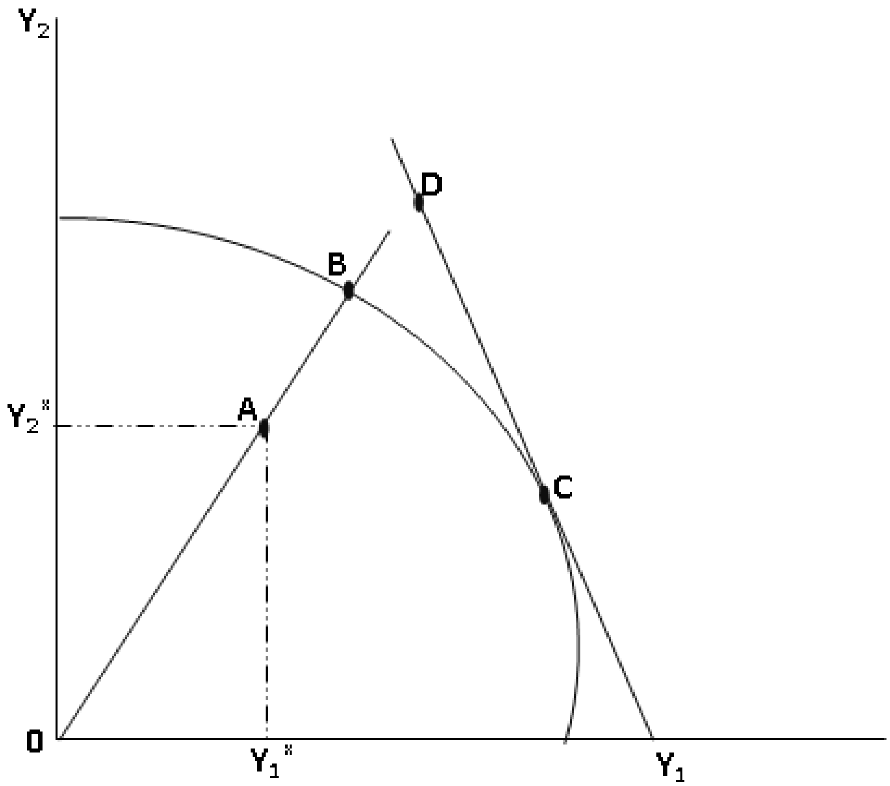


Figure.2.2 (b): Output - orientation efficiency measure

2.14 Stochastic production frontier (SPF)

Farrell's, (1957) article has led to development of several techniques for the measurement of efficiency of production. These techniques can be broadly categorized into two approaches: parametric and non-parametric. The parametric stochastic frontier production function approach and non-parametric mathematical programming approach, commonly referred to as data envelopment analysis (DEA) are the two most popular techniques used in efficiency analysis. The main strengths of the stochastic frontier approach are that it deals with stochastic noise and permits stochastic tests of hypotheses pertaining to production structure and the degree of inefficiency (Sharma etal, 1999).www.en.wikipedia Org/ wiki/stochastic frontier analysis).

Stochastic frontier production function (SFPF) have been the subject of considerable econometric research during the past two decades, originating with a general discussion of the nature of inefficiency in Farrel,(1957). In traditional economic theory, efficiency is generally assumed as an outcome of price-taking and 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 under the prevailing technology. However, variation 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 combination. The econometric technique developed by Battese and Coelic (1998), www.unedu.an/staff/gBattese, allows for a decomposition of these effects and 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(Kompas,2001). The stochastic production frontier (Aginer, 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 errors and other factors, such as effects of weather, luck, etc., on value of the output variable, together with combined effects of unspecified inputs 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. The main distinguishing characteristic of the parametric frontier is the assumption of an explicit function from given technology and thus the frontier is expressed in a mathematical form. Nonparametric is not based on any explicit model of frontier or the relationship of the observations to the frontier (Forsund, et al; 1980).

(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.

Stochastic frontier production function was there after developed to overcome the efficiency (Ogundari and Ojo, 2006). The frontier production function model is estimated using maximum likelihood producers. This is because it is considered to be asymptotically more efficient than the corrected ordinary least square estimators (Coelli,1995), (Battese and coelli, 1995,) www.springerlink.com /index/h5x6j80852428mp1. The maximum likelihood estimates for all the parameters of the stochastic frontier and inefficiency model, defined by equation simultaneously obtains by using the program, FRONTIER VARTION 4.1, which estimates variance parameters in terms of the parameterization.

2.15 The stochastic production frontier with the Cob-Douglas production function

The Cob-Douglas production function is probably the most widely used form for fitting agricultural production data, because of its mathematical properties, ease of interpretation and computational simplicity (Heady and Dillon, 1969, Fuss et al, 1978). The Cob-Douglas production function has convex isoquants, but it has unitary elasticity of substitution, it does not allow for technically independent or competitive factors, nor does it allow for stage I and III along with stage II. That is MPP and APP are monotonically decreasing function for all X- the entire factor-factor space is stage II given $0 < b < 1$, which is the usual case. However, the Cob-Douglas may be good approximation for the production processes for which factors are imperfect substitutes over the entire range of inputs values. Also, the Cobb-Douglas is easy to estimate because, in logarithmic form, its linear in parameters; its parsimonious in parameters (Beattie and Taylor, 1985). A stochastic Cob-Douglas production frontier model may be written as:

$$Yi=f\ (XiB)\ exp.\ (Vi-Ui) \ldots\ldots.(1) \qquad I=1, 2 \ldots N$$

Where the stochastic production frontier is (XiB) exp. (Vi), Vi having some symmetric distribution to capture the random effects of measurement error and exogenous stocks which cause the placement of the deterministic Kernel (XiB) to vary across firm. The technical inefficiency relative to the stochastic production frontier is then captured by the one side error component $U \geq 0$. The explicit form of the stochastic Cob-Douglas production frontier is given by:

$$Yi = \beta_0 + {}^{n}\Sigma_{j=1}\beta_j \ln X_{ij} + v_i - u_i \ldots\ldots (2)$$

Where: y_i is the frontier output, β0is intercept, βj the elasticity of yi with respect to X_{ij}, X_{ij} is the physical input, V_i-U_i a composed error**.**

2.16 Frontier 4.1

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 variable, and it can be used when the functional forms have the dependent variable both in logged or in original units.

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 http:// www.uq.edu.au/economics/cepa/frontier.htm.

2.17 Linear programming techniques

Linear programming is an important analytical tool made available to economists. It has been found beneficial in many important applications and it offers exciting opportunities in the future. It can serve as an important management aid to individual farms or marketing firms (Heady and Candler, 1973).

Linear programming deals with problems in which the objective function is to be optimized (i.e. maximized or minimized) subject to linear equality constraints and sign restrictions on variables. The LP model may include constraints. Moreover, the variables maybe non-negative or unrestricted in sign (Taha, 1982).

A linear programming has three quantities' components: an objective, alternative method or process for attaining the objective and resources or other restrictions (Heady and Cander, 1973).In order to develop a general solution method, the linear programming problem must be put in a common which is called the standard form

2.17.1 Linear programming (LP) in brief

From an application perspective, mathematical (and therefore linear) programming is an optimization tools, and/or technological decisions required by contemporary techno-socio- economic applications.

2.17.2 Definition of Linear programming

Heady and Candler(1973) defined linear programming as an efficient way of determining optimum plans only if there are numerous enterprises or processes and numerous restrictions attaining specific objective such as maximizing farm profits or minimizing production costs . The (LP) can serve as an important management aid to individual farms or marketing firms. Gass (1964) stated that, programming is concerned with the efficient use or allocation of limited resources to meet desired objectives. Bazaraa and Jarvis (1977) see a linear programming problem as a problem of minimizing or maximizing a linear function in the presence of linear constraints of the inequality and /or the equality type.

Another definition reported by Dent, Harrison and Wood Ford (1986) is that linear programming is one of a class of operations research methods referred to as mathematical programming; the linear programming technique is a general methodology that can be applied to a wide range of determining a profit maximization combination of farm enterprises that are feasible with respect to a set of fixed farm constraints. Mohamed (1986) reported that, LP provides a means to find the level of decision variable(s) that would maximize the objective function subject to a set of constraints. A linear programming problem is a social case of a mathematical programming problem. From an analytical perspective, a mathematical program tries to identify an extreme (minimum or maximum) point of a function which furthermore satisfies a set of constraints i.e.; linear programming is the specialization of mathematical programming to the case where both, function and the problem constraints are linear (Kouruma, 1982).

2.17.3 Why use LP

The great advantage of programming is that it allows one to test a wide range of alternative adjustments and to analyze their consequences thoroughly with a small input of managerial time (Beneke and Winterbo, 1973). Linear programming is a powerful tool of analysis which can be used to look at several budgets of a farm at a time and depict the optimal enterprises in profit maximization or cost minimization context (Kouroumes, 1982).Bazarra and Javis (1977) emphasized that the simplex method of linear programming enjoys wide acceptance because of:

1- Its ability to model important and complex management decision problems and

2- Its capability for producing solutions in a reasonable amount of time. Malik (1994) sees the most important advantages of linear programming is the flexibility in stating objectives that will satisfy the consumption requirements of the house hold. Furthermore, the byproduct of the solution provides rich information on economic issue, like shadow prices and average productivities. One should be careful in utilizing linear programming results in explaining farmers' behavior, because of the normative nature of L.P analysis and due to its dependence on the degree of accuracy of the coefficients and assumptions which were used in the model formulation. Never the less, LP still provides an essential indicator of the degree to which farmers are market- oriented and gives an adequate analysis of input-output relationship (Malik, 1994).

2.17.4 Limitations of the LP model

The LP technique suffers from several limitations which can be stated as follows:

1- Programming cannot help the manager in the difficult task of formulating price expectations.

2- Activities that involve decreasing costs cannot be treated adequately with programming methods.

3- Restraints are sometimes difficult to specify.

4- LP is of little help in estimating input- output relationship; it can only specify data needed.

5- LP proceeds as if the price and input-output expectations we have formulated were reliable for all farm products, and the result is that farms treated as they were equally without risk i.e. risk preference of the operator don't take into consideration.

6- One of the assumptions of the LP is that each additional unit of the output requires the same quantity of the input. But if you recall the law of diminishing return to scale, the amount of dairy production declines per kilogram.

2.18 Budget analysis

A profitability measurement technique is employed after calculating the product budget. This requires calculation of total returns and total variable costs. Gross margins for the different farm products are to be calculated and compared. The comparison between margins for different products in study area will give a clear picture about the profitability of the different products.

For estimation of gross margins, some fixed costs are omitted and mostly variable costs are considered. Kay (1981) stated that, the gross margins are estimated for single unit of each enterprise, and they are the difference between total returns and total variable costs.

Calculating the gross margins; on the other hand, requires best estimates of yield or production levels for each enterprise together with expected output price. Total income per unit is equal to output price times yield or production. These estimates directly affect the estimated gross margin. The calculation of total variable costs requires a list of each variable input needed, the amount required and the price of each. Also, cost estimates are obtained to determine the relative effect of each item on the total cost.

2.19 Previous studies

The reference review is link between current studies and previous studies, considering that previous studies enrich knowledge of scientific and practical efforts and represent knowledge balance in terms of quantity and type in general, and also contribute to the identification of approaches, research methods, analytical tools and the target area that any new scientific study depends on it. The reference review aims to examine the relevant previous studies and research and review the most important findings, indicators and recommendations of pervious economic studies that can be used in the field of economic efficiency in both productivity and employment aspects of agricultural economic resources in the production of the most important flowing studies. Despite the scarcity of scientific and economic studies in the field of technical distributional economic competence, some of them were obtained through the international information and communication networks, and most of the studies dealt with the subject of efficiency according to the methodology of the scientist (Farrell) was foreign studies, its review may help to keep pace with scientific development in outside world.

There were no previous studies in the study area, the state of south kordofan, the locality of Habiella in the Habiella agricultural schemes. Other studies in other region, locally and globally, somewhat similar to that study were found, and they served as a guide for the researcher or student in preparing the current study in order to benefit forum the curricula, and methods that were followed for this study.

Ibrahim and, Ahmed, (2015) Studied Measuring the Efficiency Profile of Crop Production in Traditional Rain- fed Sector of North Kordofan state, Sudan.

The predicted economic efficiencies (EE) for sorghum, millet, groundnut and sesame estimated as inverse of cost efficiencies differs substantially among the farmers, the economic efficiency of sorghum ranging between 1% and 88% with a mean economic efficiency of 48%. Economic efficiency of millet was ranging between 4% and 96% with a mean economic efficiency of 65%. Economic efficiency of groundnut ranging between 1% and 96% with a mean economic efficiency of 92%. Economic efficiency of sesame ranging between 7% and 97% with a mean economic efficiency of 67%. This means that if the average farmer in the sample area was to reach the economic efficiency level of its most efficient counterpart, then the average farmer could experience a cost saving of 45.5% [i.e. 1-(48/88) x100], 30.9% [i.e. 1(61.5/89) x100], 4.2% [i.e. 1-(92/96) x100] and 31% [i.e. 1-(67/97) x100] for sorghum, millet, groundnut and sesame respectively.

Ibrahim, (2017) Studied Economic Efficiency of Sorghum and Millet Production for Small Scale Farmers in Traditional Rain fed, North Kordofan State, Sudan

The average economic efficiency score of millet was 15%. This means that the millet farms use the combination of inputs at a cost inefficiencies level, they could potentially reduce their overall cost by 85% and still attain the current output level. The estimated coefficient of the parameters of stochastic frontier cost function of sorghum and millet were presented. The estimated coefficient of the variables (cost of farm area, cost of land preparation, tillage cost, sowing cost, weeding cost, seeds cost, fertilizers cost, pesticides cost and cost of harvesting) used in regression analysis some of this variable was found to be positive and significant, and other negatively significant. The positive and significant variables imply that the cost of variable used have direct relationship with total cost of production used as output. In other words, cost of variables increase by the value of each coefficient as the quantity of each variable is increased by one. The negatively significant variables imply that the cost of variable used have indirect relationship with total cost of production used as output.

Ibrahim, (2011) Studied Analysis of production efficiency and profitability of Watermelon in Kaga and Kukawa Local Government areas of Borno State, Nigeria The results of farm budgeting analysis showed a net farm income of N105, 002.95 per hectare. Mean technical efficiency of 86 percent was achieved by watermelon farmers in the study area meaning that there is a scope for increasing watermelon production efficiency by 14 percent in the study area. Years of farming experience, extension contact, years of cooperative membership. And amount of credit received were significant variables for improving technical efficiency while age, educational level, household size and marital status were observed to increase technical inefficiency. The return to scale was 0.941 suggesting that the production function was characterized by decreasing returns to scale, hence watermelon producers operate in stage II of the production surface.

The results of the study revealed that the farmers had mean age of 41 years, 12 years of farming experience, 15 percent had access to extension services and 47 percent obtained credit. The results of the profitability analysis revealed a net farm income of N105, 002.95 per hectare and average rate of return of 0.86. Thus, for every naira invested in watermelon production there is a profit of 86 kobo. The results of the stochastic frontier and cost function analyses revealed a mean technical, allocative and economic efficiencies levels of 86, 25 and 21 percents implying that there is scope of increasing efficiencies by 14, 75 and 79 percents respectively. The main sources of technical and allocative inefficiencies were years of farming experience, extension contact, membership of cooperative societies, amount of credit obtained and educational level. The constraints faced by the farmers include incidences of pests and diseases, encroachment on their farms by pastoralists, sudden climatic change, inadequate capital and inputs, high transportation costs and market glut. The study recommends that the inefficiency variables of extension contact, years of cooperative membership and access to credit should be addressed through adequately trained and equipped extension workers, right use of credit facilities and the formation of cooperative societies and making membership a condition for microcredit benefit.

Adam, (2004) Studied Economic Efficiency in Rain-fed Farming Sector Sinnar State – Sudan

The results revealed that operating capital in the traditional sector was underutilized and labor and seeds were over-utilized. In the semi-mechanized sector operating capital and herbicides were underutilized, while labor and seeds were over utilized. The farmer's basic plans showed that the traditional farmers cultivated a combination of sorghum, sesame, pearl millet, cowpea and groundnut, while the semi-mechanized farmers cultivated a combination of sorghum, sesame, pearl millet, and sunflower. The allocative efficiency analysis has revealed that the optimum cropping pattern for the traditional farmers is by cultivating sorghum and cowpea. The optimum cropping pattern for the semi-mechanized farms is by cultivating: only millet for the small farms, sesame and sunflower for the medium farms and sorghum and sunflower for the large farms. This optimum cropping pattern has increased the income of farmers by 43%, 31.3%, 24.7%, and 24.2 for the traditional farmers, semi-mechanized farmers, semi-mechanized large farmers, and semi mechanized small farmers, respectively. The study suggested that the government facilitate timely provision of necessary financial resources to farmers for improving the efficiency of resource use. The Agricultural Extension Department is to educate the farmers about the optimum use of inputs.

