In the name of ALLA the most beneficial and merciful

Sudan University of Science and Technology

College of Graduate Studies

Department of Agricultural Economics

Economic Analysis of the Competitiveness and Cropping Pattern of Small-Scale Farms in the Rain-Fed Sector of Gadarif State - Sudan

التحليل الاقتصادي لمعرفة القدرة التنافسية والتركيب المحصولي للمزارع –صغيرة الحجم في القطاع المطري– بولاية القضارف– السودان

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Approval Page

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الآية

﴿ ٱلَّذِى جَعَلَ لَكُمُ ٱلْأَرْضَ مَهْدًا وَسَلَكَ لَكُمْ فِيهَا سُبُلًا وَأَنزَلَ مِنَ ٱلسَّمَآءِ مَآءً فَأَخْرَجْنَا بِهِۦٓ أَزْوَٰجًا مِّن نَّبَاتٍ شَتَّىٰ ﴾

صدق الله العظيم

سورة طه، الآية: (٥٣)

DEDICATION

THIS WORK IS DEDICATED TO:

My lovely parents

May Allah prolong their life and bless them, Amen.

My dear sisters

Who never stopped encouraging me

My lovely daughter ***Najat*** *...May Allah save her.*

All my friends everywhere,

I offer this work.

Nuha

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Abstract

This study aimed to study the socioeconomic characteristics of small-scale farm' house hold head in the rain-fed sector of Gadarif State, investigate the social profitability and competitiveness of the main crops grown in the state and determine the optimal cropping sequence. Both primary and secondary data were used in the study. Multistage random sampling technique was used to collect primary data on small-scale farms from three villages of the state by means of questionnaire, during 2012/2013 season. Secondary data were collected from Central Bureau of Statistics and Federal Ministry of Agriculture. Descriptive statistics, F-test, Policy Analysis Matrix (PAM), and linear programming technique were used to achieve the stated objectives. The results revealed that, yields and net returns of small-scale farms was so poor, even though the majority of farmers were in the active age group, married with reasonable family members, has long agricultural experience and somehow large farm size.

Results of the policy analysis matrix showed that, government intervention for improving the profitability and competitiveness of the main crops grown in Gadarif state (sesame, groundnuts, sorghum and millet) is still short of optimum. Despite the fact that all crops were financially and socially profitable and has high comparative advantages under the current policy measures. Farmers producing sorghum, sesame and millet were taxed in domestic-inputs. The situation was worse for the socially profitable groundnut-crop, which taxed in domestic inputs, out-put transfer and total transfer. These policy discouraged female-farmers, the main producers of groundnuts in the state, from continuing cultivating this crop. However, it is worth mentioning here that, sorghum, sesame and millet were supported by the government in terms of tradable inputs and revenue transfer, even though, small scale farmers confirms they

receive nothing. Sensitivity analyses proved that sesame was a competitive crop and have a substantial profitability and comparative advantages. Other crops, sorghum millet and groundnuts revealed slight profitability and comparatives advantages under the current policy situations, agricultural practices and environmental conditions.

On the other hand, results of the linear programming technique revealed that the current cultural practices and crop sequence, in which sorghum do not come after sesame, was not the optimal one. Food-crops (sorghum and millet) did not enter the optimal cropping pattern under the current sequences and policy measures, with sesame dominated the total land. The crop sequence of groundnuts, sesame, sorghum and millet proved to be the optimal cropping pattern that improves farmer's returns. Under such sequence, the four crops entered the optimum plan and farmer's returns exceed the current situation by 181.94%, but if full technical packages were adopted, farmers' returns doubled three times. The study stresses the importance of microfinance and provision of subsidies to small-scale farms in rain-fed sector particularly groundnuts to improve their competitiveness and profitability. Subsidies might be in the forms of long lease of the land with cheaper prices, subsidized inputs and output. Both microfinance and subsidy program should be linked with extension program to ensure that small-scale farms adopt the recommended crop sequence and recommended technical packages.

ملخص الدراسة

هدفت هذه الدراسة لدراسة الخصائص الاجتماعية والاقتصادية لرب الأسرة في المزارع صغيرة الحجم الموجودة في القطاع المطري بولاية القضارف، وتحليل الربحية الاجتماعية والقدرة التنافسية للمحاصيل الرئيسة المزروعة في الولاية بالإضافة لتحديد أمثل تعاقب محصولي. استُخدمت كل من البيانات الأولية والثانوية في هذه الدراسة، حيث تم استخدام أسلوب العينة العشوائية متعددة المراحل لجمع البيانات عن المزارع صغيرة الحجم من ثلاثة قري بولاية القضارف عن طريق الاستبانة لموسم ٢٠١٣/٢٠١٢. كما تم جمع البيانات الثانوية من الجهاز المركزي للإحصاء ووزارة الزراعة الاتحادية. تم استخدام أسلوب الإحصاء الوصفي واختبار (F) ومصفوفة تحليل السياسات (PAM) والبرمجة الخطية للوصول للأهداف المذكورة. أظهرت النتائج أن إنتاجية وعائدات المزارع صغيرة الحجم ضعيفة جداً بالرغم من أن الغالبية العظمي من المزار عين في العمر الإنتاجي النشط ومتزوجون ولديهم عدد معقول من أفراد الأسرة ولديهم خبرة زراعية طويلة ومزارع نوعاً ما كبيرة الحجم.