Adel (2009) conducted a study aimed at estimating the economic efficiency of the Egyptian wheat and bean crops in the Northern state and the Nile River state in the winter season (2004-2005). The random field exponential production and cost of Cobb-Douglas was selected to measure the technical and economic efficiencies of wheat and Egyptian beans in the two states. The results showed that farmers those who shared Egyptian beans are more economically efficient than farmers who grow wheat in each of the two states. The results of the economic efficiency of Egyptian wheat and beans for each year during the period from 1996 to 2007 showed that the Northern state had the superiority, as it was found on average the highest economic efficiency in the production of wheat and beans. Egyptian beans are from River Nile state. The result of the analysis indicated that Egyptian beans were more competitive than wheat, while both have competitive advantage, which means economic efficiency or efficient use of resources in their production

Ibrahim, (2017) Studied economic efficiency of sorghum and millet Production for small Scale farmers in traditional rain fed, North Kordofan State, Sudan

The results of the descriptive statistical analysis indicated that 76% of farmers males, and the mean age was 44.08 years; also most farmers (85.4%) were married and (63.4%) have attained some sort of education. An average economic efficiency estimated of sorghum and millet farmers obtained was found to be 0.39 (39%) and 0.15 (15%), respectively. The results revealed that there was significant inefficiency effect in sorghum and millet production in traditional rain fed sector, and 99 % production was associated with inefficiency. Based on the findings, the study recommended that economic efficiency can be achieved through improved farmer specific efficiency factors, which include improved farmer education, access to credit, and access to improved extension services. In addition to that enhancing institutional promotion of agricultural research sectors, and investment in agriculture to raise agricultural productivity. If the farmers address the inefficiency determinants, sorghum and millet production will be maximized in the rain fed sector in North Kordofan state.

Ibrahim, (2011) analyzed the production efficiency and profit ability of watermelon in kaga and kukawa local government areas of Borno state, Nigeria. The results of the study revealed that the farmers had mean age of 41 years, 12 years of farming experience, 15 percent had access to extension services and 47 percent obtained credit. The results of the profitability analysis revealed a net farm income of N105, 002.95 per hectare and average rate of return of 0.86. Thus, for every naira invested in watermelon production there is a profit of 86 kobo. The results of the stochastic frontier and cost function analyses revealed a mean technical, allocative and economic efficiencies levels of 86, 25 and 21 percents implying that there is scope of increasing efficiencies by 14, 75 and 79 percents, respectively. The main sources of technical and allocative inefficiencies were years of farming experience, extension contact, membership of cooperative societies, amount of credit obtained and educational level. The constraints faced by the farmers include incidences of pests and diseases, encroachment on their farms by pastoralists, sudden climatic change, inadequate capital and inputs, high transportation costs and market glut. The study recommended that the inefficiency variables of extension contact, years of cooperative membership and access to credit should be addressed through adequately trained and equipped extension workers, right use of credit facilities and the formation of cooperative societies and making membership a condition for microcredit benefit.

CHAPTER THREE

STUDY AREA AND RESEARCH METHODOLOGY

3.1 Description of the Study area

Area of the Study

South Kordofan State is selected as study area for some reasons, the most important one is that the state is one of the most important agricultural rain fed areas in the Sudan where the mechanized and traditional agricultural farming is practiced.

The total area of the state is about 138000 km2 equivalent to 1.38 million hectares, contributing to the national agricultural crop production by estimates as for sorghum 9%, millet 3%, sesame 6%, groundnut 5%, cattle 17.4%, sheep 7.5%, and goats 9.8%. About 85% of South kordofan land is covered by range and forests (wood lands), 14% arable land, and the remaining (less than1%) is bare area, settlements and water molecule. The agricultural area in the state is about 1.38 million hectare (14% of the total area) out of which 30% is traditional and 70% is mechanized. Above twenty supporting agricultural services and NGOs have worked in the state (SKSIO, 2008)

3.2 Climate

South kordofan state lies in the area between latitudes 27.5 – 32 degrees east and latitudes 10.5 – 11.5 degrees north- Semi dry and wet climate is dominant in the clay strip of the state with very wide range and diversification in the vegetative cover, The maximum temperature ranges between 30- 4oc° throughout year, while the minimum temperature ranges between 17- 20 c° in the wet season. Humidity ranges between 20 – 30% for the period of dry season and up to 80% in the raining season (Western Sudan Resource Management Program) (WSRMP, 2007).

3.3 Rain

Rain fall is the most important climatic index of productivity, at the same time it is the most variable climatic element both in time and space. The total rain fall alone is not enough, the distribution is more important, the annual rain fall is very significant according to report by (IFAD, 2004).

South kordofan state can be divided into main zones in accordance with the rain fall. (Hamdi, 2010).

Table (3.1): Rain fall level (mm) in Habiella Agricultural scheme seasons (1999- 2020)

Seasons	Month's							Total
	April	May	Jon	Jolly	August	September	October	
1999/20	9	13	12.5	65	182.5	127	79.5	488.5
2000/01	….	68.5	27	34.5	191.5	54	53.5	429
2001/02	….	51	103.5	109.5	115.5	119	…..	489.5
2002/03	……	4	88	193	211	157	42	910
2003/04	……	45.5	146	127	132	98.5	39	146.4
2004/05	…	45	217	88	97	64.5	…..	661.5
2005-/06	…..	22	127.5	135	207.5	114	108	741
2006/07	…..	104	158	154.5	253.5	452	21	1143
2007/08	31.9	2.3	248.4	228	440.5	105	18	874
2008/09	62	127.5	129	138	166	100.5	56	779
2009-10	…	10	32.5	168.5	117	191	36	556
2010/11	….	37	90.5	147	178.2	71.6	117	691.3
2011/12	….	51.5	37.5	145	147.5	179.5	23	578
2012/13	…..	28	129.5	193	244	162	7	763.5
2013/14	……	6	251	103	334	196.5	…..	917.5
2014/15	49	120	130	156	260	160	28	943
2015/16	….	51	146.6	76	143.5	197	120	734.1
2016/17	……	25	117.2	195.3	128	88	5	558.5
2017/18	……	51.2	60	195.4	148.1	152.5	…..	607.2
2018/19	….	22.5	65	198	149.2	155	30	619.7
2019/20	…..	60	75	200	168	180	45	728

Source: Agricultural Experts Groups Office of rain agriculture al Dalang (2019)

Habiella agricultural locality in south kordofan state is located 47 km southeast of the city of Dalang between latitudes 9-12 degrees north and 27-32 loglines east and bordered by the north of al-Quiz and south of eastern countryside and east al-Delami locality and west al-Dalang locality.

Habiella region is one of the largest and most important agricultural areas in south kordofan state and in the second place after the Abugebiha region in terms of agricultural area and productivity.

The planned and arable area is about (713000) fed with 500 fed, 1000 fed, and 1500 fed per Scheme. It has large out- of- state and out- of-state frames who play an active role in the states

Production and productivity.

About 95% of the people working in agriculture are agricultural workers and others are in the area working in livestock and trade. Habiella area is characterized by light and heavy mud lands arable.

Its rainfall ranges from 450 to 700 mm per year and may reach more than 1000mm in some seasons, and is dominated by a rich savanna climate, and the crops cultivated are sorghum, millet, sesame, cotton, guar and other cash crops generating income and other food crops.

Table (3.2): Area, planned/ fed, year of planning and farmers% in and out of state in Habiella scheme

No	Area	Years of planning	Planned area/ fed	Number of farmers	Farmers % from the state	Farmers % out of the slate
1	Old Habiella	1970	211500	425	94	6
2	Habiella private	1973- 1976	178500	393	93	7
3	Kurtala	1983	203740	235	65	35
4	Alsifaifeer	2000	70100	280	80	20
5	North Habiella	1984	50000	2000	97	3
Total		713840		3332		

Source: Agricultural Expert Groups Office of rain agriculture, al Dalang (2019)

Table (3.3): cultivated Areas, / fed, Production and Productivity (sack and kantar) of Sorghum and Sesame crops in Habiella scheme, Seasons (2010-2020)

Season	Area cultivated/ fed		Production		Productivity	
	Sorghum	Sesame	Sorghum/ sack	Sesame/ kantar	Sorghum /sack	Sesame /kantar
2010/11	394823	83915	789646	98405	2	1
2011/12	1159166	602576	2318332	60256	2	1
2012/13	1542106	441141	3094212	441147	2	1
2013/14	1444101	552131	2166152	55211	1.5	1
2014/15	1534411	543210	3068822	1086420	2	2
2015/16	2278265	556690	2278265	556690	1	1
2016/17	2989244	192525	5978488	192525	2	1
2017/18	329889	228519	659778	228519	2	1
2018/19	4035689	268913	4035689	268913	1	1
2019/20	5812245	312129	8718368	312129	1.5	1

Source: General Administration Rain fed agricultural Mechanization south kordofan state.

3.4 The tasks of the Department of agricultural Mechanization in the state, especially in the Habiella Agricultural scheme

The General Administration of Rain-fed Agriculture is the only body responsible for the development of rain-fed agriculture in the state because of its long experience of its cadres throughout history who worked for a period of more than 25 years during which they worked in most different parts of Sudan implementing and supervising the following tasks:

- Explore areas suitable for investment by field and soil inspection soil.
- Planning with the help of the area authority projects and develop the necessary map and links it to the general map of Sudan.
- The Department of agricultural Mechanization opens roads and removes the remains of herbs, plants and trees.
- The validity of the projects is to conduct field surveys in addition to the social survey of the planned area.
- Identifying the road house and paths of the Nomadic Arabs.
- Giving serial numbers for projects.

- Announcement in the various media about the distribution and condition of projects.
- Handing over projects to their owners after completing the procedures by signing a contract regulating the relationship between the farmer and the Debarment of agricultural mechanization.
- Monitoring the implementation of the terms of the contract in relation o the application of the agricultural rotation and other technical aspects.
- Report the outbreaks and diseases that affect the corps to the concerned authorities and follow with them the control measures.
- Monitoring the agricultural situation in general and reporting to the higher authorities charged with responsible for formulates suitable policy.
- Recording and monitoring the rain records and the area invested in the season, and average, productivity, and cost of production and pest and diseases.

Table (3.4): Sorghum area, production and productivity of agricultural crops in Habiella scheme in seasons 2010 / 20

Seasons	Cultivated area/ fed	Productivity/ sack	production/ sack
2010/ 11	363373	2.7	280175
2011/ 12	319798.2	2.8	735467
2012/ 13	531493.7	2.9	133879.8
2013/ 14	472997	1.3	504214.8
2014/ 15	255450.2	1.7	546124
2015/ 16	14220.5	2.9	13384
2016/ 17	144410	1.5	13490
2017/ 18	251490	2.1	520300
2018/ 19	191351	1.3	382010
2019/ 20	182010	1.8	364020

Sources: (Ministry of Production and Economic Resources, South Kordofan State-Agricultural Sector (2020)

3.5 Research Methodology

3.5.1 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. Both primary and secondary data were collected to test the requirements of the objectives of the study.

3.5. 2 Primary Data

Primary data were collected by using a structured questionnaire using a random sampling technique through direct personal interviewing. The primary data were collected during Season 2019/202. The primary data include information about the socio- economic characteristics of producers such as age, education level, number of family members, and experience. All farms in Habiella Agricultural scheme were homogenous and therefore random sampling was used. The Sample size was 191 farmers out of 3332 farmers.

The study used the descriptive and analytical method to study the phenomenon of economic efficiency of sorghum and sesame production. It will apply Frontier and Data Envelopment Analysis software to estimate technical, allocative and economic efficiencies. Moreover, Linear program (LP) will be applied to estimate the optimum crops pattern of Habiella Agricultural Scheme.

3.5.3 Data collection

The equation

This research will use Attribute Sample

formula for the sample size**:**

$$S = Z^2 * N * E (1 – E) / [(A^2 * N) + (Z^2 * E (1 – E))]$$

Where:

S = required sample size (191),

Z = Factor for the desired confidence level (1.96),

N=Population size (3332),

E= Expected error rate (5%),

A = Precision range (3%).

1.5.4 Sample size distribution

Table (3.5): Presents the prescribed selected farmers from each site of Habiella Agricultural Scheme.

N0	Sector name	Tenancy size (Fed)	Farmers community	%	Farmers' Samples size
1	Old Habiella	1000	425	13	25

2	Habiella Directed	1500	392	12	23
3	Kurtala private	1000	180	5	9
4	Kortala Directed	1500	55	2	4
5	Alsifaifeer	650	280	8	15
6	North Habiella	1000	2000	60	115
Total			**3332**	**100**	**191**

Source: Filed Survey (2019)

Table (3.6): Sample size distribution between Contractual Farmers' and non-Contractual Farmers'

N0	Sector name	Contractual Farmers' Sample size	non- Contractual Farmers' Sample size	Farmers' Sample size
1	Old Habiella	8	17	25
2	Habiella Directed	7	16	23
3	Kurtala private	3	6	9
4	Kurtala Directed	1	3	4
5	Alsifaifeer	5	10	15
6	North Habiella	37	78	115
Total		**61**	**130**	**191**

Source: Filed Survey (2019)

Where

Total Farmers' in Habiella Scheme = 3332

Total area Planning = 772600 Fed

Total Contracts Farmers' = 1055

Total non-Contractual Farmers' = 2277

Contractual Farmers' (%) = 0 .32

Non-Construal Farmers' (%) = 0 .68

3.5.4 Secondary data

Secondary data were collected from the relevant institutional sources, which include Ministry of Agriculture and Forests, and the Ministry of Production and Economic Resources, South Kordofan State, Agricultural Sector, Information Center, in addition to different documents, records, books, internet, papers, journals and reports.

3.6 Analytical techniques (Methods of analysis)

To a chive the objectives of the study a variety of analytical techniques were used. Tabular as well as simple descriptive statistics were used throughout the study to describe the socio-economic characteristics of the producers. Gross margin analysis, forecasting of sorghum and sesame production in Habiella scheme, in addition to, stochastic frontier production function technique and linear programming (L.P)

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 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 and course of actions, among many which are possible, for production of two crops sorghum and sesame production in Habiella scheme farms in way that minimizes farms revenue and satisfies domestic consumption.

3.7 Specification of Stochastic Production Frontier model

The model includes farm's factors influencing the producer technical efficiency. Stochastic production frontier model of Cobb-Douglas form was used to find out the farms technical efficiency for sorghum and sesame production in Habiella scheme farms. In total parameters were estimated in stochastic production frontier model including five parameters and three parameters in the inefficiency model.

In order to estimate the level of technical efficiency in manner with the theory to of production function we have specified a Cobb-Douglas form of production has some known properties that justify its wide application in economic literature (Henderson and Quant, 1971).The model includes the tenant's factor in flouncing the farmer technical efficiency. Stochastic production frontier model of the Cobb-Douglas form used to find out the tenants technical efficiency for crop production in Habiella Scheme identifying the factors that affect inefficiency is one major step that should be taken in raising that efficiency of production activities (Muhammad Lawal et. Al, 2009). In total 12 parameters were estimated in the stochastic production frontier model including 5 parameters in the stochastic frontier model and 7 parameters in the inefficiencies model.

3.8 Technical Efficiency of sorghum and sesame production

Technical efficiency of crops Sorghum and sesame.

The model is written as follows

$$\mathbf{Inyi} = \boldsymbol{\beta_0} + \sum_{j=1}^{n} \boldsymbol{\beta_j} \mathbf{Inx_{ij}} + \mathbf{v_i} - \mathbf{u_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

$$LnYi = ln\beta i + \beta 1lnX1i + \beta 2lnX2i + \beta 3lnX3i + \beta 4lnX4i + \beta 5lnX5i + \beta 6\ lnX6i + VI - Ui \quad \ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where Y = annul total sorghum and sesame production (kg),

3.8.1 Technical Efficiency of Sorghum production the model is written as follows

$$Lnyi = \boldsymbol{\beta}0 + \sum_{j=1}^{5} \beta j\ 1n\ xij + VI - Ui \quad \ldots\ldots\ldots\ldots\ldots \text{(3)}$$

$$TEi = yi / yi^* = f(xi : \beta)\ exp\ (vi - ui) / f\ (xi : \beta)\ exp\ vi = exp\ (-ui) \quad \ldots\ldots\ldots \text{(4)}$$

Where: yi is the actual production of the firm or farm i and yi* is the optimal production, is either TEi is the technical efficiency of the firm or farm that is, which takes values between zero and one (0- 1)

The cob-Douglas function below was used to estimate the production

$Lny = ln\beta 0 + \beta_1 lnX_1 + \beta_2 ln X_2 + \beta_3 ln X_3 + \beta_4 ln X_4 + \beta_5 ln X5 + ei$ …………… (5)

Where:

ln = the national logarithm.

Yi = yield of sorghum production (kg).

X1= seed cultivated (SDG) /fed.

X2 = gasoline of sorghum (SDG)/ Gallon/ fed.

X3 = Labors of sorghum (person).

X4 = pesticide of sorghum (SDG) /fed.

X5 = area cultivated of sorghum / fed.

$\beta 0$, βj, VI and Ui as previously defined in equation.

ei = error threshold consisting of white noise.

ui = represents the effect of technical efficiency.

3.8.2 Technical Efficiency of sesame production

Where

Yi = yield of sesame production (kg).

X1= seed of sesame cultivated (SDG) /fed.

X2 = gasoline of sesame (SDG).

X3 = Labors of sesame (person).

X4 = pesticide of sesame (SDG) /fed.

X5 = area cultivated of sesame/ fed.

3.9 Inefficiency Effect Model

The μi in the stochastic production frontier model is non-negative random variable, associated with the farm's technical inefficiency in production and assumed to be in dependently distributed, such that the technical inefficiency effect for the i-th farmers, μi, will be obtained by truncating (ate zero) of the normal distribution with mean, ui, and variance $\sigma 2$,such that

$Ui = \sigma_o + \sum_{s=1}^{6} \sigma s\ Zai$ ……………….. (5)

$R = \sigma_o + \sigma_1 Z_1 + \sigma_2 Z_2 + \sigma_3 Z_3 + \sigma_4 Z_4 + \sigma_5 Z_5 + \sigma_6 Z_6 + e$ ……….. (6)

3.9.1 Technical inefficiency of Sorghum production

Where

R = in technical efficiency

Z_1 = experience years

Z_2 = level of education yeas

Z_3 = extension in a season numbers

Z_4 = finance (SDG)

Z_5 = age of project (years)

Z_6 = rain and the range distribution

3.9.2 Technical Inefficiency of Sesame production

Where

R = in technical efficiency
Z_1 = experience years
Z_2 = level of education yeas
Z_3 = extension in a season numbers
Z_4 = finance (SDG)
Z_5 = age of project (years)
Z_6 = rain and the range distribution

These are included in the model to indicate their possible influence on the technical efficiencies of the farmers. The β's, σ's are scalar parameters to be estimated. The variances of the random errors, σv2 and that of the technical inefficiency effects σu2 and overall variance of the model σ2 are related thus: σ2 = σv2 + σu2 and the ratio γ = σu2/ σ2, measures the total variation of output from the frontier which can be attributed to technical or inefficiency (Battese and Corra, 1977). Where the γ parameter has value between zero and one, the parameters of the stochastic frontier production function model is estimated by the method of maximum likelihood, using the computer program, FRONTIER Version 4.1.

3.10 Linear programming techniques

Linear programming is an important analytical tool made available to economists. It has been found beneficial in many important applications and it offers exciting opportunities in the future. It can serve as an important management aid to individual farms or marketing firms (Heady and Candler, 1973).

Linear programming deals with problems in which the objective function is to be optimized (i.e. maximized or minimized) subject to linear equality constraints and sign restrictions on variables. The LP model may include constraints. Moreover, the variables maybe non-negative or unrestricted in sign (Taha, 1982).

A linear programming has three quantities' components: an objective, alternative method or process for attaining the objective and resources or other restriction

(Heady and Cander, 1973).In order to develop a general solution method, the linear programming problem must be put in a common which is called the standard form.

3.10.1 Linear programming (LP) in brief

From an application perspective, mathematical (and therefore, linear) programming is an optimization tools, and/or technological decisions required by contemporary techno-socio- economic applications.

3.10.2 Definitions of LP

Heady and Candler(1973) defined linear programming as an efficient way of determining optimum plans only if there are numerous enterprises or processes and numerous restrictions attaining specific objective such as maximizing farm profits or minimizing production costs . The (LP) can serve as an important management aid to individual farms or marketing firms. Gass (1964) stated that, programming is concerned with the efficient use or allocation of limited resources to meet desired objectives. Bazaraa and Jarvis (1977) see a linear programming problem as a problem of minimizing or maximizing a linear function in the presence of linear constraints of the inequality and /or the equality type.

Another definition reported by Dent, Harrison and wood ford (1986) is that linear programming is one of a class of operations research methods referred to as mathematical programming; the linear programming technique is a general methodology that can be applied to a wide range of determining a profit maximization combination of farm enterprises that are feasible with respect to a set of fixed farm constraints, Mohamed (1986) reported that, LP provides a means to find the level of decision variable(s) that would maximize the objective function subject to a set of constraints. A linear programming problem is asocial case of a mathematical programming problem. From an analytical perspective, a mathematical program tries to identify an extreme (minimum or maximum) point of a function which furthermore satisfies a set of constraints i.e.; linear Programming is the specialization of mathematical programming to the case where both, function and the problem constraints are linear (Kouruma, 1982).

3.10.3 Linear Programming (LP) techniques

Prelude

Linear Programming (LP) techniques was used determine the optimal cropping sequent of machined famers in the rain-fed sector of South kordofan State.

Spread sheet of the excl solver was used to run the on analysis. The structure of the Linear Programming (LP) model

Have an account on the (LP) model is given. The parameters and coefficients of the model, method of estimation and assumption employed are discussed hereafter.

The objective function:

The objective function of this model was to maximize farmer's net return from crop production. The mathematical from the model followed the gnarl maximization function (Dent et al.1986□ Hazel, 1986):

$$\text{Max } Z = \sum_{t-1}^{n} RjXj$$

Subject to

1- Constrains of the from = $\sum_{t-1}^{n} aijxj \leq bi$
2 – And non- negativity Constrains = $xj \geq 0$, j = 1, 2,…, n

Where:

Z= objective function value.

Xj= productivity of the main crops produced under the rain- fed sector of Habiella Scheme in South kordofan State , the corps were (Sorghum and Sesame).

Rj = net return/ fed of the j activity,

a = number of restrictions in the model.

aij= the cost of the i^{th} resource required to produce one unit of the j^{th} activity.

bi= vector of resource availability.

One and only one of the symbols ≥, =, ≤ holds for each of the bi constrains equation. Both the objective function and constrains most be liner equation.

3.11 Empirical specifications of the Linear Programming Model

3.11.1 Technical coefficients of the model

A simplified tableau of the model technical coefficients is presented is table (3.2) the first row of the model represents the activities set, which is equal to the actual area allotted for each crop cultivated in the study area. The maximum area of activity set most be less than or equal to average area farmer (fed).

Linear programming is considered as an appropriate technique for economic analysis of ration formulation because it provides a means of finding the level of decision variable(s), the results to be produced by such technique are based:

-Firstly; the decision making to which it is applied always involves constraints on the decision making body.

-Secondly; input and out-put prices are assumed to be constant.

-Thirdly, the firm's input- output, output- output and input- input relations are presumed to be linear.

Table (3.7) tableau of the linear programming model

Activity set	Crop				
	Sorghum ((x1)	Sesame (x2)			
Area					
Productivity (kg/fed	Kg1	Kg2			
Price (SDG/kg)	P1	P2			

Return	P1Kg1	P2Kg2	P1Kg1+ P2Kg2		
Input cost (SDG/ fed)					
seeds	71	234	71kg1+234kg2	≤	5000
Pesticide	44	29	44kg1+29k2	≤	
cost item (SDG)					
Ploughing	178	186	178kg1+186kg2	≤	364
Cultivate	192	186	192kg+186kg2	≤	378
Chemical Pesticides	16.53	20	16.53kg1+20kg2	≤	36.53
First clean	205	205	205kg1+205kg2	≤	410
second clean	37	26	37kg1+26kg2	≤	63
oils and strainers	37	35	37kg1+35kg2	≤	71
Labor	125	140	125kg1+140kg2	≤	265
machine cost	23	24	23kg1+24kg2	≤	47
cut &collecting	739	834	739kg1+834kg2	≤	1583
Harvesting	163	201	163kg1+201kg2	≤	364
Transportation	79	70	79kg+70g2	≤	149
food for labor	150	145	150kg1+145kg2	≤	295
Sacks	75	63	75kg1+ 63kg2	≤	138
machine maintenance	30	30	30kg1+ 30kg2	≤	60
Storage	12	13	12kg1+ 13kg2	≤	25
Operational costs					
Land preparation	173	179	173kg1+179kg2	≤	352
Labor cost	125	140	125kg+140kg	≤	265
Gasoline cost	55	55	55kg1+kg2	≤	110
Machine cost	23	24	23kg1+24kg	≤	47
Others	83	92	83kg1+ 92kg2	≤	175

Other constraints					
Capital and hand	1	1	1 Kg1+ 1kg2	≤	3000

Nouha, 2016

CHAPTER FOUR
RESULTS AND DISCUTION

In this chapter, the results are presented and discussed in forms of tables and figures that include descriptive statistics, analysis of the socio-economic characteristics of the producers in the study area and, budget analysis, technical efficiency analysis, linear programming and forecasting models.

4.1 Socio-economic characteristics of the producers in the study area

This section gives the empirical results of socio-economic characteristics of the producers which expected to have greater effect directly or indirectly, on the productivity of crops in the study area. The socio-economic characteristics studied are (sex, age, family size, number members working, educational level, farm experience, secondary economic activities, contract, extension services and finance).

4.1.1 Producers' Sex

Most of the producers in Habiella Scheme (season, 2019/20) were males, which represent 99.5% and just only one, were female representing about 0.5%.

Table (4.1): Distribution of Producers according to sex

Sex	Frequency	Percent
Male	190	99.5
Female	1	0.5
Total	191	100

Source: Filed Survey (2019)

4.1.2 Producers age

Producer age is expected to have influence on productivity and output of an individual as it affects his mental and physical abilities. Upton (1979) stated that the farmer age has an influence on management performance although the overall direction of this influence is not clear. On one hand as man ages, he gains experience and would expect his decision making ability to improve. On the other hand, it was found that goals change, with increasing age people usually towards leisure and reducing work. He also found that younger producers adopt new ideas more readily than older producers. The average age of the sample producers is 48 years.

According to the results obtained in table (4.2), the most active producers' ages ranged between 30-75 year. The best average producers ages were 45-60 years which equivalent to (39.9%), and about (4.1%) less than 30 years.

Table (4.2): Distribution of Producers According to Age

Age group	Frequency	Percent
Less than 30year	8	4.1
30 – 45	71	36.9
45 – 60	75	39.9
60 – 75	37	19.1
Total	191	100

Source: Filed Survey (2019)

4.1.3 Producers' family size

The average family size of the producers was (8) members in Habiella Agricultural Scheme (season, 2019/20) were about 53.1 percent was less than 8 members 27.1 percent and more than (8) members 19.8 percent.

Table (4.3): Distribution of Producers According to Family size

Family numbers	Frequency	Percent
1-5	52	27.1
6 -10	101	53.1
11 – 15	38	19.8
Total	191	100

Source: Filed Survey (2019)

4.1.4 Number of household members working in the farm

Table (4.4) showed the distribution of producers according to the number of persons per household working in the farm. The majority of the sample producers 46.6% have family size of about two persons. Some families have one person working in the farms representing 5.2%, other families have three members of household representing 17.3% and families have four members representing 21.5%, families have 5 members working representing 5.8% and families having 5 and 6 members working farms representing 0.5% of the sampled producers. Household members are expected to work with their parents in the farm, hence reducing their costs.

Table (4.4): Distribution of Producers According to the numbers of household Members working in the farm

Numbers	Frequency	Percent
1	10	5.2
2	89	46.6
3	33	17.3
4	41	21.5
5	11	5.8
6	5	2.6
7	1	.5
8	1	.5
Total	191	100.0

Source: Filed Survey (2019)

4.1.5 Educational level

As shown in table (4.5), most of the producers 80.1% have attained some sort of education. The illiteracy level is 19.9% of the sample, 42.5% of them has joined secondary education; about 27.8%, 8.3%, 1.5% received primary, university and above university education, respectively. This means about 42.5% of the producers received good education. The average education level of the producer growing sorghum and sesame crops in Habiella Agricultural scheme season 2019/20 equal 42.5%. Relationships between educational levels and sorghum and sesame production, as higher educational levels of producers give higher capability of adopting improved techniques in crops production. Furthermore, higher educational levels usually associated with good management and ability to take right decisions.

Rania (2007) mentioned that, there are positive relationship between educational levels and sorghum and sesame crops production, as higher educational level crops producers have the higher capability of adopting improved techniques in crops production.

Table (4.5) Distribution of Producers according to educational levels

Education	Frequency	Percent
Illiterate	38	19.9
Primary	53	27.8
Secondary	81	42.5

University	16	8.3
Above University	3	1.5
Total	191	100

Source: Filed Survey (2019)

4.1.6 Farming experience

The survey showed that the majority of the sample farmers (36.4%) have more than 10 years in the farms work, with an average experience ranging between 10-20 years (Table 4.6). This long experience in farming activity lead to increasing productivity and technical efficiency in Habiella Agricultural Scheme farms, as most of the producers in the Habiella Agricultural Scheme rent lauds. This experience improves expected to have positive effect in sorghum and sesame production, hence improving production and decreases production cost. This long experience in farming activity is due to the land ownership in the Habiella Scheme producers.

Table (4.6): Distribution of sorghum and sesame producers according to experience

Experience (years)	Frequency	Percent
1-10	50	26.2
11-20	69	36.4
21- 30	44	23
31- 40	24	12.4
More than 40	40	2
Total	191	100

Source: Filed Survey (2019)

4.1.7 Secondary economic activities

The secondary activities are of great importance in Habiella Agricultural Scheme farms in providing alternative income sources to the producers, as shown in (table 4.7) below, 52.9% of the producers have other income sources generally, the other secondary activities are employees which represent 12.6 %, 22.5% trade, 4.7% are patron livestock and Farmer lost 7.3% .

Table (4.7): secondary economic activities of the sampled farmers

Second activities	Frequency	Percent

Employee	24	12.6
Trade	43	22.5
Herders	9	4.7
Other	101	52.9
Lost and missed	14	7.3
Total	191	100.0

Source: Filed Survey (2019)

4.1.8 Contracts

The average Contracts of the producers found about 31.1% of the interviews, and about 68.1% producers did non Contract in Habiella Agricultural Scheme (season, 2019/20) it's in clears Table (4.8) below.

Table (4.8): distribution of Producers According to Contract and non Contract

Contract	Frequency	Percent
Contract	61	31.9
non contract	130	68.1
Total	191	100.0

Source: Filed Survey (2019)

4.1.9 Extension services in the season

Most of the farmers in Habiella Scheme (season, 2019/20) did not receive extension services, representing 79.1%, 151 farmers, received extension services 13.6%, 26 farmers, received extension serves 5.2%, 10 farmers received extension services and just 2.1%, 4 farmers received extension services.

Table (4.9): Distribution of Producers to receives extension serves

Number	Frequency	Percent
0	151	79.1
1	26	13.6
2	10	5.2
3	4	2.1
Total	191	100.0

Source: Filed Survey (2019)

4.2 Budget analysis

A profitability measurement technique is employed after calculating the product budget. This requires calculation of total returns and total variable costs. Gross margins for the different farm products must be calculated and compared. The comparison between margins for different products in study area will give a clear picture about the profitability of the different products. For estimation of gross margins, some fixed costs are omitted and mostly variable costs are considered. Kay (1981) stated that, the gross margins are estimated for single unit of each enterprise, and they are the difference between total returns and total variable costs.

Calculating the gross margins; on the other hand, requires best estimates of yield or production levels for each enterprise together with expected output price. Total income per unit is equal to output price time's yield or production. These estimates directly affect the estimated gross margin. The calculation of total variable costs requires a list of each variable input needed, the amount required and the price of each. Also, cost estimates are obtained to determine the relative effect of each item on the total cost.

Budget may be defined as a detailed quantitative statement of farm plan, or change in farm plan, and the forecast of its financial situation (Ahmed, 1995).

Farm budget for sorghum and sesame crops production for mechanized farms is presented.

4.2.1 Budget analysis of sorghum and sesame crops production for mechanized farms in Habiella Agricultural Scheme

Table (4.10): Average cost items per feddan for sorghum and sesame crops in Habiella Agricultural Scheme, season 2019/20

Cost items (SDG)	Crop	
	Sorghum	Sesame
land preparation	173.3	179
Seeds	71.3	234.3
Ploughing	178	185.4
Planting	192	186.3
Re – Planting	2.1	2.3
Grubbing	0	2.2

First weeding (1)	205.4	205
Second weeding (2)	37	26.3
Fertilizer	1.4	1.1
Pesticides	44	29
Gasoline	55.1	55.2
Oils and refineries	36.7	35.2
Labor	145	139.7
rental	22.7	24.3
Cutting and collecting	739.2	834.2
Threshing	163.3	201.2
Transporting	79	70.2
Food cost	150.3	145
Taxes	2	3
Sacks	75	63
Machine maintenance	30	30.4
Charity	0.4	0.06
Storage	12	12.5
Others	83	92
Total	**2498.2**	**2756.86**

Source: Filed Survey, (2019)

4.2.2 Crop returns

Table (4.11): Average price, productivity, returns, and Profit per fed, for sorghum and sesame in study area, season (2019-2020).

Average price/SDG/ kg		Productivity/Kg/fed		Gross return/ SDG/fed		Profit/SDG/fed	
Sorghum	Sesame	Sorghum	Sesame	Sorghum	Sesame	Sorghum	Sesame
18.4	82	148.3	54.4	2728.72	4460.8	230.52	1703.94

Source: Filed Survey (2019)

From the table above, it is found that the average yield per feeding was 148.3 kg for sorghum crop, and 54.4 kg for sesame crop is the table (4.10) above. From table (4.11)**,** the total average cost/fed for sorghum was 2498.2 SDG and total average cost/fed for sesame was 2756.86 SDG.

4.2.3 Price: Farmers usually sell crops at very low prices after harvesting due to their immediate need for cash to meet different consumption requirement. Furthermore, they lack facilities for marketing and storage. The prices used in this study was the average price received for sorghum and sesame which were 18.4 SDG/ kg, 82 SDG/ kg respectively, table (4.11)**.**

4.2.4 Gross returns: The yields and prices were used to calculate the returns per feddan for sorghum and sesame crops, the crops residues per feddan were also included in the gross return as shown in table (4.11)**,** the average returns per feddan for sorghum and sesame were found to be 2728.72 SDG/ fed and 4460.8 SDG/ fed, respectively.

4.2.5 Profit: The profit of a crop is the difference between its gross returns and its total costs (fixed + variable) of production. As observed in table (4.10), the average profits per feddan for sorghum and sesame crops were found to be 230.52SDG and 1703.94SDG, respectively.

Table (4.12): Average crops budget analysis per fed for sorghum and sesame in Habiella Agricultural Scheme's season 2019/20

Items	**Crop**	
	Sorghum	Sesame
Yield kg/ fed	148.3	54.4
Price SDG/ kg	18.4	82
Gross return SDG/ fed	2728.72	4460.8
Crop residues	0	0
Total average costs	2498.2	2756.86
Profit/SDG	230.52	1703.94

Source: Filed Survey, Season 2019/ 20

From the table **(4.12)** above, it is found that the Average Profit per fed for sesame crop higher than sorghum crop1703.94SDG, 230.52 SDG respectively. Then sesame crop optimum crop in Habiella Agricultural Scheme's season 2019/20.