أظهرت نتائج مصفوفة تحليل السياسات (PAM) أن تدخل الحكومة لتحسين الإنتاجية والتنافسية لأهم المحاصيل المزروعة في ولاية القضارف (الذرة– الدخن– السمسم– الفول السوداني) كان غير أمثل، بالرغم من حقيقة أن كافة المحاصيل المزروعة كانت مربحة اجتماعياً وماليا ً، ولديها ميزة تنافسية عالية في ظل السياسات الحالية. فقد فرضت ضرائب المدخلات المحلية على المزارعين منتجي الذرة والسمسم والدخن، وكان الوضع أسوأ بالنسبة لمحصول الفول السوداني ذو الربحية الاجتماعية الذي فرضت عليه ضريبة المدخلات المحلية وضريبة تحويلات الإنتاج والضريبة الكلية للتحويلات، وقد ثبطت هذه السياسة المزارعات،أكبر منتجي الفول السوداني في الولاية، من مواصلة زراعة هذا المحصول. تجدر الإشارة هنا إلى أن الذرة والسمسم والدخن قد تلقوا دعماً من الحكومة في المدخلات القابلة للمتاجرة وتحويلات العائدات إلا أن صغار المزارعين ينفون ذلك. أثبت تحليل الحساسية أن السمسم محصول منافس ولديهربحية وميزة تنافسية عالية، بينما أظهرت المحاصيل الأخرى المتمثلة في الذرة و الدخن والفول السوداني ربحية وميزة تنافسية هشة في ظل السياسات والعمليات الفلاحية والظروف المناخية الحالية.

من جهة ثانية فقد أظهرت نتائج تحليل البرمجة الخطية أن العمليات الفلاحية والتعاقب المحصولي الحالي الذي لا تأتي الذرة فيه بعد السمسم لم يكن الأمثل، فلم تدخل المحاصيل الغذائية (الذرة والدخن) التركيبة المحصولية المثلي في ظل التعاقب المحصولي والسياسات المتبعة، بينما ساد السمسم كافة الأرض الزراعية. أثبت التعاقب المحصولي الذي تأتي فيه الذرة بعد السمسم بأنه أفضل نمط محصولي يعظم عائدات المزارع، وقد دخلت الأربعة محاصيل

التركيبة المحصولية المثلي في ظل التعاقب وزاد عائد المزارع بنسبة ١٨١.٩٤%، ولكنه عند تطبيق كافة الحزم التقنية فإن عائدات المزارع ستضاعف ثلاثة مرات. أكدت الدراسة على أهمية التمويل الأصغر وتقديم الدعم للمزارع صغيرة الحجم في القطاع المطري، خاصة محصول الفول السوداني، لتحسين التنافسية والربحية، ويمكن توفير الدعم في شكل الإيجارات طويلة المدى وبأسعار رمزية للأراضي الزراعية ودعم مدخلات الإنتاج. كما يجب ربط التمويل الأصغر وبرنامج الدعم ببرامج الإرشاد الزراعي للتأكد من أن المزارع صغيرة الحجم قد تبنت التعاقب المحصولي الأمثل والحزم التقنية الموصي بها.

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Introduction

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Introduction

1.1 Agricultural sector of Sudan

Agricultural is the backbone of Sudan economy, the second largest country in Africa (1.88 million km^2) (Ministry of Information, 2011), contributing substantially to the Gross National Product (31.6%) (Central Bureau of Statistics, 2009) and 93% of nonoil export revenue (FAO, 2011), employing the majority of the country's workforce (50.6%) (Central Bureau of Statistics, 2009), and providing raw materials for other sectors. Further, this sector plays a significant role in the Sudan's foreign trade. Moreover, it provides income, employment, food and farm energy. The main agricultural exportable products are cotton, gum Arabic, livestock, meat, cereals mainly sorghum, oilseeds (sesame and groundnuts), and others.

The agricultural sector of the Sudan is divided into three farming systems: irrigated (1.6 million ha), mechanized rain-fed and traditional rain-fed systems (18.8million ha) (Arab Organization for Agricultural Development, 2012). The estimated area under the three systems is approximately 17 million hectares constituting about 20% of the potential agricultural lands (Mustafa, 2006). The rain-fed sector which is confined mainly to central Sudan occupied the largest area (six million ha) but produces the least productivity. The annual rainfall rarely exceeds 700 mm and is limited to four months (July-October). The average annual rainfall, which varies in both frequency and quantity, is estimated at 400-700mm. The main crops produced in rain-fed sub-sector are sorghum and sesame. Sorghum, in the rain-fed subsector of the Sudan, occupied about 85% of the total cultivated area and contributes about 65% of the total sorghum production in the country. In fact, this crop is considered as one of the main

food crop in the country. Sesame came second in terms of land (10%) and contributes about 53% of the total sesame production. In addition, considerable areas are cultivated with groundnuts, sunflower, cotton, and guar. The sub-sector accounts for about 18 percent of the crops contribution to the GDP (Ministry of Agriculture and Forestry, 2009). Regardless of the largest area occupied by this subsector, the general trends of its food crops production (2008-2011) reflect a diminishing pattern (Babiker, et al 2011).