4.3 Technical Efficiency Analysis

4.3.1 Equation model technical Efficiency of sorghum and sesame production

$LnYi = ln\beta i + \beta_1 lnX_1 i + \beta_2 lnX_2 i + \beta_3 lnX_3 i + \beta_4 lnX_4 i + \beta_5 lnX_5 i + + VI - Ui$

Where:

ln = the national logarithm. Yi = yield of sorghum production (kg).

X1= seed cultivated (SDG) /fed. X2 = gasoline of sorghum (SDG)/ Gallon/ fed.

X3 = Labors of sorghum (person). X4 = pesticide of sorghum (SDG) /fed.

X5 = area cultivated of sorghum / fed.

ei = error threshold consisting of white noise.

ui = represents the effect of technical efficiency.

4.3.2 Results and discussion of estimating technical efficiency (TE)

The technical efficiency was estimated by the method of random border analysis (SFA) according to the superior logarithmic production function (TL), by focusing on the basic and used inputs from all farms of the research sample producing sorghum and sesame corps in study area, and estimates of economic and technical efficiency were obtained (Appendix No.2 and No.3) several values for the parameters of the dependent on variables of the logarithmic superior production function by (maximum likelihood).

Sigma-squared 0.92242102E+10. Log likelihood function = -0.22529576E+04. Gamma = 0.50000000E-01. Maximum possible t- test probabilities

4.3.3 The sorghum crop producers Technical Efficiency Analysis

Stochastic frontier version 4.1 program (Coelli, 1996) was used to estimate the level of technical efficiency for sorghum production. The maximum likelihood (ML) estimate of Cobb-Douglas stochastic production frontier model with assumption of half-normal distribution for sorghum farms production technical efficiency, and technical inefficiency, were presented in table (4.13).

Table (4.13) Maximum Likelihood Estimate for the Parameters of stochastic Frontier production function and technical Inefficiency effects model in sorghum farmers in Habiella scheme

Parameters	Variables	factor of production Elasticity	standard-error
	Model production function		
$\boldsymbol{\beta}0$	Constant	-24	1.21
$\boldsymbol{\beta}_1$	Seeds	27.84*	35.32
$\boldsymbol{\beta}_2$	Gasoline	-53.63*	35.43
$\boldsymbol{\beta}_3$	Labor	679.1***	48.00

β_4	Pesticides	59.6	60.6
β_5	Total area of sorghum	138.7***	41.7
	Yield of Scale	**227.61**	
	Model of inefficiency		
σ_o	Constant	0.57	1.01
σ_1	Experience	-36.51***	4.66
σ_2	level of education	20.9 **	3.22
σ_3	Extension services	0.14	1.00
σ_4	Finance	0.00004	0.00003
σ_5	Years of the project	-0.33	1.12
σ_6	Rain amount and distribution	0.66	1.01
	Sigma – square	9.2	1.00
	Gamma	0.00	0.00

Source: Filed Survey, Season 2019/ 20

***, ** and * asterisks on the value of the parameters indicate its Significant at 1, 5 and 10 present (%) level of Significance, respectively.

Table (4.13) presents ML estimate of sorghum crop farms. Stochastic frontier and technical efficiency affects models in Habiella scheme farms. Most of the estimate β coefficients of the stochastic frontier model for all farms models have the expected sings**.**

Seeds X_1: Seed is an important factor affecting corps yield. The coefficient of seed has a positive sign and significant at 10 percent level of significance for sorghum farms. Positive significant parameter of seed means that technical efficiency increases with increase in the improve Seed/kg due to increase in number of cultivated area, that means seed is one of the main determinants of crop production in Habiella scheme farms. This means that when seed increases by one unit the technical efficiency increases by 27.84 units for Sorghum.

Gasoline X_2: The most important factor affecting crops production is availability of gasoline/ gallon. Gasoline depends on the crop condition and soil type. The coefficient of gasoline gallon number had a negative sing and appositive significant at 10 percent level significance for Sorghum. A positively significant parameter of gasoline means that technical efficiency increase with increase in gasoline gallon number. That means gasoline is one of the main determinants of crop production in Habiella scheme. This means that when gasoline increases by one unit the technical efficiency increases by -53.63 units for Sorghum.

Labour X_3: The coefficient of labor has positive sing and has positive significant effect upon the efficiency model for sorghum production. The level of significance for sorghum crop at 1%. Labor is required to carry out crop activities timely, particularly weeding and harvesting. A positively significant parameter of labour means that technical efficiency increase with increase in labour number. That means labour is one of the main determinants of crop production in Habiella scheme. This means that when labour increases by one unit the technical efficiency increases by 679.1 units for Sorghum. Although in Sudan there over all abundance supply of labour, organized agriculture, for example New Halfa scheme, faces shortage of labour hours in just very limited times, El- Feil (1993). Yassin (1996), Babiker (1998) results concluded that, labour was significantly important factor of agricultural production in Gezera scheme, Khalid (2010).

Pesticides X_4: The coefficient of Pesticide has positive sign and negative significant of this variable, and then the effect of this variable and its connection with negative relationship for Sorghum farms. Negative significant reflects the bad effects of increase of pesticide on production level of corps; negative significant parameter of Pesticide means that technical efficiency decreases with the increase of Pesticide due to expenses of more amount of money to care the crop from in Habiella scheme season 2019/ 2020. This means that when pesticide increases by one unit the technical efficiency decreases by 59.6 units for Sorghum production in study area.

Total area of sorghum X_5: Total size cultivated area of the sorghum crop; the coefficient of Total size area has positive sing, and has positive significant effect upon the efficiency model for sorghum production. Level of significance crop at 5%. Total area of sorghum appositively significant parameter of Total area means that technical efficiency increase with increase in Total size area number. That means Total area is one of the main determinants of crop production in Habiella scheme. This means that when total size area increases by one unit the technical efficiency increases by 138.7 units for Sorghum crop. And this agrees with the expectations and concepts of economic theory.

4.3.4 Sorghum producer's technical efficiency in study area

As shown in table (4.14), mean technical efficiency of the Sorghum farms production was 0.99, whit minimum of Less than 90 % and maximum 100%. This means hat on average, the farms produced only 99 percent of output that attainable by best practice, given their current level of production input and technology used, this implies that respondents can increase output by 1% from given full production input the farmer are technically efficient.
According to the results obtained in table (4.14), the most active producer's technical efficiency ranged is (90-99). Also the best average producers (90-99) were technical efficiency which equivalent to1%.

Table (4.14) Distribution Frequency of technical efficiency for Sorghum producer's in study area

Technical efficiency	Frequency	Percent (%)
Less than 90	3	2
90-99	107	61
99-100	65	37
Total	175	100

Source: Filed Survey, Season 2019/ 20

Mean efficiency of the Sorghum = 0.99159195E+00 **(**APPENDIXIES (2))
Mean economic efficiency of the Sorghum = Technical efficiency *Allocative Efficiency = TE% * AE% = EE%, 0.52*0.82 Equal=0.43
Thin Mean economic efficiency of the Sorghum in the Habiella Scheme season 2019/20 Equal =0.43.

4.3.5 Frequency1: Distribution of technical efficiency for Sorghum producers

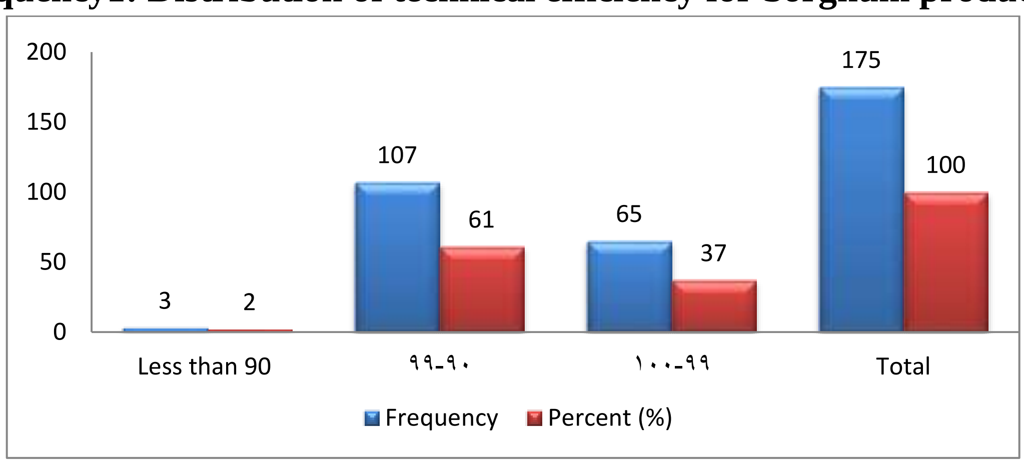
Present%


Figure 4.1: Distribution of technical efficiency for Sorghum producers
Source: Filed Survey, Season 2019/ 20

Figure (4.1) Frequency distributions of technical efficiency for sorghum producer's have wide range of technical efficiency ranging from 37 present between 99- 100, and less than 90 show 2 present. The frequency distribution of the efficiency estimates obtained from the stochastic frontier for sorghum farms (figure 5.1) shows that 99 percent of the farms operate with efficiency ranging between (99and 100) and 37 percent of them operate with efficiency ranging less than 90, 2 present. This implies that on average, the sorghum farms producing sorghum in Habiella scheme farms achieved almost 99 percent of the potential stochastic frontier sorghum production level given their current level of production inputs and technology used. 99 percent of sorghum farms model for producers in the Habiella scheme production.

4.3.6 Inefficiency Model Equation Sorghum production

$R = \boldsymbol{\sigma} 0 + \boldsymbol{\sigma} 1Z1 + \boldsymbol{\sigma} 2Z2 + \boldsymbol{\sigma} 3Z3 + \boldsymbol{\sigma} Z4 + \boldsymbol{\sigma} 5Z5 + \boldsymbol{\sigma}6Z6 + e$

4.3.7 Inefficiency of Sorghum production

Where

R = in technical efficiency. Z_1 = experience years.

Z_2 = level of education yeas. Z_3 = extension in a season numbers.

Z_4 = finance (SDG). Z_5 = age of project (years).

Z_6 = rain and the range distribution.

Table (4.13), present ML estimates of presents ML estimates of sorghum and producers stochastic inefficiency, the estimated δ coefficients associated with explanatory variables in the model for inefficiency effects for the Habiella Agricultural scheme farmers. Most of the estimated δ coefficients of the stochastic frontier model for all farmers' models have expected signs.

Experience Z_1: The experience year's level showed that, had negative sings and significant at 1% level significance for sorghum producer, negative sings parameter of experience of farmers means that the inefficiency effect decrease with increase in experience years. This result is in conformity with the finding of Rahman (2002). He found a negative association between the technical inefficiency and farmers' experience (-36.51). Indicating that the technical inefficiency increase with increase number of years the producer engaged in agricultural production. This unexpected coefficient sign can be attributed to the fact that, farm with relatively high number of year as producer are to be relatively old. Old producer may be less educated, as well as, they are more conservative to adopt the new technology and hence expected to be more inefficient, which was the same result obtained by Ahmed, (2015).

Level of education Z_2: Level of education the coefficient education level positive sign and significantly difference from zero at 5 percent level of significance for sorghum, parameter of level education means that technical inefficiency decrease with the increase in education of farm operators. Variable showed that direct relationship between years of education and the output of the sorghum crop. This is a normal result which means education add t farmers knowledge and indicators of their awareness and their abilities of taking decision on how and what to produce, approaching credit allotting their a available resources and adopting new agricultural technologies Rahman, (2002). These fore educations, aware new and knowledge reduce the inefficiency. So conclude that level education has positive effect on crop sorghum production in the Habiella agricultural scheme.

Extension services Z_3: Extension services has positive sing and negative significantly effect upon the efficiency effects for sorghum, this means that, tenants with Extension services are more technically efficient than tenants with no Extension services. The technical inefficiency effect decrease sorghum production. (Khalid, 2010). Negative relationship with the efficiency of the sorghum crop producer through the positive sign of its elasticity value, coefficient (0.14).

Finance Z_4: The coefficient of finances has positive sign and negative significant effect for sorghum crop producers in Habiella agricultural scheme, indicating the relationship has no effect with the efficiency of the sorghum crop, which means that all the advanced finance have no positive effect on increasing technical efficiency for sorghum crop producers in the field. Coefficient (0.00) and stander deviation (0.00)

Years of the project Z_5: The years of the project producer have negative sign and also negative Significance for sorghum producer in study area. This variable was not shown through (t-test) and it was also associated with inverse relationship with the efficiency of the sorghum crop, producers through the negative sing of its elasticity value, which means that -0.33 is not suitable for producing sorghum which will lead to a decrease in sorghum production and negatively affect the production and thus lack technical efficiency to produce this quantity of the product. This is reason why famers (producers) seek to know years of the project suitable for production, which leads to technical efficiency.

Rain and the range distribution Z_6: The coefficient of rain and the range distribution in inefficiency model has positive sign and negative Significance for sorghum producer. Negatively significant parameter of rain and the range distribution means that technical inefficiency decreases with increase in rain and the range distribution of farm operators**.** This did not appear through the t-test, and it was also associated with an inverse relationship with the efficiency of the sorghum crop producer through the negative sing of its elasticity value, coefficient (0.66) and stander deviation (1.01) indicating the relationship has no effect with the efficiency of the sorghum crop, which means that all the advanced rain/mm and the range distribution in a season have no positive effect on increasing technical efficiency for sorghum crop reducers in the area of study.

4.3.8 Yield of scale

Yield of scale means the relative response of production as a result of a change in the factor of production in a certain percentage, and the yield of volume with the previous production function is a set of elastics of the five factors of production in the event that they change at the rate of one unit. There are three cases yield of scale**:**

- If all factor of production area increased by a certain percentage, the output will increase by a greater percentage, that is: > 1.
- If all factor of production area decreased by a certain percentage, the output will decreased creasy by a greater percentage, that is: <1.
- If all constant yield of the volume is the situation that indicates an increase in all factor of production that leads to an increase output in production to itself, that is: = 1

4.3.9 Return to Scale of sorghum

The return to scale relationship between input and output could be seen from the sum of the regression coefficients (elasticity's). It is assumed that the sum of elasticity's of one, the return to the scale is constant, if the sum is less than one; the return to scale is decreasing, and if the sum of elasticity's is greater than one indicates increasing return to scale. That means for equal proportion increase inputs, the response of sorghum crop output is at equal production, in the scale is constant, the response is less than proportional, the scale is decreasing, and the response is greater than proportional, in the scale is increasing. The sum of efficiency coefficients (elasticity's) for sorghum size producer was 227.61. The scale relationship between input and output (return to scale) were in the range of increasing return to scale for all producer size categories. These result indicated that for 100% increase of input production, of sorghum output would increase 22761%. The increasing return scale might be the result of economic of scale because of the factor of production may be efficient and more productive.

4.3.10 Equation model technical Efficiency of sesame production

$LnYi = ln\beta i + \beta_1 lnX_1 i + \beta_2 lnX_2 i + \beta_3 lnX_3 i + \beta_4 lnX_4 i + \beta_5 lnX_5 i + VI - Ui + ei$

Where:

ln = the national logarithm. Yi = yield of sesame production (kg).

X1= seed cultivated (SDG) /fed. X2 = gasoline of sesame (SDG)/ Gallon/ fed.

X3 = Labors of sesame (person). X4 = pesticide of sesame (SDG) /fed.

X5 = area cultivated of sesame / fed.

ei = error threshold consisting of white noise.

ui = represents the effect of technical efficiency.

4.3.11 Results and discussion of estimating technical efficiency (TE)

The technical efficiency was estimated by the method of random border analysis (SFA) according to the superior logarithmic production function (TL), by focusing on the basic and used inputs from all farms of the research sample producing and sesame crop in study area, and estimates of economic and technical Efficiency were obtained (Appendix No.3) several values for the parameters of the independent variables of the logarithmic superior production function by (maximum likelihood). Sigma-squared = 0.24966775E+08. Log likelihood function = -0.16661035E+04. Gamma = 0.52000000E+00

4.3.12 Sesame crop producers Technical Efficiency Analysis

Stochastic frontier version 4.1 program (Coelli, 1996) was used to estimate the level of technical efficiency for **sesame** production. The maximum likelihood (ML) estimate of Cobb-Douglas stochastic production frontier model with assumption of half-normal distribution for sorghum farms production technical efficiency, and technical inefficiency, were presented in table (4.15).

Table (4.15) Maximum Likelihood Estimate for the Parameters of stochastic Frontier production function and technical Inefficiency effects model in sesame farmers in Habiella scheme

Parameters	Variables	factor of production Elasticity	standard-error
	Model production function		
$\boldsymbol{\beta}0$	Constant	775.09	81.7
$\boldsymbol{\beta}_1$	Seeds	44.6***	4.6
$\boldsymbol{\beta}_2$	Gasoline	28.5***	5.04
$\boldsymbol{\beta}_3$	Labor	5.71*	3.4
$\boldsymbol{\beta}_4$	Pesticides	-6.03	5.7
$\boldsymbol{\beta}_5$	Total area of sesame	4.13	10.3
	Yield of Scale	**76.91**	
	Model of inefficiency		
$\boldsymbol{\sigma}_o$	Constant	-149.1	94.6
$\boldsymbol{\sigma}_1$	experience	143.0	90.95
$\boldsymbol{\sigma}_2$	level of education	88.9	119.9
$\boldsymbol{\sigma}_3$	Extension services	-1154.9	733.7
$\boldsymbol{\sigma}_4$	Finance	0.0000034***	0.0000013
$\boldsymbol{\sigma}_5$	Years of the project	-50.6	167.06
$\boldsymbol{\sigma}_6$	Rain amount and distribution	203.8	130.19
	Sigma-square	35988980	1.1
	Gamma	0.74	0.07

Source: Filed Survey, Season 2019/ 20

***, ** and * asterisks on the value of the parameters indicate its Significant at 1, 5 and 10 present (%) level of Significance, respectively.

Table (4.15) presents (%) ML estimate of sesame crop farms. Stochastic frontier and inefficiency effects models in Habiella scheme farms. Most of the estimate $\boldsymbol{\beta}$ coefficients of the stochastic frontier model for all farms models have the expected sings**.**

Seeds X_1: Seed is a very important factor affecting on corps yield. The coefficient of seed has positive sign and significance at 1 percent level of significant for sesame farms and positive relationship with the output, as the increase in the farmer's (Koody, 2015). Positive significant parameter of seed means that technical efficiency increases with increase in the improve Seed/kg due to increase in number of cultivated area, that means seed is one of the main determinants of crop production in the stud area. This means that when seed increases by one unit the technical efficiency increases by 44.6 units for sesame.

Gasoline X_2: The coefficient of gasoline factor has positive sign and has positive significant effect upon the efficiency model for sesame production (Nuoha, 2016). The level of significance for sesame crop at 1%. Positively significant parameter of gasoline means that technical efficiency increase with increase in gasoline/gallon number. That means gasoline is one of the main determinants of crop production in Habiella scheme. This means that when gasoline increases by one unit the technical efficiency increases by 28.5 units for sesame.

Labour X_3: The labour coefficient has positive sign and significant effect upon the efficiency model for sesame production. The level of significance for sesame crop at 10%. Labor is required to carry out crop activities timely, particularly weeding and harvesting. A positively significant parameter of labour means that technical efficiency increase with increase in labour/men number. That means labour is one of the main determinants of crop production in Habiella scheme. This means that when labour increases by one unit the technical efficiency increases by 5.71 units for sesame. Although in Sudan there over all abundance supply of labour, organized agriculture, for example New Halfa scheme, faces shortage of labour hours in just very limited times, (El- Feil (1993). Yassin (1996), Babiker (1998) results concluded that, labour was significantly important factor of agricultural production in Gezera scheme, (Khalid (2010). Then labour factor is very important, in the volume of the output of sesame crop in Habiella Agricultural scheme.

Pesticides X_4: Pesticide coefficient showed positive sign and negative significant of this variable, and then the effect of this variable and its connection with negative relationship for coefficient farms between output and technical efficiency. Negative significant reflects the bad effects of increase of pesticide which lead to decrease in production level of corps; negative significant parameter of Pesticide means that technical efficiency decreases with the increase of Pesticide due to expenses of more amount of money to care the crop from in study area season 2019/ 2020.

Total area of sesame (X5): The total area of sesame crop; in Habiella agricultural scheme the coefficient has positive sign, and has insignificant effect upon the efficiency model for sesame production. Total area of sesame had negatively significant parameter effect bestrewn output and technical efficiency which means technical efficiency decrease with increase in Total size area for sesame in study area.

4.3.13 Sesame producer's technical efficiency in study area, 2019/20

As shown in the table (4.16), technical efficiency of the **sesame** farms was less than 30, 11 Percent, between 30 – 60, 51 Percent, 60-90, 33 Percent and more than 90, only 5 Percent. This means hat on average, the farms produced only 51 percent of output that attainable by best practice, given their current level of production input and technology used. This implies that respondents can increase output by 1 percent from given full production input of the farmer when technically efficient.

Table (4.16) Distribution Frequency of technical efficiency for sesame producers in study area

Technical efficiency	Frequency	Percent (%)
Less than 30	18	11
30-60	86	51
60-90	55	33
More than 90	9	5
Total	168	100

Source: Filed Survey, Season 2019/ 20

Mean technical efficiency of the sesame = 0.54
Mean allocative efficiency of the sesame = 0.11
Mean economic efficiency of the sesame = Technical efficiency *Allocative efficiency = TE% * AE% = EE%, 0.54*0.11l = 0.06
Thin Mean economic efficiency of the sesame crop in the Habiella Scheme (season, 2019/20) = 0.06.

4.3.14Frequency 4.2: Distribution of technical efficiency for sesame producers

Percent

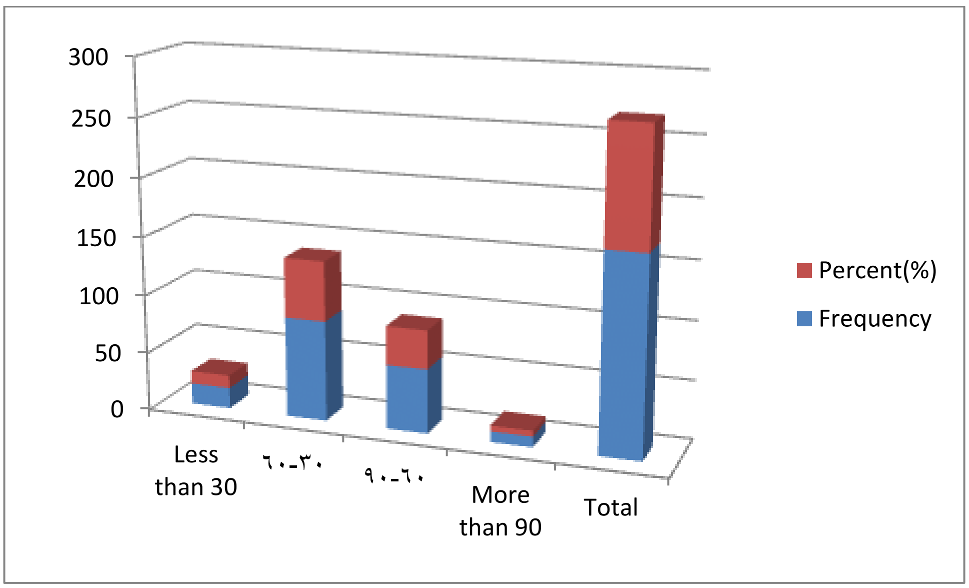


Figure 4.2: Distribution of technical efficiency for sesame producers

Source: Filed Survey, Season 2019/ 20

Figure (4.2) Frequency distributions of technical efficiency for sesame producer's showed technical efficiency ranging from 51 present between 30- 90, and less than 30 show 11 present. The frequency distribution of the efficiency estimates obtained from the stochastic frontier for sesame farms (figure 4.2) shows that 51 percent of the farms operate with efficiency ranging between (30and 90) and 51 percent of them operate with efficiency ranging. This implies that on average, the sesame farms producing sorghum in Habiella scheme farms achieved almost 51 percent of the potential stochastic frontier sorghum production level given their current level of production inputs and technology used.

4.3.15 Inefficiency Model of Sesame production

Table (4.15), present ML estimates of presents ML estimates of sesame and producers stochastic inefficiency, the estimated δ coefficients associated with explanatory variables in the model for inefficiency effects for the Habiella

Agricultural scheme farmers. Most of the estimated δ coefficients of the stochastic frontier model for all farmers' models have expected signs.

Experience Z_1: The experience years of producers in Habiella scheme season 2019/20, showed positive sign and insignificance of the variable by comparing the realized of experience and inefficiency. Relationship between year of experience and the output of the sesame crop was negative, and this means that the increase in years of experience leads to a decrease in the efficiency of the sesame crop.

Level of education Z_2: The coefficient years of education had positive signs and insignificant for sesame crop producer in the area study. Negatively significant parameter of education level means that technical inefficiency decrease with increase in the education operators. This is normal result, which means education adds to producer's knowledge and indicators of their awareness and their abilities of taking decisions on how and what to produce and adopting new technologies (Rahman, 2002). Therefore education, awareness and knowledge reduce the inefficiency, which was the same result obtained by Ahmed (2015).

Extension services Z_3: The extension services have negative sign and insignificant for sesame crop producer in the area study. Extension services has not important effect on productivity and output of the individual as it affects the mental and physical abilities, Safa,(2019. Negatively Significant parameter of extension services means that technical inefficiency decrees with the increase of extension serves of producers due to accumulated extension services and knowledge, this result ensures the justification of extension serves coefficient result.

Finance Z_4: The finance coefficient positive sign and significantly difference from zero at 1 percent level of significance for sesame crop, parameter of level finance means that technical inefficiency decrease with the increase in finance of farm operators. Variable showed that direct relationship between finance level and the output of the sesame crop. This is a normal result which means finance add farmers knowledge and indicators of their awareness and their abilities of taking decision on how and what to produce, approaching credit allotting their available resources and adopting new agricultural technologies Rahman, (2002). Therefore finance and knowledge reduce the inefficiency. Level finance has positive effect on crop sesame production in the Habiella agricultural scheme.

Years of the project Z_5: Years of project showed the significance in study area with negative sign and also negative significant for sesame crop farms. Years of the project negative effect on productivity and output of the individual as it. Negatively significant parameter of years of the project means that technical inefficiency decreases with the increase of years of the project of producers due to accumulated experience and knowledge. That means negative relationships between years of the project and output productivity for sesame to lead technical inefficiency.

Rain amount and distribution Z_6: the coefficients rain amount and distribution had positive signs and insignificant level of significance for sesame crop farmers. A negative significant parameter of rain amount and distribution of farms means that the technical inefficiency effects decrease with increase in rain amount and distribution. That means negative relationships between the rain amount and distribution and technical inefficiency for sesame crop in study area.

4.3.16 Return to Scale sesame production

The return to scale relationship between input and output could be seen from the sum of the regression coefficients (elasticity's). It is assumed that the sum of elasticity's of one, the return to the scale is constant, if the sum is less than one; the return to scale is decreasing, and if the sum of elasticity's is greater than one indicates increasing return to scale. That means for equal proportion increase inputs, the response of sesame crop output is at equal production, the scale is constant, the response is less than proportional, the scale is decreasing, and the response is greater than proportional, the scale is increasing. The sum of efficiency coefficients (elasticity's) for sorghum size producer was 76.91. The scale relationship between input and output (return to scale) were in the range of increasing return to scale for all producer size categories. These result indicated that for 100% increase of input production, of sesame output would increase 7691%. The increasing return scale might be the result of economic of scale because of the factor of production may be efficient and more productive.

4.4 L linear programming model analysis

4.4.1 Linear programming model's technical input-output coefficients

Micro Soft Excel Solver was used to solve linear programming problems, linear programming models result shows that the cost of cultivating sorghum and sesame were 2487.53 SDG and 2767 SDG respectively, in Habiella agricultural scheme as shown (Table 4.17).

4.4.2 Optimal cropping pattern in study area

Result of the linear programming model, which was used to determine the optimal cropping pattern, the returns for sorghum and sesame where (2729 SDG, 4461 SDG) respectively in season 2019/20.

4.4.3 The Current and optimal returns under the agricultural practices and crops sequences sesame return was more than sorghum.

The result of linear programming showed that: the optimal cultivated area must be (0.75 and 1.25) fed sorghum, sesame respectively. Therefore the returns for sorghum and sesame are presented 2729 SDG and 4461 SDG, in table (4.17).

It is clear from table (4.17) that initial value was 7190 SDG but the optimal return was **7623** SDG increase was 433 SDG, as shown in the Table (4.17) below.

4.4.4 Semi mechanized

Table (4.17): Semi mechanized (traditional)

		Sorghum	Sesame			
	Returns/fed	2729	4461			7190
	Changing(area)	0.75	1.25			
						RHS
	seeds cost/SDG/fed	71	234	345.75	<=	305
	land preparation	173	179	353.5	<=	352
	Ploughing	178	186	366	<=	364
	Planting	192	186	376.5	<=	378
	Planting	16.53	20	37.3975	<=	36.53
	First weeding	205	205	410	<=	410
	Second weeding	37	26	60.25	<=	63
	Pesticides	44	29	69.25	<=	73
	Gasoline	55	55	110	<=	110
	Oils and refineries	37	35	71.5	<=	72
	Labor	125	140	268.75	<=	265
	machine cost	23	24	47.25	<=	47
	cutting &collecting	739	834	1596.75	<=	1573
	Harvesting	163	201	373.5	<=	364
	Transportation	79	70	146.75	<=	149
	food for labor	150	145	293.75	<=	295

	Sacks	75	63	135	<=	138
	Machines maintenance	30	30	60	<=	60
	Storage	12	13	25.25	<=	25
	Others	83	92	177.25	<=	175
	Total	**2487.53**	**2767**			**5254.53**
max z	**7623**					

Source: Filed Survey, Season 2019/ 20

4.4.5 Results of the sensitivity analysis for Sorghum and sesame crops used zero tillage solvers

The result of the linear programming model, which was used zero tillage solver analysis, decreased the cost of some input and increased other. Increased returns of both crops (Sorghum 7728 SDG, and sesame 19680 SDG) and also increased the area of Sorghum 0.91(fed) and decreased the area of sesame 1.02(fed), and the total return was 27285.33182 SDG, as explained in table (4.18) below.

4.4.6 Zero tillage

Table (4.18): zero tillage

		Sorghum	Sesame			RHS
	Returns/fed	7728	19680			
	Changing	0.910899	1.028755			
labor	seeds/ cost/SDG/fed	71	220	291	<=	291
	land preparation	170	179	339	<=	349
	Ploughing	180	186	355.3103	<=	366
	Planting	250	300	536.3513	<=	550
	Chemical Pesticides	200	200	387.9308	<=	400
	Second weeding	100	100	193.9654	<=	200
	Pesticides	344	300	621.9758	<=	644
	Gasoline	55	55	106.681	<=	110
	Oils and refineries	100	100	193.9654	<=	200
	machine cost	100	100	193.9654	<=	200
	cutting &collecting	770	1000	1730.147	<=	1770
land/fed	Harvesting	160	200	351.4949	<=	360

capital	Transportation	100	150	245.4032	<=	250
	Sacks	150	160	301.2357	<=	310
	Machines maintenance	100	100	193.9654	<=	200
	Storage	50	50	96.98271	<=	100
	Others	100	100	193.9654	<=	200
max z	**27285.33182**					

Source: Filed Survey, Season 2019/ 20

4.4.7 Results of the sensitivity analysis of Sorghum and sesame crops using full mechanized technique

The result of the linear programming model, which was used full mechanized technique solver analysis, result of study decreased the cost of some inputs and increased the others inputs and increases return both crops Sorghum 9660 SDG and sesame 26560 SDG and increase area of Sorghum 0.91(fed) and decries area of sesame 1.02(fed), and total return was 36123.03 SDG, is clear in the table (4.19) below.

4.4.8 Full mechanized technique

Table (4.19) full mechanized technique

		Sorghum	Sesame			RHS
	Returns/feddan	9660	26560			
	Changing	0.910899	1.028755			
labor	seeds cost/SDG/fed	71	220	291	<=	291
	land predation	170	179	339	<=	339
	Plugging	200	186	373.5282	<=	386
	Planting	250	300	536.3513	<=	550
	Chemical Pesticides	100	100	193.9654	<=	200
	Second weeding	100	100	193.9654	<=	200
	Pesticides	150	150	387.9308	<=	400
	Gasoline	100	155	147.6714	<=	155
	Oils and refineries	200	100	285.0553	<=	300
	machine cost	450	300	672.9861	<=	700
	cutting &collecting	770	1000	1730.147	<=	1770
land/ fed	Harvesting	160	200	351.4949	<=	360
capital	Transportation	100	150	245.4032	<=	250

	Sacks	129	160	282.1068	<=	289
	machine maintenance	300	200	479.0207	<=	500
	Storage	50	50	96.98271	<=	100
	Others	100	100	193.9654	<=	200
max z	**36123.03**					

Source: Filed Survey, Season 2019/ 20

Table: 4.20 the reruns (SDG/ fed) of farmers and optimal cropping pattern of the using different scenarios in study area

Crop	Optimal semi mechanized		adoption zero tillage		adoption full mechanized technique	
	Area	Returns	Area	returns	Area	returns
Sorghum	0.75	7623	0.91	27285.33182	0.91	36123.03
Sesame	1.25		1.02		1.02	
Total	2		1.93		1.93	
Increase from actual farmers returns	6%		258%		374%	

Source: Filed Survey, Season 2019/ 20

4.4.9 Discussion of LP results

The results of the model in comparing the optimal situation, the table 4.20 above the information obtained from linear programming analysis includes the objective function value and the optimal return combination ratio was 6%, 258%, 374%, semi mechanized, adoption zero tillage and adoption full mechanized technique respectively. The study found the scenario adoption full mechanized technique is the optimal scenario.

4.4.10 Main problems and constrains of production and productivity of sorghum and sesame crops in stud area season 2019/ 20 using the zero tillage and full mechanized technique

Although the production of sorghum and sesame crops using zero tillage and full mechanized technique increased the production and productivity, profitability, improved the level of farmers' income and local income, but it has several problems, constrains and obstacles which are explained as follows :-

- There is low adoption of Zero tillage and full mechanized technique in the study area.

- In advantage of farming equipment and tools provision to farmers in Habeilla agricultural scheme.
- The costs of zero tillage and full mechanized technique were very high compared to the normal cultivation, for fear of season failure and loss.
- Rain-fed seasonal farming has some disadvantage from study area because they can spray today and the same day he rain can fall and wash away pesticide and the famer can face high risk.
- Lack of agricultural machineries and plows with the required scientific specifications in the region or study area.
- Risk when using agricultural machinery and plows due to the lack of mobile workshops and skilled labor in the Habeilla scheme.
- The increase in the costs of renting machinery and purchasing pesticides, as well as renting in the middle of the season, which he farmer expects to be futile.