The impact of diminishing production and productivity pattern of the semi-mechanized rain-fed sub-sector on the country economics situation is drastic. Huge amount of food crops has been imported (Central Bank of Sudan Reports 2009, 2012, 2013).Likewise, more than 46% of the country was food insecure lying below the poverty line, (Central Bureau of Statistics, 2009), and about 8% under severe poverty (Ministry of information, 2011). To overcome such problem, the government undertakes different policy measures to improve this sector. Among these policies were liberalization policy (1992), and agricultural Revival Program (2010-2014). The liberalization policy (Economic reform programs), changed the agricultural sector as well as the Sudanese economy from the an economy led by government decisions or central planning (public sector), to economy guided by market forces characterized by competition, in addition, to giving a greater role for the private sector to lead the development process. On the other hand, the Revival Program encourages researches and provides subsidies to rain-fed sector in order to improve the productivity.

1.2 Problem Statement

The problem of the study revolved around small-scale farms in the rain-fed sector of Gadarif state. Their poor yield and returns in one hand and the adoption of different governmental policy and research results to

improve their productivity, competitiveness, marketability and net returns on the other hand. Some of the government policy measures stresses the importance of the horizontal and vertical expansion of crops production, expansion of the cash crops areas on expenses of food crops mainly sorghum and provision of microfinance. It also encourages researches (technological improvement) to solve agricultural problems mainly to find the optimal cropping sequence.

Information on the different policy options and technological improvement (research results) on small-scale farms net returns and crops profitability (private and social) and competitiveness is important in decision making at macro and micro levels. In general, such information allows the formulation of appropriate policies and helps to understand and predict short and long run impacts of policies and technologies on production. Knowledge of such information is also important for understanding the dynamics of the producers. Further, it could be useful for government planning and structuring of programs and services, the distribution of which is based on production behavior and response to the changes in such options.

Analysis of the governmental policies on small-scale farms in the rain-fed sector has been limited. Accordingly, research on impact of government policies and research results (crop-rotation sequence) on the small-scale farms is of paramount importance for the formulation of useful recommendations and conclusions that will aid policy makers, planners and producers to greatly improve this sector and guarantee efficiency in both production and rational use of natural resources.

1.3 Objectives of the study

The main objective of this study is to examine the effect of alternative economic policies and technological improvements on small-scale farms'

returns productivity and competitiveness, in the rain-fed sector of Gadarif State, Sudan. More specifically are to:

- Study the socioeconomics characteristics of the farmers in the study area.
- Examine the social profitability and competitiveness of the main crops produced under the rain-fed area of Gadarif State.
- Determine the optimal cropping pattern of small-scale farms under different scenarios of policy measures.

1.4 Hypotheses

a. All crops produced under rain-fed sector of Gadarif state are of high social profitability and competitive and comparative advantages.
b. The introduce crop sequence in which sorghum come after sesame substantially improves small-scale farms returns.

1.5 Research methods and analytical techniques

1.5.1 Data collection

Both primary and secondary data were used to collect the required information, although primary field data from the basic source is the main data source. Farmers were interviewed by means of a structured questionnaire. Primary data on technical and economic aspects of different crops grown in Gadarif State and marketing were collected. These include, among others, agricultural practices for different crops grown in the study area, various factors of production and post-production costs, producer prices, technology levels, credit status and government incentives and supply. Secondary data on various types that serve the objectives of the study, including market prices and national production figures were collected from different institutional sources such as Ministry of Agriculture and Irrigation, Gadarif State Ministry of Agriculture and Forestry,

Agricultural Bank, Ministry of Finance and Economic Planning, the Central Bureau of Statistics and the Central Bank of Sudan.

Multistage random sampling technique were used to collect data from 175 respondents distributed in three villages [Kajara (57 respondents), Janan (61 respondents) and Kassab (57 respondents)] of rain-fall area in Gadarif state by means of questionnaire. A relatively large sample size of 175 respondents will be collected, even though homogenous population exists in the area.

1.5.2 Analytical techniques

In order to arrive at the stated objectives, a number of methodological approaches were employed, namely:

- Descriptive statistical methods were used to study the socioeconomic characteristics of the farmers in the study area.
- Policy analysis matrix (PAM) was used to examine both the competitiveness and social profitability of the main agricultural crops in the study area
- Linear programming model was used to examine the optimal cropping-sequence (optimal cropping pattern) based on different scenarios of technological improvement (Striga control, water harvesting) and policy measures (agricultural incentives and microfinance policies).

1.5.3 Study area

This study was conduct in rain-fed sector of Gadarif State, the granary of Sudan. This state has been chosen due to its strategic location and fundamental role it plays in the food security of the country. More than one fifth of the country total cultivated area (40 million acres) and 50% of the rain-fed crops are produced in Gadarif State. About 20-35%, over 50%, and about 10-15% of the total sorghum sesame and millet production in the

country (MOA Gadarif, 2010). The State is located in eastern Sudan between the longitudes 33.30 and 36.30 degrees East and latitude 12.40 - 12.40 degrees North, and covers an area of 71.62 thousand km2. The state extend from the plains of Butana in the west to the Ethiopian plateau in the east, and from the Atbara and Rahad Rivers in the south border to Kassala State in the north, Khartoum State in the north west, Gezira state in the west, Sennar State in the south. It also has international borders with Ethiopia and Eritrea. The climate of the state is characterized by semi-arid climate in the northern and north-west where the average rainfall varies between 500-1,000 ml/year during the period between July to October. The total population of the state is estimated at 1.14 million heads, with average an annual growth rate of 3.27 and average population density of less than 117 people/Km2, (Central Bureau of Statistics, 2009).