CHAPTER FIVE

Summary, Conclusions and Recommendations

5.1 Summary

This study was conducted in Habiella locality in south kordofan state. The main Objective of the study is to estimate the economic efficiency of Sorghum and sesame corps production in Habiella scheme, south Kordofan sate, more specifically were to: Describe the Scio-economic characteristics of sorghum and sesame producers. Estimate the profitability of the two crops production in the study area. Determine the farmer’s technical efficiency of producing sorghum and sesame in the study area; also investigate the main factors behind technical inefficiency in producing sorghum and sesame in study area, and determine the optimum crop combination that maximizes farmers’ returns. Both primary and secondary data were used for the study purposes. Primary data were collected through structured questionnaire using sampling techniques. A sample of 191 producers was selected during 2019-2020; in Habiella Scheme community. Secondary data were collected from different relevant sources, to achieve the Objective of study a verity of analytical techniques were applied, tabular as well as general descriptive statistics, a gross margin analysis (farming Budget), and Stochastic Frontier production function and linear programming model .

5.2 Summary of the main results

The descriptive statistics of Scio-economic characteristics showed that the Most of the producers in Habiella Scheme (season, 2019/20) were males, which represent 99.5% and just only one, were female who represent about 0.5%.

Average age of the sampled producers was 48 years; within active age of (30-75). Most of producers (80.1%) have attained some sort of education. This means that about 52.3% producers received good education. The average family member working in farms was found to be two persons. Average experience in farms work of range about 10-20 years. The stochastic frontier production function analysis revealed that mean economic efficiency of producer was 0.43% and 0.06% for sorghum and sesame farms, respectively. Mean technical efficiency of producer was 0.99% and 0.54% for sorghum and sesame farms, respectively. Analysis of the determinates of technical efficiency indicated that herd Seed, Gasoline, Labor, Pesticide and Total of area sorghum were significant variables for improving technical efficiency. Experience, education Level, Extension services, Finance, Age of project, Rain and the range distribution, Area affected by livestock/fed were significant in explaining technical efficiency in Habiella Agricultural Scheme farms (season, 2019/20). The result of the optimal plan were compared with plan, it is clear that most of the sesame crop farmers best than sorghum crop farmers. Crops Yield / kg/ fed 148.3kg and 54.4 kg sorghum and sesame respectively. The profitability analysis result Crops production sorghum and sesame 230.52 SDG and 1703.94 SDG respectively in Habiella Scheme. The record showed the highest profit in Habiella Scheme sesame crop than sorghum.

5.3 Conclusions

The study concluded that, most farmers (producers) in Habiella Agricultural Scheme agricultural (season, 2019/20), was in the active age group, and also has attained some sort of education. The average family size of the sample producers was 8 and had good experience in sorghum and sesame crops farms. The producers' socio-economic characteristics had positive effect on technical efficiency of producers and negative effect on in technical efficiency in Habiella Agricultural Scheme farms. Mean technical efficiency of sorghum 0.99%, and economic efficiency of sorghum was 43%. Mean technical efficiency of sesame 54%**,** and economic efficiency was 6%. Also, the results revealed that sex, age, family size, number of working members, educational level, and farm experience, secondary economic activities, contract producer, were significant variables for improving technical efficiency.

The study showed that increase of sorghum and sesame crops expenditures had positive effects on production level of sorghum and sesame farms. The results of linear programming (LP) models revealed that the total return was 2729 SDG for sorghum and 4461 SDG for sesame farms. Result of the linear programming model, optimum net returns was 433 SDG, presented 6% in study area. Result of the linear programming model, which was used Zero tillage solver analysis Sorghum return was 7728 SDG, and sesame return was 19680SDG, and total return Sorghum and sesame was 27285.33182 SDG. The result of the linear programming model which was used full mechanized technique solver analysis, result of study increases return both crops Sorghum was 9660 SDG and sesame was 26560 SDG and total return was 36123.03 SDG.

Main problems and constrains in study area using the zero tillage and full mechanized technique:

- In advantage of farming equipment and tools provision to farmers in Habeilla agricultural scheme.
- Lack of agricultural machineries and plows with the required scientific specifications in the region or study area.
- Risk when using agricultural machinery and plows due to the lack of mobile workshops and skilled labor in the Habeilla scheme.
- The increase in the costs of renting machinery and purchasing pesticides, as well as renting in the middle of the season, which the farmer expects to be futile.

Recommendations:

- ➢ The activation some government policies in agriculture flowing an increase production and productivity.
- ➢ Provide input of output (production) at the time the appropriate the region.
- ➢ To follow the packets technical recommended.
- ➢ The establishment of market stock market local by locality Habiella.
- ➢ The establishment of stores specifications required for the region in the study area.
- ➢ Availability information marketing the region and link markets large neighboring.
- ➢ Availability of industries manufacturing micro- and macro-, the proliferation of the culture of the value-added or value change in the region.
- ➢ Raise the current level of efficiency of producers.
- ➢ Rugged roads and streets and lack of security in the production area.
- ➢ The peak period labour could be solved by mechanization of Agricultural operations.
- ➢ Adoption of the recommended improved technologies will increase farmers' income.
- ➢ The exception services in the Habiella Agricultural scheme should be over hauled and progressed. This is with the aim of enlisting the confidence of the tenants on usefulness of exception information.

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APPENDIXIES (1)

بسم الله الرحمن الرحيم

جامعة السودان للعلوم والتكنولوجيا

كلية الدراسات العليا والبحث العلمي

إستبانة لدراسة بعنوان: الكفاءة الاقتصادية لمحصولي الذرة والسمسم في مشروع هبيلا الزراعي - بولاية جنوب كردفان

تنويه: المعلومات المطلوبة تستخدم في الأغراض العلمية فقط

(أ) البيانات الشخصية الإجتماعية:-

1- النوع: (1) ذكر ☐ (2) انثى ☐

2- العمر: (1)................... سنة

3- عدد أفراد الاسرة: (.....) القصر ☐ قيد الدراسة ☐ العمالة ☐ المسنين والمرضى ☐

4- عدد سنوات التعليم: (1) .... سنة

(ب) الخصائص الإقتصادية:-

5- عدد سنوات الخبرة في مجال الزراعة:(.......)

6- المهنة (النشاط الإقتصادي) ومستوى الدخل بالجنيه السوداني في السنة

المهنة الاساسية	المهنة الثانوية	الدخل السنوي من الزراعة	الدخل السنوي من غير الزراعة

7- هل تمتلك ثروة حيوانية:(1) نعم ☐ (2)لا ☐

كم يبلغ الدخل منها في الموسم ....

8- هل تمتلك آلة زراعية: (1) نعم ☐ (2) لا ☐

9- نوع الآلة .... هل تؤجر اللآله (1) نعم ☐ (2) لا ☐

10- اذا كان الاجابة بنعم كم يبلغ الدخل منها في الموسم .... جنيه

11- كم مرة اتلقيت الخدمات الارشادية في الموسم ....

(ج) العمليات الزراعية

12- موقع القطاع بالمشروع: (1) هبيلا القديمة ☐ (2) هبيلا الموجه ☐ (3) كرتالا الخاص ☐ (4) كرتالا الموجه ☐ (5) الصفيفير ☐ (6) شمال هبيلا ☐

13- عمر المشروع الانتاجي (كم سنة وانت تستغله) .... سنة

14- حجم الحيازة .... فدان

15- نوع الحيازة المزروعة: (1) إيجار ☐ (2) شراكة ☐ (3) أخرى حدد....... ☐

16- اجمالي المساحة المزروعة في هذا الموسم بالفدان ....

17- مساحة المحاصيل المزروعة أدناه في هذا الموسم بالفدان

المحصول	المساحة المزروعة/ الفدان	الانتاج /جوال/ قنطار	الانتاجية /جوال/ قنطار
الذرة			
السمسم			

18- هل استخدمت التقاوي المحسنة لمحصول الذرة بمزرعتك في الموسم الاخير: (1) نعم ☐
(2) لا ☐

19- هل استخدمت التقاوي المحسنة لمحصول السمسم بمزرعتك في الموسم الاخير:(1) نعم ☐
(2)لا ☐

20- ما هو مصدر تقاوي الذرة التي زرعتها في الموسم الاخير:(1) من مخزونك الخاص ☐
(2) السوق ☐ (3) المنظمات ☐ (4) وزارة الزراعة ☐

21- ما هو مصدر تقاوي السمسم التي زرعتها في الموسم الاخير: (1) من مخزونك الخاص ☐
(2) السوق ☐ (3) المنظمات ☐ (4) وزارة الزراعة ☐

22- تاريخ الزراعة، كمية التقاوي وتاريخ الحصاد

المحصول	تاريخ الزراعة	كمية التقاوي/ فدان	تاريخ الحصاد
الذرة			
السمسم			

23- هل العمالة متوفرة اثناء الموسم: (1) نعم ☐ (2)لا ☐

24- كم كان عدد العمال في الموسم: ....

25- كم مرة قمت بنظافة (كديب) مزرعتك في الموسم الاخير: (1) مرة واحدة ☐ (2) مرتين ☐
(3) ثلاث مرات ☐

26- هل تعرضت مزرعتك لإصابة بالآفات أو التلف من قبل الماشية: (1) نعم ☐ (2) لا ☐

27- هل تعرضت مزرعتك للاصابة (بمرض ،الآفة) اوالتلف وكم تبلغ المساحة المتأثرة

المحصول	المرض أو الآفة	التلف بالماشية	المساحة المتأثرة
الذرة			
السمسم			

28- هل استخدمت الاسمدة والمبيدات في مزرعتك في الموسم الاخير:
(1) نعم ☐ (2)لا ☐

29- ما مدى استخدامك الدورة الزراعية في مزرعتك (1) جيد ☐ (2) وسط ☐
(3)لا استخدم ☐

30- ماهي كمية الامطار ومدى توزيعها (1)جيد ☐ (2) متوسط ☐ (3)ضعيف ☐

(د)التمويل

31- ما هو مصدر تمويلك في الموسم الاخير: (1) ذاتي ☐ (2) البنك ☐ (3) تاجر ☐
(4) اخرى حدد.......... ☐

32- كم من المبلغ التي تم تمويلك به من البنك الزراعي في الموسم الاخير..................

33- صيغة التمويل: ....

34- هل كان زمن التمويل في فترة مناسبة: (1)نعم ☐ (2) لا ☐

35- التمويل الذي حظيت به من البنك كافي: (1) نعم ☐ (2) لا ☐

(و)العمليات التسويقية

36- كيف تم تخزين حصادك في الموسم الاخير: (1) تقليدي ☐ (2) المخزن ☐ (3) مخزن شبه حديث ☐

37- ما هو السوق الذي سوقت فيه محصولك في الموسم الاخير: (1) محلي ☐ (2) الابيض ☐ (3) الخرطوم ☐ (4) اخرى حدد .... ☐

38- ما هو الوقت المناسب بالشهرالذي قمت فيه ببيع محصولك في الموسم الاخير: (1) شهر (........)

39- كم كان متوسط سعر الجوال الواحد او القنطار لمحصولك في الموسم الاخير بالجنيه السوداني: (1) الذرة ....(2) السمسم..................

40- تكاليف الانتاج لمحصولي الذرة والسمسم بالجنيه السوداني/ فدان

الرقم	البيان	الذرة	السمسم
1	تحضير الارض		
2	الحراثة		
3	الزراعة		
4	الرقاعة		
5	الشلخ		
6	الكديب الاول		
7	الكديب الثاني		
8	التسميد		
9	المبيدات		
10	تكلفة الجازولين		
11	الزيوت و المصافي		
12	تكلفة العمالة		
13	تكلفة ايجارالالات الزراعية		
14	القطع والجمع		
15	الدرس (الدق) او الحت		
16	تكلفة الترحيل		
17	الاعاشة (الميز)		
18	الضرائب والجبايات		
19	تكلفة الجوالات		
20	صيانة الالة		
21	الزكاة		
22	التخزين		
23	اخرى		
الجملـــــــــــــــــــــــة			

41- العائد الكلي من الانتاج لمحصولي الذرة والسمسم بالجنيه السوداني

المحصول	المساحة المزروعة	الانتاج	العائد	التكاليف	الربح	الخسارة
الذرة						
السمسم						
اعلاف الذرة						

APPENDIXIES (2)

Output from the program FRONTIER (Version 4.1c)

Instruction file = terminal

data file = g:sorg.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a production function

The dependent variable is not logged

The ols estimates are:

	coefficient	standard-error	t-ratio
beta 0	-0.41068466E+05	0.20129700E+06	-0.20401927E+00
beta 1	0.13543640E+02	0.24042366E+02	0.56332391E+00
beta 2	-0.43252827E+02	0.14792695E+03	-0.29239315E+00
beta 3	0.82615362E+03	0.28256580E+04	0.29237565E+00
beta 4	0.88974441E+02	0.14569251E+03	0.61070018E+00
beta 5	0.23399778E+03	0.28943121E+03	0.80847461E+00

Sigma-squared 0.92242102E+10

log likelihood function = -0.22529576E+04

the estimates after the grid search were :

beta 0	-0.23954983E+05
beta 1	0.13543640E+02
beta 2	-0.43252827E+02
beta 3	0.82615362E+03
beta 4	0.88974441E+02
beta 5	0.23399778E+03
delta 0	0.00000000E+00
delta 1	0.00000000E+00
delta 2	0.00000000E+00
delta 3	0.00000000E+00
delta 4	0.00000000E+00
delta 5	0.00000000E+00
delta 6	0.00000000E+00
delta 7	0.00000000E+00
Sigma-squared	0.92008229E+10
gamma	0.50000000E-01

iteration = 0 func evals = 20 llf = -0.22533688E+04
-0.23954983E+05 0.13543640E+02-0.43252827E+02 0.82615362E+03
0.88974441E+02
0.23399778E+03 0.00000000E+00 0.00000000E+00 0.00000000E+00
0.00000000E+00
0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
0.92008229E+10
0.50000000E-01
gradient step
iteration = 5 func evals = 93 llf = -0.22530214E+04
-0.23955026E+05 0.24457931E+02-0.44097460E+02 0.82307216E+03
0.85914257E+02
0.23154946E+03 0.91821943E-02-0.50442697E+00 0.25228070E+00
0.64010990E-03
0.24515064E-04-0.19033387E-01 0.10669237E-01 0.19871823E-01
0.92008229E+10
0.39745706E-01
iteration = 10 func evals = 225 llf = -0.22529250E+04
-0.23955146E+05 0.26962046E+02-0.49022277E+02 0.81464096E+03
0.77550946E+02
0.22465465E+03 0.36014644E-01-0.15042870E+01 0.91316158E+00
0.53045820E-02
0.24898668E-04 0.45866672E-01 0.40952050E-01 0.70764999E-01
0.92008229E+10
0.37889050E-01
iteration = 15 func evals = 354 llf = -0.22527638E+04
-0.23955612E+05 0.33298083E+02-0.68582993E+02 0.78169800E+03
0.44890598E+02
0.19769150E+03 0.14103480E+00-0.53689073E+01 0.34931844E+01
0.23890974E-01
0.30209460E-04 0.31327217E+00 0.15938083E+00 0.26919744E+00
0.92008229E+10
0.15296052E-01
iteration = 20 func evals = 480 llf = -0.22527435E+04

-0.23955700E+05 0.35087623E+02-0.72163756E+02 0.77544005E+03
0.38803501E+02
0.19259752E+03 0.16100728E+00-0.61335474E+01 0.39935062E+01
0.27407493E-01
0.27945163E-04 0.35930148E+00 0.18195785E+00 0.30733406E+00
0.92008229E+10
0.13826146E-01
iteration = 25 func evals = 542 llf = -0.22525727E+04
-0.23957080E+05 0.27841738E+02-0.53631760E+02 0.67908211E+03
0.59597137E+02
0.13874424E+03 0.57443346E+00-0.36516643E+02 0.20875327E+02
0.14521568E+00
0.27128552E-04-0.33784325E+00 0.67849546E+00 0.12823762E+01
0.92008229E+10
0.60898035E-06
the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	-0.23957080E+05	0.12077364E+01	-0.19836349E+05
beta 1	0.27841738E+02	0.35323291E+02	0.78819773E+00
beta 2	-0.53631760E+02	0.35433761E+02	-0.15135780E+01
beta 3	0.67908211E+03	0.48004862E+02	0.14146111E+02
beta 4	0.59597137E+02	0.60622566E+02	0.98308503E+00
beta 5	0.13874424E+03	0.41738596E+02	0.33241233E+01
delta 0	0.57443346E+00	0.10101345E+01	0.56867027E+00
delta 1	-0.36516643E+02	0.46600597E+01	-0.78360891E+01
delta 2	0.20875327E+02	0.32280493E+01	0.64668551E+01
delta 3	0.14521568E+00	0.10002188E+01	0.14518392E+00
delta 4	0.27128552E-04	0.30454558E-04	0.89078790E+00
delta 5	-0.33784325E+00	0.11175363E+01	-0.30231077E+00
delta 6	0.67849546E+00	0.10125251E+01	0.67010236E+00
delta 7	0.12823762E+01	0.10325948E+01	0.12418968E+01
sigma-squared	0.92008229E+10	0.10000000E+01	0.92008229E+10
gamma	0.60898035E-06	0.17286943E-04	0.35227765E-01

log likelihood function = -0.22525727E+04
LR test of the one-sided error = 0.76979589E+00

with number of restrictions = 9
[note that this statistic has a mixed chi-square distribution]
number of iterations = 25
(maximum number of iterations set at : 100)
number of cross-sections = 175
number of time periods = 1
total number of observations = 175
thus there are: 0 obsns not in the panel
covariance matrix :
0.14586271E+01 -0.19218676E+02 0.23245020E+02 0.32502661E+02
0.39938359E+02
0.28181825E+02 -0.96336468E-01 0.27057777E+01 -0.19454520E+01 -
0.13050066E-01
-0.94867711E-05 -0.31661288E+00 -0.10692621E+00 -0.17173178E+00 -
0.93332395E-07
0.81160046E-05
-0.19218676E+02 0.12477349E+04 -0.10163727E+04 -0.13631996E+04 -
0.17994785E+04
-0.12057672E+04 0.39155624E+01 -0.98802201E+02 0.72248490E+02
0.43924294E+00
0.70434231E-03 0.13192966E+02 0.43225938E+01 0.68535645E+01
0.18219018E-05
-0.36501235E-03
0.23245020E+02 -0.10163727E+04 0.12555514E+04 0.16485962E+04
0.21439770E+04
0.14547895E+04 -0.47838563E+01 0.11816251E+03 -0.89322989E+02 -
0.59717330E+00
-0.31629192E-03 -0.17524995E+02 -0.52769646E+01 -0.83219775E+01 -
0.49190269E-05
0.49223822E-03
0.32502661E+02 -0.13631996E+04 0.16485962E+04 0.23044668E+04
0.28324155E+04
0.19976699E+04 -0.68256379E+01 0.19144564E+03 -0.13771832E+03 -
0.92372730E+00