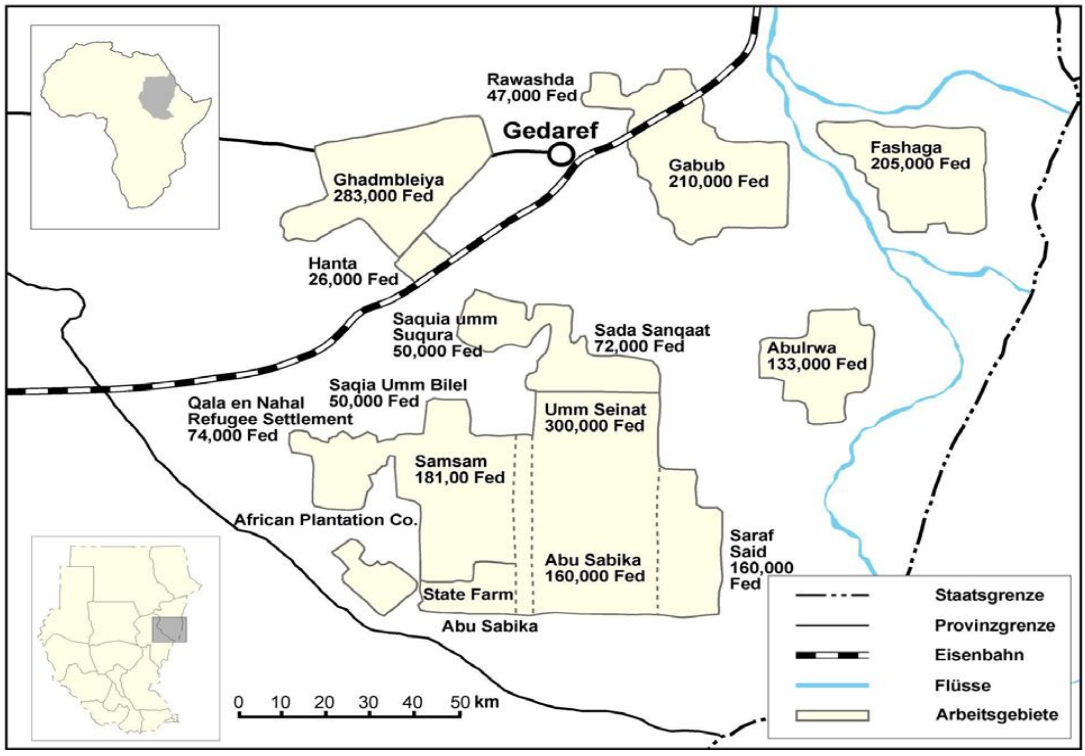

Figure 1.1: Gadarif Map

Source: Mustafa. R, 2006.

1.6 Organization of the Study

This Study is organized into five chapters. The first chapter is an introductory one it includes the problem statement, the research objectives, research methods and methodology. Chapter two reviews the literature related to the study. Chapter three is devoted to the analytical frameworks. Chapter four discusses the results of the study and chapter five is the summary, conclusions and recommendations.

Chapter Two

Literature Review

Chapter Two

Literature Review

This section is divided into three parts: 1) historical background related to the study and, 2) review of the Sudanese economy in general and the agricultural sector in particular, and 3) discuses different agricultural policies conducting in order to improve the performance of the Agricultural sector.

2.1 Part One: Historical Study

Welfare analysis methods in last view year regarded as one of the important economic analysis of agricultural policies, many different studies conducted on this field in both developed and developing countries used partial equilibrium analysis. So great research effort was done in order to find new criteria simple to measure, understand, and to be used in the analysis of the effect of agricultural policies on agricultural products. Hence, new method appears is the policy analysis matrix (PAM) which was developed by two scientists Monke and Pearson in 1989. Since the appearance of (PAM) many studies in different countries were conducted using this method. Glenn and Hamid (1999) studied the comparative economic advantage of alternative agricultural production options in Swaziland. They used many crops in their study: maize, cotton, sugar cane, pineapple, grapefruit, oranges and cabbage. Their PAM results revealed that, sugar cane, pineapple, grapefruit and cotton have high and stable competitiveness. It also revealed that, maize got limited intervention, groundnuts enjoyed net subsidy, cotton was highly taxed; and vegetables and oranges have restricted comparative advantage due to some variation in crop yields.

Shinde, (et al, 2015) formulated a LP model to determine the optimum cropping pattern for different farms in the command area of Kalwande, coastal belt of Maharashtra state, Konkan region, Ratnagiri. They concluded that rabi-paddy was not feasible in terms of water availability and benefits obtained. On the other hand, vegetable, and horticultural crops revealed good potentials to get maximum net returns. The optimal cropping pattern that maximizes farmer's net returns was found to be horticultural, vegetables and pulses.

Emam. A. and Bushara (2003) used PAM to investigate the competitiveness of the Sudanese lamb meat in Saudi Arabia Market during (1999-2003). Their findings revealed that Sudanese lamb-meat export were financially and economically profitable and has high comparative advantages in spite on the taxes imposed on its exports.

Abdul Azeem and Alfeel (2004) studied the competitiveness and profitability of local wheat in Gezira scheme (Sudan). They found that, Gezira scheme has high comparative advantages in producing wheat as an import substitute crop, despite, the high taxes imposed by the government.

Basem, Khaled, Ahmed and Saud (2005) used PAM in their study of the effect of agricultural policies on wheat production in Saudi Arabia. They recommended cultivating wheat on large-scale farm because it got high comparative advantage. Wheat production became more competitive in case of the reduction of social costs of both domestic resources and tradable inputs. They calculated the efficiency of the water resources consumption of wheat production in three categories area, it was found that the large area category saved huge amount of water, thus reducing social loss for wheat.

Noor and Javed (2005) studied the competitiveness and policy analysis of potato production under different agro-ecological zones of

northern areas of Sudan. Their PAM analysis revealed that, the study area has high comparative advantage in producing potato as import substitution only but not for export. They also concluded that, single cropping zone in the research area was more competitive than marginal double cropping and double cropping zones for import substitution. They used the nominal protection coefficient (NPC) to assess role of the policy on both import substitution and export promotion regimes. They concluded that the current sets of agricultural and macro-economic policies were consistent with competitiveness of potato production for import substitution, but not consistent for export promotion.

Elzaki et al. (2006) studied the comparative advantage and optimal cropping patterns of the main crops produced under the agricultural farming systems of Sudan. Results of the optimal plan of their linear programming technique revealed that, Food crops did not enter the optimal plans. They recommend that farmers should cultivate food-crops for self-sufficiency because it is cheaper to produce them locally than to import them. The PAM results showed that, food crops has high comparative advantages.

Ohajianya and Oguoma (2009) in their study about optimum cropping patterns under limited resource conditions: a micro-level study in Imo State, Nigeria found a high difference between the existing and optimum farm plans under limited and borrowed capital situations. Farmer's resources were not optimally allocated and after optimization, farm income and employment of labour was highly increased. Sensitivity analysis stresses the importance of maintain labour wages on a reasonable level without affecting farmer's income, and increasing the cultivated land.

Albert and Chuma (2010) used PAM to study the intensification of rice production systems in Southeastern Nigeria. Their results showed that,

rice production under various systems (upland, lowland and double rice cropping systems) and technologies were socially profitable and financially competitive. It also revealed that, a substantial tax was imposed on rice imports in Nigeria and the government investment in intensifying rice production had a positive effect on the output of local rice production.

Emam A and Musa (2011) used PAM to study of the competitiveness of sugar cane in Kenana Sugar Company (Sudan). They concluded that, sugar production was highly competitive. Their sensitivity analysis revealed that, sugar was highly sensitive to variations in yield, world price and exchange rate.

Linear Programming was applied in many studies on developing countries to determine the optimum cropping pattern, that is, to plan for the cropping system by involving more than one crop simultaneously during the same cropping period, (Mohamed& Said, 2011).

Tanko, L. and Babam, K. M. (2011) examined the resource use pattern for small-scale arable crop-based farmer son their study of molding efficient resource allocation patterns for arable crop farmers in Niger state– Nigeria. Their LP results revealed a substantial difference between the existing and optimum plans under both limited and borrowed capital situations. Cereal-legume cropping patterns dominated both the existing and optimum plans.

It is very clear from the mentioned literature that, there were many study conducted to assess the comparative advantages and determine the optimal cropping patterns for the main crops cultivated in the rain-fed sector of Sudan, but, none of them has taken in consideration the current policy measures and research results.

2.2 Part Two: Sudanese economy

Agriculture is the mainstay of the Sudanese economy. It provides nutrients necessary to meet the needs of the population. It is total contribution in the non-oil export revenue was 93%. Agriculture provides employment for more than 80 percent of the labor force in rural areas. The agricultural sector is usually divided into two: irrigated and rain-fed. The rain-fed sub-sector sub-divided into two further categories traditional and semi-mechanized. The rain-fed sector depends mainly on the rainfall, thus are usually subject to huge production fluctuations owing to variable rainfall. The semi-mechanized sub-sector, which is practiced by large-scale business enterprises, is historically a low-input: low-output system. The traditional system is conducted in smaller units by households using greater levels of labor input, and usually receive high returns in terms of yields/ha. On the other hand, the irrigated sector is made up of small and medium-scale mechanized, commercial farms on large-scale. The majority of the irrigated sector is based on gravity irrigation, but some schemes depend on privately owned pump. The irrigated subsector occupied an area of 1.7 million hectare and produces about 25% to 30% of domestic cereal production, on the other hand, the rain-fed sub-sector produces the remaining 70% of cereals from about 12 million hectare of rain-fed (CFSAM, 2011).

The traditional sector is subsistence farming comprised mostly of small family units of 10 to 50 ha. The semi-mechanized sector consists of numbers of big farmers and companies comprising accumulations of registered area of about 6.7 million ha. In the semi-mechanized sector farmers usually used the approaches of low-cost, soil-mining, combined with low-input. This approach leads to low yields of crops from the vast areas leased at very low rents from local authorities. The decision on the type of

the crop to be grown is based on the return on investment, prices and government incentives. Farmers in the traditional subsector pay much attention to good farming practices than the investors in the mechanized subsector with a wider use of crop rotation, more frequent and timely sowing, weeding, and higher sowing rates. These smaller farms regularly produce about 95 percent of the pearl millet, 38 percent of the sorghum, 67 percent of the groundnut and 38 percent of the sesame. The mechanized subsector usually provides 40 percent of sorghum and 62 percent of sesame. However, the mechanized sector showed a decline sorghum yield over the past ten years, the traditional subsector has recorded a rise in production. As might be expected from the above description, crop production in the rain-fed subsectors is characterized by high annual fluctuations owing to rainfall variation; whereas in the irrigated sector, production and productivity levels are reasonably stable (FAO, 2011).