-0.67013959E-03 -0.22460989E+02 -0.75754076E+01 -0.12164212E+02 -
0.66148380E-05
0.57645991E-03
0.39938359E+02 -0.17994785E+04 0.21439770E+04 0.28324155E+04
0.36750955E+04
0.24970076E+04 -0.82247789E+01 0.20530224E+03 -0.15428023E+03 -
0.10254555E+01
-0.62495755E-03 -0.29760319E+02 -0.90767990E+01 -0.14337303E+02 -
0.81096161E-05
0.83071312E-03
0.28181825E+02 -0.12057672E+04 0.14547895E+04 0.19976699E+04
0.24970076E+04
0.17421104E+04 -0.58838951E+01 0.15960259E+03 -0.11623420E+03 -
0.77792582E+00
-0.53570012E-03 -0.19944682E+02 -0.65192229E+01 -0.10417280E+02 -
0.57451493E-05
0.52622600E-03
-0.96336468E-01 0.39155624E+01 -0.47838563E+01 -0.68256379E+01 -
0.82247789E+01
-0.58838951E+01 0.10203717E+01 -0.59359445E+00 0.42129016E+00
0.28350989E-02
0.21423477E-05 0.64714436E-01 0.22654492E-01 0.36584805E-01
0.20035372E-07
-0.16187684E-05
0.27057777E+01 -0.98802201E+02 0.11816251E+03 0.19144564E+03
0.20530224E+03
0.15960259E+03 -0.59359445E+00 0.21716157E+02 -0.13823296E+02 -
0.93663652E-01
-0.93017011E-04 -0.15098502E+01 -0.66702932E+00 -0.11093873E+01 -
0.52385083E-06
0.27713921E-04
-0.19454520E+01 0.72248490E+02 -0.89322989E+02 -0.13771832E+03 -
0.15428023E+03
-0.11623420E+03 0.42129016E+00 -0.13823296E+02 0.10420303E+02
0.63867693E-01

0.56314882E-04 0.11721667E+01 0.47163299E+00 0.77614143E+00
0.39887904E-06
-0.24918400E-04
-0.13050066E-01 0.43924294E+00 -0.59717330E+00 -0.92372730E+00 -
0.10254555E+01
-0.77792582E+00 0.28350989E-02 -0.93663652E-01 0.63867693E-01
0.10004376E+01
0.33940090E-06 0.79140338E-02 0.31752594E-02 0.52295720E-02
0.29497359E-08
-0.17135726E-06
-0.94867711E-05 0.70434231E-03 -0.31629192E-03 -0.67013959E-03 -
0.62495755E-03
-0.53570012E-03 0.21423477E-05 -0.93017011E-04 0.56314882E-04
0.33940090E-06
0.92748013E-09 0.25081609E-05 0.24433903E-05 0.42515690E-05 -
0.60709212E-12
0.25840979E-10
-0.31661288E+00 0.13192966E+02 -0.17524995E+02 -0.22460989E+02 -
0.29760319E+02
-0.19944682E+02 0.64714436E-01 -0.15098502E+01 0.11721667E+01
0.79140338E-02
0.25081609E-05 0.12488873E+01 0.71207578E-01 0.11141806E+00
0.75005677E-07
-0.73481749E-05
-0.10692621E+00 0.43225938E+01 -0.52769646E+01 -0.75754076E+01 -
0.90767990E+01
-0.65192229E+01 0.22654492E-01 -0.66702932E+00 0.47163299E+00
0.31752594E-02
0.24433903E-05 0.71207578E-01 0.10252071E+01 0.40772096E-01
0.22159113E-07
-0.17611103E-05
-0.17173178E+00 0.68535645E+01 -0.83219775E+01 -0.12164212E+02 -
0.14337303E+02
-0.10417280E+02 0.36584805E-01 -0.11093873E+01 0.77614143E+00
0.52295720E-02

0.42515690E-05 0.11141806E+00 0.40772096E-01 0.10662520E+01
0.35151635E-07
-0.26585245E-05
-0.93332395E-07 0.18219018E-05 -0.49190269E-05 -0.66148380E-05 -
0.81096161E-05
-0.57451493E-05 0.20035372E-07 -0.52385083E-06 0.39887904E-06
0.29497359E-08
-0.60709212E-12 0.75005677E-07 0.22159113E-07 0.35151635E-07
0.10000000E+01
-0.35509566E-11
0.81160046E-05 -0.36501235E-03 0.49223822E-03 0.57645991E-03
0.83071312E-03
0.52622600E-03 -0.16187684E-05 0.27713921E-04 -0.24918400E-04 -
0.17135726E-06
0.25840979E-10 -0.73481749E-05 -0.17611103E-05 -0.26585245E-05 -
0.35509566E-11
0.29883839E-09

Technical efficiency estimates:

firm	year	eff.-est.
1	1	0.10000000E+01
2	1	0.99820841E+00
3	1	0.99934197E+00
4	1	0.99934487E+00
5	1	0.99962471E+00
6	1	0.99961699E+00
7	1	0.99979496E+00
8	1	0.99973198E+00
9	1	0.99947532E+00
10	1	0.99977722E+00
11	1	0.10000000E+01
12	1	0.10000000E+01
13	1	0.10000000E+01
14	1	0.10000000E+01
15	1	0.10000000E+01
16	1	0.99831278E+00

17	1	0.10000000E+01
18	1	0.99893939E+00
19	1	0.10000000E+01
20	1	0.99885157E+00
21	1	0.99931077E+00
22	1	0.99815508E+00
23	1	0.99973580E+00
24	1	0.10000000E+01
25	1	0.10000000E+01
26	1	0.10000000E+01
27	1	0.99958868E+00
28	1	0.99965994E+00
29	1	0.10000000E+01
30	1	0.99974582E+00
31	1	0.99848714E+00
32	1	0.98890043E+00
33	1	0.99974127E+00
34	1	0.10000000E+01
35	1	0.10000000E+01
36	1	0.10000000E+01
37	1	0.10000000E+01
38	1	0.10000000E+01
39	1	0.99806711E+00
40	1	0.99972699E+00
41	1	0.99971853E+00
42	1	0.10000000E+01
43	1	0.10000000E+01
44	1	0.99233106E+00
45	1	0.10000000E+01
46	1	0.99950440E+00
47	1	0.99957463E+00
48	1	0.99864251E+00
49	1	0.10000000E+01
50	1	0.10000000E+01
51	1	0.10000000E+01

52	1	0.10000000E+01
53	1	0.99655818E+00
54	1	0.99834631E+00
55	1	0.99960132E+00
56	1	0.99738916E+00
57	1	0.99964482E+00
58	1	0.99919326E+00
59	1	0.99928730E+00
60	1	0.99969561E+00
61	1	0.99963183E+00
62	1	0.99972873E+00
63	1	0.10000000E+01
64	1	0.10000000E+01
65	1	0.99951159E+00
66	1	0.69693318E+00
67	1	0.10000000E+01
68	1	0.10000000E+01
69	1	0.99953196E+00
70	1	0.10000000E+01
71	1	0.10000000E+01
72	1	0.99980837E+00
73	1	0.99774604E+00
74	1	0.10000000E+01
75	1	0.99704185E+00
76	1	0.10000000E+01
77	1	0.99958360E+00
78	1	0.99973786E+00
79	1	0.99972414E+00
80	1	0.10000000E+01
81	1	0.99985058E+00
82	1	0.10000000E+01
83	1	0.99974618E+00
84	1	0.10000000E+01
85	1	0.99974712E+00
86	1	0.99951931E+00

87	1	0.99977104E+00
88	1	0.99976970E+00
89	1	0.10000000E+01
90	1	0.10000000E+01
91	1	0.99965915E+00
92	1	0.10000000E+01
93	1	0.99958640E+00
94	1	0.99546237E+00
95	1	0.99972861E+00
96	1	0.10000000E+01
97	1	0.99971716E+00
98	1	0.10000000E+01
99	1	0.99937804E+00
100	1	0.99970472E+00
101	1	0.99955153E+00
102	1	0.10000000E+01
103	1	0.10000000E+01
104	1	0.10000000E+01
105	1	0.10000000E+01
106	1	0.10000000E+01
107	1	0.10000000E+01
108	1	0.10000000E+01
109	1	0.10000000E+01
110	1	0.10000000E+01
111	1	0.99960198E+00
112	1	0.99958646E+00
113	1	-0.56014171E-01
114	1	0.10000000E+01
115	1	0.10000000E+01
116	1	0.99975178E+00
117	1	0.99815915E+00
118	1	0.99976678E+00
119	1	0.10000000E+01
120	1	0.10000000E+01
121	1	0.99957987E+00

122	1	0.99929488E+00
123	1	0.99977831E+00
124	1	0.99793822E+00
125	1	0.10000000E+01
126	1	0.99962973E+00
127	1	0.99947458E+00
128	1	0.10000000E+01
129	1	0.99928490E+00
130	1	0.99974991E+00
131	1	0.99880741E+00
132	1	0.99972602E+00
133	1	0.10000000E+01
134	1	0.99962303E+00
135	1	0.99896958E+00
136	1	0.99918906E+00
137	1	0.10000000E+01
138	1	0.99955132E+00
139	1	0.99940066E+00
140	1	0.99880870E+00
141	1	0.99860055E+00
142	1	0.10000000E+01
143	1	0.99972086E+00
144	1	0.10000000E+01
145	1	0.99937279E+00
146	1	0.99954887E+00
147	1	0.10000000E+01
148	1	0.99916893E+00
149	1	0.99971297E+00
150	1	0.99923976E+00
151	1	0.99966562E+00
152	1	0.99946813E+00
153	1	0.99961188E+00
154	1	0.10000000E+01
155	1	0.10000000E+01
156	1	0.99965614E+00

157	1	0.99277713E+00
158	1	0.99972851E+00
159	1	0.99524834E+00
160	1	0.99940791E+00
161	1	0.99963399E+00
162	1	0.99958146E+00
163	1	0.10000000E+01
164	1	0.99890725E+00
165	1	0.99911441E+00
166	1	0.99875262E+00
167	1	0.99928667E+00
168	1	0.99945245E+00
169	1	0.99385838E+00
170	1	0.99873190E+00
171	1	0.10000000E+01
172	1	0.10000000E+01
173	1	0.99912419E+00
174	1	0.99976348E+00
175	1	0.10000000E+01

Mean efficiency = 0.99159195E+00

APPENDIXIES (3)

Output from the program FRONTIER (Version 4.1c)
instruction file = terminal
data file = g:sesm.txt
Tech. Eff. Effects Frontier (see B&C 1993)
The model is a production function
The dependent variable is not logged
the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	-0.25484625E+04	0.74670527E+04	-0.34129430E+00
beta 1	0.32365644E+02	0.37413159E+01	0.86508717E+01
beta 2	0.32036225E+02	0.55266144E+01	0.57967180E+01
beta 3	0.72726522E+01	0.31857719E+02	0.22828540E+00
beta 4	-0.67371911E+01	0.62581737E+01	-0.10765427E+01
beta 5	0.43451457E+01	0.11906915E+02	0.36492623E+00
sigma-squared	0.24966775E+0		

log likelihood function = -0.16661035E+04
the estimates after the grid search were :

beta 0	0.90318552E+03
beta 1	0.32365644E+02
beta 2	0.32036225E+02
beta 3	0.72726522E+01
beta 4	-0.67371911E+01
beta 5	0.43451457E+01
delta 0	0.00000000E+00
delta 1	0.00000000E+00
delta 2	0.00000000E+00
delta 3	0.00000000E+00
delta 4	0.00000000E+00
delta 5	0.00000000E+00
delta 6	0.00000000E+00
delta 7	0.00000000E+00
sigma-squared	0.35988979E+08
gamma	0.52000000E+00

iteration = 0 func evals = 20 llf = -0.16651186E+04
0.90318552E+03 0.32365644E+02 0.32036225E+02 0.72726522E+01-0.67371911E+01
0.43451457E+01 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.35988979E+08
0.52000000E+00
gradient step
iteration = 5 func evals = 92 llf = -0.16618006E+04
0.90317731E+03 0.37989631E+02 0.33743225E+02 0.54841206E+01-0.69469624E+01
0.39944417E+01 0.73216094E-03 0.16114401E+00-0.83879584E-01-0.74313014E-02
0.30938131E-05 0.28571846E-01 0.23439241E-02-0.61172568E-02 0.35988979E+08
0.61636235E+00
iteration = 10 func evals = 204 llf = -0.16607988E+04
0.90317013E+03 0.43316642E+02 0.28329528E+02 0.44318977E+01-0.77771086E+01
0.39445798E+01 0.32947240E-02 0.92878717E+00-0.39000519E+00-0.43823420E-01
0.36744918E-05 0.19787124E+00 0.12381937E-01-0.42116339E-01 0.35988979E+08
0.70514668E+00
iteration = 15 func evals = 333 llf = -0.16604142E+04
0.90303333E+03 0.42734407E+02 0.29477477E+02 0.55859477E+01-0.69560914E+01
0.65568967E+01 0.26567490E+00 0.45102140E+02-0.15093437E+02-0.23743014E+01
0.37539047E-05 0.12472149E+02 0.75289316E+00-0.21714101E+01 0.35988979E+08
0.71845710E+00
iteration = 20 func evals = 469 llf = -0.16602587E+04

0.90299601E+03 0.43827847E+02 0.28620237E+02 0.52684771E+01-0.75666952E+01
0.68546808E+01 0.33045584E+00 0.56184591E+02-0.18807500E+02-0.29617613E+01
0.34275904E-05 0.15528052E+02 0.93847774E+00-0.27102585E+01 0.35988979E+08
0.73529744E+00
iteration = 25 func evals = 593 llf = -0.16602078E+04
0.90297283E+03 0.43766725E+02 0.28618207E+02 0.61248548E+01-0.72145497E+01
0.38114200E+01 0.34083548E+00 0.62109529E+02-0.21253503E+02-0.33673816E+01
0.33833228E-05 0.16847075E+02 0.10376835E+01-0.31331338E+01 0.35988979E+08
0.73150179E+00
iteration = 30 func evals = 742 llf = -0.16600743E+04
0.90204722E+03 0.43653777E+02 0.28516413E+02 0.51965629E+01-0.73915020E+01
0.34342567E+01-0.25365640E+01 0.76458721E+02-0.83582185E+02-0.15082292E+02
0.34803386E-05-0.18942496E+02 0.10166145E+01-0.20218254E+02 0.35988979E+08
0.72412979E+00
iteration = 35 func evals = 871 llf = -0.16600560E+04
0.90212670E+03 0.43144137E+02 0.28882611E+02 0.53890928E+01-0.71459248E+01
0.33561460E+01-0.23169218E+01 0.73630358E+02-0.78032235E+02-0.14061414E+02
0.34549480E-05-0.16551405E+02 0.99104152E+00-0.18778158E+02 0.35988979E+08
0.71353115E+00
iteration = 40 func evals = 1012 llf = -0.16600231E+04
0.90017224E+03 0.43382536E+02 0.28626424E+02 0.53862197E+01-0.76138432E+01

0.33990617E+01-0.46867288E+01 0.85950156E+02-0.69304630E+02-0.32179983E+02
0.33230967E-05-0.44798055E+02 0.40387279E+01-0.48213388E+02 0.35988979E+08
0.71140846E+00
iteration =   45 func evals =   1161 llf = -0.16599851E+04
0.89708537E+03 0.43225074E+02 0.28861241E+02 0.53847884E+01-0.69748407E+01
0.32490513E+01-0.83376558E+01 0.10530702E+03-0.52300527E+02-0.60645930E+02
0.33460435E-05-0.88158982E+02 0.89303183E+01-0.94543673E+02 0.35988979E+08
0.71609696E+00
iteration =   50 func evals =   1298 llf = -0.16599766E+04
0.89766469E+03 0.43087064E+02 0.29047820E+02 0.54727065E+01-0.68836235E+01
0.33229003E+01-0.74907477E+01 0.10229899E+03-0.50365895E+02-0.55071175E+02
0.34282479E-05-0.77664691E+02 0.81523723E+01-0.85583551E+02 0.35988979E+08
0.71572630E+00
iteration =   55 func evals =   1439 llf = -0.16597856E+04
0.87962347E+03 0.44198571E+02 0.28411115E+02 0.61722281E+01-0.69353317E+01
0.33349690E+01-0.27323947E+02 0.11728776E+03-0.13602759E+01-0.21575608E+03
0.32969498E-05-0.61530873E+02 0.37859561E+02-0.34933314E+03 0.35988979E+08
0.74580257E+00
iteration =   60 func evals =   1590 llf = -0.16597537E+04
0.87208517E+03 0.44662724E+02 0.27682644E+02 0.61688878E+01-0.63938530E+01
0.13466264E+01-0.36473130E+02 0.12577969E+03-0.19215807E+01-0.28430538E+03