The agricultural GDP grew remarkably from 24% in 2007 to 29% in 2010 with the average agricultural GDP growth amounted to about 9.2% in 2010. From this, one can conclude that, the accelerated GDP growth of the 2010 was mainly attributed to the high and relatively stable agricultural production. While a number of factors explained the noticeable increase of agricultural production, the most important of them was the weather.

The industrial sector has also contributed to the economic growth, its contribution in GDP declined from 10.6% in 2003 (because exploitation and exportation of oil) to 6.2% in 2010. At the bingeing of 2008, global finance problem extended it is effect to the Sudanese economy and resulted in large gap between the financial and real economy which led to increase in inflation. This problem coupled with additional value added taxes (increased

from 12% to 15%) on commodities has negatively affected the economy and its performance (Osman, 2011).

The Sudan government has launched the National Agricultural Revival Program (NARP) in 2005 to improve the agricultural sector. The aims of NARP is to improve the productivity of the agricultural products in the country, implementation of the large irrigation schemes, encourage the development of the agro-industry, improve infrastructure, and increase spending on irrigation, land preservation, fertilizers, and credit services (EPAR, 2008). The market liberalization policy that has been adopted in 1992 has changed the Sudanese economy from an economy led by governmental sector to an economy led by private sector. This requires an enormous engagement in capacity building of the private sector. Some of the clear policies include:

- Facilitation of involvement in the services associated with export like storage,
- Transportation and communications.
- Establishment of measures of quality and standards.
- Establishment of export councils for major crops.
- Realignment of trade policies and regulations to facilitate trade.

Financial institutions have been playing an important role in agricultural production. They are regarded as the main sources of credit of most farmer in Sudan. Therefore, there are two main sources of credit are formulated by financial institutions in Sudan: formal sources (such as the Agricultural Bank of Sudan (ABS) and the other commercial banks) and the informal sources (locally called Shail systems).

According to Hamid (2001), finance in Sudan is provided in three different ways: Elsalam, Murabaha and Musharaka. Elsalam is usually used

to finance sorghum growers in both irrigated and rain-fed areas. State banks evaluate the financial requirements from sowing until harvesting. Cash is given to the grower who delivers the harvested sorghum to the bank. The bank sells the product and deducts the loan payment at a monthly interest estimated at 2% to 3% of the loan value. The remainder goes to the grower. Murabaha is usually used to finance the procurement of agricultural assets such as tractors with an average interest rate of 1.25% per month. Clients have to provide a guarantee for the loan which should be paid back in a specified period of time. On the other hand, in the Musharaka (Partnership) form of finance the client has to conduct a feasibility study showing the commercial viability of his project and should also contribute to the capital cost. Profits are shared according to the relative contribution of each part to capital costs and an incentive of about 15% of gross profit is given to the clients who manage the project. Other commercial banks are generally reluctant to finance agriculture because of the high risks associated with its production and marketing.

According to Hamid (2001), the most common informal method in Sudan is called locally the Shail. The meaning of Shail is a leverage derived from the meaning of lifting the burden (money need) by the lender off the borrower shoulder. The most common type of the Shail, money lender gives loan to farmers who pledge to deliver a specific quantity of output equivalent to the value of the loan at the time of harvest. The Shail could be in cash or in kind, but repayment is generally in kind at lender set prices that are substantially lower than harvest prices. Money lenders (merchants) who provide loans to farmers in the Shail methods, benefit in two ways, accumulating sorghum at harvest (collecting loan in kind) and selling goods

to farmers. Their interest rate sometimes reached about 726% (KEVANE, 1993).

The amount of credit dispersed in Gadarif, Kassala, Sennar and Blue Nile states decreased from US$ 57 in year 2009 to US$ 25 million in 2010/11 season (MOA, 2011). This substantial decrease, according to the local banks, attributed to the poor repayments of last year's loans following the very poor 2009/10 rain-fed season. Bank loans are made through the non-interest Salam system in all banks in the Sudan (CFSAM, 2011).

2.3 The agricultural policy of the Sudan

Agricultural policy is a sub-policies or sector economic policies that are planned, prepared and applied in the agricultural sector. It requires full harmonization between agricultural policy and other economic policies in all economy sectors. The consequences of agricultural policy are not limited to specified farmers, but it extends to the other groups of community. The agricultural policy often includes two or more methods, consistent with one another regarding the achievement of certain objectives.The purposes of the agricultural policies are improve the welfare of the overall communities. This could be done through the achievement of the overall strategy of the state in the agricultural sector, intertwine and interact with the various policies that direct other sectors in the society. Policies include among others, the agricultural development-oriented group (such as policies related to investment, finance, prices, taxes, support, research, extension, infrastructure, services), and policies of exploitation of resources and the use of production inputs and the identification and selection of production systems. In order to achieve the full benefits of the agricultural sectors in the Sudan the government has embarked in different policies.

The economic reform program has been implemented in the late 1970s. During that time, the Sudan's economy had experienced severe interdependent structural problems that inhibited economic growth (World Bank, 1985). The internal sectors, in particular the agricultural sector, have suffered from additional cumulative demand resulting in inflationary pressures in the economy (Hag Elamin and El Mak, 1971). The internal and external variables were directly affected. High rates of inflation and unemployment, which led to excess aggregate demand, were existed. This situation coupled with civil war in the south and frequent incidence of drought further aggravated the problem. On the other hand, the deteriorated conditions of international trade, prevailed economic stagnation in country, shrinking of international financial flows, and aids oriented towards the country, has resulted in an overall economics disorder of the country. To address these issues, the government has launched numbers of development plans and programs. These plans and programs include; the Ten Year Plan (1960/61-1969/70), the Five-Year Plan (1970/71-1974/75), the Amended Five Year Plan (1970/71-1976/77), the Six-Year Plan (1977/78-1980/81), the First Three Year Public Investment Program (1979/80-1981/82), the Third Three Year Public Investment Program (1982/83-1984/85), the Four Year Salvation, Recovery and Development Program (1988/89-1991/92), and the Three Year National Economic Salvation Program (1989/90-1991/92). Other deviation: include the Five-Year plan (1972-1977), the Economic Recovery Program (ECRP-1978-1985), the Four Year Economic Salvation Program (1987-1989), the National Economic Salvation Program (NESP - 1990-1993), the Ten Year National Comprehensive Development Strategy (1992-2002), the liberalization program (1992 to date), the Green Revival Program (2006-2010).

The Green Revival Program has been implemented during 2006-2010, under the State's National Comprehensive Strategy. This strategy necessitates quick actions to increase the efficiency of the agricultural sector and agriculture led industries of the country, in order to, enhance the competitiveness of Sudanese commodities and in the preparation for accession to the World Trade Organization (WTO). The strategic objectives were; increase export of horticultural and livestock commodities.

- Introduce and integrate livestock in crop rotation.
- Introduce sustainable natural resource conservation and management.
- In agricultural investment the agricultural revitalization emphasizes on:
- Improvement of regulations that enhance investment in agriculture and livestock sectors.
- Development of infrastructure and supporting services.
- Promotion of private sector investment.

In the same vein the objectives of the Long-term Strategy (2003-2027) for agricultural development **are:**

- Ensuring food security: availability of food at reasonable prices, stable quantities of safe and nutritious food accessible to all citizens at all times.
- Promotion of agricultural exports through enhancing the competitiveness of the commodities in which the Sudan enjoys a comparative advantage.
- Sustainable development of natural resources and control of desertification.
- Poverty reduction through generating employment opportunities, improving living conditions and contributing to the overall growth of the economy.

- Forward linkage with those sectors supplying agriculture with inputs and backward linkage with those sectors receiving agricultural products and raw materials.
- To allocate a percentage that should not be less than 1% of the Growth National Product (GNP) for funding scientific research.
- Production of wheat to meet the country's need for wheat by 2011.
- Doubling the land area allotted for forests, grazing and wildlife.
- The export value of livestock, meat and animal skins will be increased by 24% by the end of the plan.

Within the Agricultural Revival Program there were many policies that were set to marketing of the agricultural products. Taking into consideration the importance of marketing for the production process, the government embraces programs for supporting marketing activities in line with the privileges allowed by the WTO and the commitments of the Sudan towards regional and international organizations. The strategies for the development of marketing of crops and livestock are based on the following points:

- Expand and distribute wholesale markets, specifically for horticultural crops on a wide-scale and coupled with the provision of the necessary services to help them to operate efficiently.
- Rehabilitate livestock markets and deliver support services such as water, feeds and quality control.
- Encourage establishment of producer organizations to enable them marketing their products, this include the provision of finance for marketing operations.

- The government is to arrange strategic partnerships between the local and international private sectors for the production and processing of dairy products, meat, fish, fruits and vegetables.

On the other hand, the government has embarked on a series of policies to ensure that producers receive inputs at the subsidized prices, these are:

- Guarantee freedom of the private sector to import inputs
- Government should arrange a strategic relationship with input producers, more specifically the fertilizers and insecticides producers. Reforms the systems of procurement of fertilizers and insecticides include the financial policies and terms of competition in tenders.

Taking the trade policy in consideration, according to data from World Bank 2010, Sudan's trade regime has opened up substantially since the reforms of the 1990s, when the government reduced tariffs, abolished most export monopolies and eliminated exchange rate controls. Further the liberalization was expected since the country has entered in accession negotiations with the WTO following its application for membership in October 1994. Since then, Sudan has signed and ratified its membership in COMESA from the beginning of its establishment and is the first country to apply zero tariffs. Imports from COMESA countries to Sudan increased substantially from US$ 65 million in 2000 to US$ 466.8 million in 2005. On the other hand, exports of Sudan to COMESA increased to reach US$ 165 million in2004, compared to US$ 36 million in 2000. The share of agricultural products in total intra COMESA trade was fluctuating with increasing trends, (reached 81.7% in 2004 compared to 59.6% in 2001). Cotton was the leading Sudanese export commodity to COMESA countries followed by sesame, live animals and seed cake, while skins, groundnuts and

meat contributed the smallest shares (Abdel Karim and Ismail, 2007). Likewise, the government has entered the Common Arab Free Trade since 2005 with the objectives reducing taxes on products of Arab origin and foster trade among the countries in the region. The Sudan benefited from this agreement, to export live animals, sesame, sorghum and fruits and vegetables to Egypt, Saudi Arabia, Jordan and UAE. The amount of Sudanese exports in 2004 reached to US$ 429.9 million (Ministry of Finance, 2005).

Sudan also has trade agreements with some Asian countries (Japan, India, and South Korea) as well as some EU countries (Germany, Italy France). Cotton, Sesame, gum Arabic, Roselle and sugar are the main exports. The largest share of Sudanese exports in 2006 went to Japan (215.7) followed by India (15.9) million Euro (CBS, 2007). Sudan has established a trade point in order to exchange business opportunities and cooperate in trade development initiatives, both within the regions and worldwide. The trade point is part of World Trade Point Federation that presently used internet to links over 100 trade points throughout. Sudan Trade Point is an advanced technological trade facilitation center, supervised by the Ministry of Foreign Trade, providing Sudanese investors and businessmen with international trade related services.