0.35659167E-05-0.80571775E+02 0.49529375E+02-0.46122691E+03
0.35988979E+08
0.75172723E+00
iteration = 65 func evals = 1736 llf = -0.16597134E+04
0.86505919E+03 0.44197181E+02 0.28067644E+02 0.63683007E+01-
0.62374104E+01
0.14586369E+01-0.44803659E+02 0.14218774E+03 0.33794521E+01-
0.34820606E+03
0.36850234E-05-0.10171150E+03 0.60598957E+02-0.56541548E+03
0.35988979E+08
0.74414032E+00
iteration = 70 func evals = 1891 llf = -0.16594770E+04
0.83416462E+03 0.42908085E+02 0.29804529E+02 0.65449189E+01-
0.68678003E+01
0.46062915E+01-0.80541971E+02 0.15710338E+03 0.18564105E+02-
0.62573232E+03
0.36366956E-05-0.69449546E+02 0.10989990E+03-0.10197124E+04
0.35988979E+08
0.73607457E+00
iteration = 75 func evals = 2035 llf = -0.16594520E+04
0.82681597E+03 0.43265987E+02 0.29556402E+02 0.67072603E+01-
0.70213417E+01
0.44589616E+01-0.88937925E+02 0.15350703E+03 0.17643333E+02-
0.69134875E+03
0.36008013E-05-0.41633304E+02 0.12170834E+03-0.11272560E+04
0.35988979E+08
0.75262280E+00
iteration = 80 func evals = 2182 llf = -0.16593241E+04
0.82371021E+03 0.43151289E+02 0.29590432E+02 0.60813234E+01-
0.66929280E+01
0.45941231E+01-0.93047685E+02 0.16069904E+03 0.34251738E+02-
0.72014863E+03
0.37290136E-05-0.10166147E+03 0.12619717E+03-0.11744882E+04
0.35988979E+08
0.73854751E+00

iteration =   85 func evals =   2329 llf = -0.16592409E+04
0.80573728E+03 0.44950260E+02 0.28390786E+02 0.52149678E+01-0.55069551E+01
0.51032919E+01-0.11352062E+03 0.15574708E+03 0.74073717E+02-0.88048955E+03
0.38577343E-05-0.99184042E+02 0.15508180E+03-0.14380981E+04 0.35988980E+08
0.75342795E+00
iteration =   90 func evals =   2477 llf = -0.16589748E+04
0.77906182E+03 0.43832054E+02 0.28709543E+02 0.56367959E+01-0.50893335E+01
0.33370970E+01-0.14475970E+03 0.12335226E+03 0.87542627E+02-0.11189588E+04
0.37151424E-05-0.53863638E+02 0.19717612E+03-0.18299533E+04 0.35988980E+08
0.72638270E+00
iteration =   95 func evals =   2625 llf = -0.16588473E+04
0.77696978E+03 0.44498923E+02 0.28596715E+02 0.56986392E+01-0.60613210E+01
0.41761687E+01-0.14690388E+03 0.14061570E+03 0.88647751E+02-0.11379732E+04
0.34867134E-05-0.50322037E+02 0.20081485E+03-0.18605386E+04 0.35988980E+08
0.74786154E+00
maximum number of iterations reached
iteration =   100 func evals =   2767 llf = -0.16588380E+04
0.77509703E+03 0.44556640E+02 0.28541908E+02 0.57108563E+01-0.60314987E+01
0.41352048E+01-0.14909543E+03 0.14300929E+03 0.88938365E+02-0.11548930E+04
0.34790539E-05-0.50614188E+02 0.20378691E+03-0.18881658E+04 0.35988980E+08
0.74972797E+00
the final mle estimates are :
coefficient   standard-error   t-ratio

beta 0	0.77509703E+03	0.81685041E+02	0.94888491E+01
beta 1	0.44556640E+02	0.45590423E+01	0.97732456E+01
beta 2	0.28541908E+02	0.50388953E+01	0.56643186E+01
beta 3	0.57108563E+01	0.33542362E+01	0.17025803E+01
beta 4	-0.60314987E+01	0.56921777E+01	-0.10596118E+01
beta 5	0.41352048E+01	0.10343751E+02	0.39977807E+00
delta 0	-0.14909543E+03	0.94641181E+02	-0.15753758E+01
delta 1	0.14300929E+03	0.90959466E+02	0.15722310E+01
delta 2	0.88938365E+02	0.11993297E+03	0.74156729E+00
delta 3	-0.11548930E+04	0.73371640E+03	-0.15740319E+01
delta 4	0.34790539E-05	0.13217740E-05	0.26321094E+01
delta 5	-0.50614188E+02	0.16706971E+03	-0.30295252E+00
delta 6	0.20378691E+03	0.13019130E+03	0.15652882E+01
delta 7	-0.18881658E+04	0.12022239E+04	-0.15705608E+01
sigma-squared	0.35988980E+08	0.10564875E+01	0.34064748E+08
gamma	0.74972797E+00	0.68929105E-01	0.10876798E+02

log likelihood function = -0.16588381E+

LR test of the one-sided error = 0.14530849E+02

with number of restrictions = 9

[note that this statistic has a mixed chi-square distribution]

number of iterations = 100

(maximum number of iterations set at : 100)

number of cross-sections = 168

number of time periods = 1

total number of observations = 168

thus there are: 0 obsns not in the panel

covariance matrix :

0.66724459E+04 -0.49364237E+02 0.64381311E+01 -0.13636249E+02 -0.59870320E+02

-0.26028450E+02 0.77278353E+04 -0.31521407E+04 -0.79539451E+04 0.59927285E+05

-0.38938290E-05 0.12678251E+04 -0.10632660E+05 0.98195092E+05 -0.27838646E+02

-0.10623799E+01

-0.49364237E+02 0.20784866E+02 -0.17161278E+02 -0.42803688E+01 -
0.42193404E+00
-0.32194978E+01 -0.56096777E+02 -0.40750072E+02 0.51153904E+02 -
0.43936060E+03
0.18337153E-05 0.12542861E+03 0.79441360E+02 -0.72184833E+03
0.20526091E+00
0.18755751E+00
0.64381311E+01 -0.17161278E+02 0.25390466E+02 0.73264110E+00 -
0.14440468E+01
0.14806589E+01 0.61528435E+01 0.60329293E+02 -0.31025235E+02
0.53465299E+02
-0.81075891E-06 -0.10112719E+03 -0.11227702E+02 0.90234734E+02 -
0.26219688E-01
-0.11704735E+00
-0.13636249E+02 -0.42803688E+01 0.73264110E+00 0.11250900E+02 -
0.17512630E+01
-0.22925328E+02 -0.14747798E+02 0.24042926E+02 -0.23793702E+02 -
0.12204947E+03
-0.13323059E-05 0.11619499E+03 0.22879420E+02 -0.19862619E+03
0.57165589E-01
-0.17196204E-01
-0.59870320E+02 -0.42193404E+00 -0.14440468E+01 -0.17512630E+01
0.32400887E+02
-0.11912593E+02 -0.71491738E+02 0.57916697E+02 0.95615836E+01 -
0.54217841E+03
-0.25238855E-06 -0.81898775E+02 0.93641816E+02 -0.88589208E+03
0.25010336E+00
-0.80299014E-02
-0.26028450E+02 -0.32194978E+01 0.14806589E+01 -0.22925328E+02 -
0.11912593E+02
0.10699319E+03 -0.29837573E+02 -0.53457140E+02 0.21757543E+02 -
0.23020118E+03
-0.97883610E-06 0.89624841E+02 0.41271951E+02 -0.37941183E+03
0.10771802E+00
0.50378725E-02

0.77278353E+04 -0.56096777E+02 0.61528435E+01 -0.14747798E+02 -
0.71491738E+02
-0.29837573E+02 0.89569532E+04 -0.37595533E+04 -0.91284841E+04
0.69427359E+05
-0.54207820E-05 0.17314599E+04 -0.12312721E+05 0.11375568E+06 -
0.32247785E+02
-0.12205350E+01
-0.31521407E+04 -0.40750072E+02 0.60329293E+02 0.24042926E+02
0.57916697E+02
-0.53457140E+02 -0.37595533E+04 0.82736245E+04 0.17207823E+04 -
0.28737840E+05
-0.16366334E-04 -0.11028696E+05 0.49502124E+04 -0.46804283E+05
0.13213541E+02
-0.20217841E+00
-0.79539451E+04 0.51153904E+02 -0.31025235E+02 -0.23793702E+02
0.95615836E+01
0.21757543E+02 -0.91284841E+04 0.17207823E+04 0.14383916E+05 -
0.71227871E+05
-0.23775083E-04 -0.17179912E+04 0.12740631E+05 -0.11689550E+06
0.33170956E+02
0.20535094E+00
0.59927285E+05 -0.43936060E+03 0.53465299E+02 -0.12204947E+03 -
0.54217841E+03
-0.23020118E+03 0.69427359E+05 -0.28737840E+05 -0.71227871E+05
0.53833976E+06
-0.35682509E-04 0.12165000E+05 -0.95501294E+05 0.88208593E+06 -
0.25006877E+03
-0.95063502E+01
-0.38938290E-05 0.18337153E-05 -0.81075891E-06 -0.13323059E-05 -
0.25238855E-06
-0.97883610E-06 -0.54207820E-05 -0.16366334E-04 -0.23775083E-04 -
0.35682509E-04
0.17470866E-11 0.15249464E-05 0.53530516E-05 -0.58371041E-04
0.16101513E-07
0.10658954E-07

0.12678251E+04 0.12542861E+03 -0.10112719E+03 0.11619499E+03 -
0.81898775E+02
0.89624841E+02 0.17314599E+04 -0.11028696E+05 -0.17179912E+04
0.12165000E+05
0.15249464E-05 0.27912287E+05 -0.18164463E+04 0.19557712E+05 -
0.53855771E+01
0.26174127E+01
-0.10632660E+05 0.79441360E+02 -0.11227702E+02 0.22879420E+02
0.93641816E+02
0.41271951E+02 -0.12312721E+05 0.49502124E+04 0.12740631E+05 -
0.95501294E+05
0.53530516E-05 -0.18164463E+04 0.16949774E+05 -0.15648986E+06
0.44367309E+02
0.17017312E+01
0.98195092E+05 -0.72184833E+03 0.90234734E+02 -0.19862619E+03 -
0.88589208E+03
-0.37941183E+03 0.11375568E+06 -0.46804283E+05 -0.11689550E+06
0.88208593E+06
-0.58371041E-04 0.19557712E+05 -0.15648986E+06 0.14453423E+07 -
0.40975280E+03
-0.15574583E+02
-0.27838646E+02 0.20526091E+00 -0.26219688E-01 0.57165589E-01
0.25010336E+00
0.10771802E+00 -0.32247785E+02 0.13213541E+02 0.33170956E+02 -
0.25006877E+03
0.16101513E-07 -0.53855771E+01 0.44367309E+02 -0.40975280E+03
0.11161658E+01
0.44251173E-02
-0.10623799E+01 0.18755751E+00 -0.11704735E+00 -0.17196204E-01 -
0.80299014E-02
0.50378725E-02 -0.12205350E+01 -0.20217841E+00 0.20535094E+00 -
0.95063502E+01
0.10658954E-07 0.26174127E+01 0.17017312E+01 -0.15574583E+02
0.44251173E-02
0.47512215E-02

Technical efficiency estimates:

firm	year	eff.-est.
1	1	0.59501890E+00
2	1	0.75019727E+00
3	1	0.87811736E+00
4	1	0.54767212E+00
5	1	0.32332431E+00
6	1	0.69849682E+00
7	1	0.89474096E+00
8	1	0.33498566E+00
9	1	0.56965158E+00
10	1	0.82000755E+00
11	1	0.49704558E+00
12	1	0.42963871E+00
13	1	0.27701178E+00
14	1	0.52060116E+00
15	1	-0.47816593E-01
16	1	0.47931452E+00
17	1	0.24481544E+00
18	1	0.65190376E+00
19	1	0.59850341E+00
20	1	0.30652657E+00
21	1	0.37037773E+00
22	1	0.28004758E+00
23	1	0.28171923E+00
24	1	0.38876760E+00
25	1	0.88006110E+00
26	1	0.85449933E+00
27	1	0.83581486E+00
28	1	0.88381364E+00
29	1	0.86570825E+00
30	1	0.87761374E+00
31	1	0.89683613E+00
32	1	0.60050893E+00
33	1	0.45351723E+00

34	1	0.74452569E+00
35	1	0.48206512E+00
36	1	0.43673264E+00
37	1	0.63841599E+00
38	1	0.35085449E+00
39	1	0.43945064E+00
40	1	0.63164293E+00
41	1	0.37917994E+00
42	1	0.63174023E+00
43	1	0.42859098E+00
44	1	0.52628173E+00
45	1	0.70192390E+00
46	1	0.54970074E+00
47	1	0.42232336E+00
48	1	0.31426716E+00
49	1	0.54664900E+00
50	1	0.91671222E+00
51	1	0.34766703E+00
52	1	0.56946837E+00
53	1	0.55227762E+00
54	1	0.90833320E+00
55	1	0.68633181E+00
56	1	0.34985414E+00
57	1	0.55905253E+00
58	1	0.63133022E+00
59	1	0.62541217E+00
60	1	0.86960914E+00
61	1	0.57299090E+00
62	1	0.76170995E+00
63	1	0.60453919E+00
64	1	0.55074191E+00
65	1	0.83096106E+00
66	1	0.75346990E+00
67	1	0.15338147E+00
68	1	0.97662722E+00

69	1	0.97291821E+00
70	1	0.91571990E+00
71	1	0.68944345E+00
72	1	0.91684795E+00
73	1	0.76864589E+00
74	1	0.24725657E+00
75	1	0.89843363E+00
76	1	0.44309832E+00
77	1	0.58288710E+00
78	1	0.79760176E+00
79	1	0.91281901E+00
80	1	0.63409498E+00
81	1	0.33693788E+00
82	1	0.55347385E+00
83	1	0.71941344E+00
84	1	0.33077010E+00
85	1	0.63277143E+00
86	1	0.51191902E+00
87	1	0.60875130E+00
88	1	0.35163001E+00
89	1	0.45907908E+00
90	1	0.92519322E+00
91	1	0.51292453E+00
92	1	0.69474388E+00
93	1	0.60490984E+00
94	1	0.39937614E+00
95	1	0.61785544E+00
96	1	0.30481698E+00
97	1	0.40953364E+00
98	1	0.51212058E+00
99	1	0.57095590E+00
100	1	0.65659015E+00
101	1	0.32484916E+00
102	1	0.74861054E+00
103	1	0.84449299E+00

104	1	0.31258108E+00
105	1	0.50136855E+00
106	1	0.49167150E+00
107	1	0.41121727E+00
108	1	0.53385550E+00
109	1	0.38640608E+00
110	1	0.54066707E+00
111	1	0.52601789E+00
112	1	0.35980290E+00
113	1	0.55382834E+00
114	1	0.74997260E+00
115	1	0.91726371E+00
116	1	0.47181593E+00
117	1	0.83267649E+00
118	1	0.71464268E+00
119	1	0.56015035E+00
120	1	0.83811693E+00
121	1	0.68285671E+00
122	1	0.41614811E+00
123	1	0.17247852E+00
124	1	0.58046811E+00
125	1	0.55915267E+00
126	1	0.42138233E+00
127	1	0.13661485E+00
128	1	0.12534744E+00
129	1	0.32655550E+00
130	1	0.23181142E+00
131	1	0.31402844E+00
132	1	0.64961177E+00
133	1	0.56175105E+00
134	1	0.48198884E+00
135	1	0.51897829E+00
136	1	0.35249096E+00
137	1	0.47175066E+00
138	1	0.72219890E+00

139	1	0.44046412E+00
140	1	0.78346687E+00
141	1	0.64424063E+00
142	1	0.37266882E+00
143	1	0.84162743E+00
144	1	0.33595423E+00
145	1	0.77308820E+00
146	1	0.28452475E+00
147	1	0.30056157E+00
148	1	0.22623261E+00
149	1	0.36897528E+00
150	1	0.23306931E+00
151	1	0.30936718E+00
152	1	0.47728291E+00
153	1	0.22114361E+00
154	1	0.27946749E+00
155	1	0.40798491E+00
156	1	0.27283690E+00
157	1	0.32408071E+00
158	1	0.42756827E+00
159	1	0.40572325E+00
160	1	0.16426472E+00
161	1	0.56292213E+00
162	1	0.24898774E+00
163	1	0.35242777E+00
164	1	0.72682691E+00
165	1	0.42277627E+00
166	1	0.35168006E+00
167	1	0.66658224E+00
168	1	0.64263099E+00

Mean efficiency = 0.54162167E+00