Chapter Three
Analytical Framework

Chapter Three

Analytical Framework

This chapter is devoted to describe the analytical framework used in the study. It focuses on the policy analysis matrix and linear programming techniques**.**

3.1 Policy Analysis Matrix Structure (PAM)

The author used the PAM, which developed by Monke and Person (1989), to test the social profitability and competitiveness of the main crops grown by small-scale farms in the rain-fed sector of Gadarif State - Sudan. The main PAM equation is written as:

$$Profit = Revenue - Costs$$

This formula can be rewritten in the form**:**

$$NSP = E(P_q)Q - e(P_t)it - (P_n)ln$$

Where:

NSP = net profit.

E = foreign exchange rate.

Pq = price of the product.

Pt = price of tradable inputs.

Pn = price of non-tradable inputs (local resources).

Q = the quantity of production.

It = the amount of tradable inputs.

In = the amount of non-tradable inputs (local resources).

Table (3.1): Policy Analysis Matrix

Statement	Revenue	Costs		Profit
		Tradable Inputs	Domestic Factors	
Private price	A	B	C	D
Social price	E	F	G	H
Divergences	I	J	K	L

Source: Monk &Person

Where:

A: Total income.

B: The cost of tradable inputs.

C: The cost of resources in local prices.

D: Prices for profit.

E: Total income using social prices (revenues without a policy).

F: The cost of tradable inputs using social prices.

G: The cost of the resources using social prices

H: Social Profits

3.1.1 Measures of private profitability:

3.1.1.1 Net Profits

(A-B-C) = (D) Profits.

Mean the difference between the revenues (A) and the costs (B+C), all measured in observed prices. The parameter (D) shows the extent of actual competitiveness of the agricultural system given current technologies, output values, input costs and policy transfers, (Abu Baker and Mohamed 2004).

(I-J-K)=(L) Net transfers or the net effect of the policy.

(A-E) = (I) Transfers of production or the impact of policy on production.

(B-F) = (J) Transfers of tradable inputs.

(C-G) = (K) Factors Transfers.

(D-H) = (L) or (I-J-K) Net transfers or the net effect of the policy.

3.1.1.2 Private Resource Cost (PRC)

PRC=C/(A-B)

(A-B)= value added

3.1.1.3 Private Cost Benefit Ratio (PCB)

PCB=(B+C)/A

(D>0, PRC<1and PCB<1)…..Condition for profitability.

3.1.1.4 Measures of Social Profitability of the Non-tradable goods

The social values of the domestic factors or non-tradable inputs (land, labor, and capital), are estimated by using the shadow price methods (best alternative usage), because they do not have border prices. Non-tradable goods can be broken down into tradable and primary factors of production (labor and land and capital, that is, the essential domestic resources).

Shadow price of labor:

The labor cost is estimated by multiplying the number of man-day by the average wage paid (EMAM 2010).The average wage rate has been collected from the labor market which is highly distorted(wage rate often differs from the opportunity cost), because of the minimum wage legislation, powerful trade unions and other elements of imperfect competition in the society. The labor market recognizes the difference of labor wage rate according to skills, sex and age.

The economic wage rate (EWR) is estimated as follows:

$$EWR = M \times AR$$

Where;

EWR= economic wage rate

M= the marginal output in domestic prices;

A= the accounting ratio which converts M into foreign exchange equivalent.

Marginal productivity can be calculated by dividing the value of total agricultural output at economic prices by the total agricultural labor force. The

main problem facing this method is that a unit output of a labor may be less than his average productivity because the remaining labor may work harder (Little and Mirrless, 1988). The other drawback is that the output from the other method for estimating marginal productivity is to estimate the number of days in which labor is more or less fully employed in the year, multiplied by the per-day marginal productivity. The shadow wage rate (**SWR**) can be estimated for each category of labor by multiplying the market wage by the appropriate conversion factor.

$$SWR = MWR \times CV$$

Where:

SWR= shadow wage rate

MWR= market wage rate of a particular category

CV= conversion factor of that category.

The conversion factors (CV) were set according to the following points:

1. Skilled labor-full employment: here the conversion factors is set to be equal to 1, That is, EWR=SWR.
2. Unskilled labor-under employment (seasonal and regional labors): here the conversion factors are set to be equal to 0.6.
3. Unemployment-Abundance (SWR=zero) sometime raise up to subsistence or supply price.

The shadow price of land (SPL)

The shadow price of land is calculated by its opportunity cost. The opportunity cost of land is the obtainable output from using land for producing the commodity. The shadow exchange rate is estimated according to:

1. Producing land: If a producing land was newly purchased and added to the project there the SWR is set to be equal to the marginal product, due to the difficulty of calculating the same annual rent or SER.

2. Producing land: if a producing land is gifted to the project (financial cost =zero), here economical cost is set to be equal to the annual rent rate and is calculated as a weighted average of the official and black market exchange rates. In case of overvalued domestic currency exchange rates, the free market rate implies an under-valuation and bears a risk premium. The shadow exchange rate is estimated by the following formula:

$$SER = AOSR(X) + ABMER(1 - X)$$

Where;

SER = Shadow exchange rate

AOER = Weighted average of official exchange rate.

ABMER = Weighted average of black market exchange rate

X= the percentage of foreign transactions priced by the official exchange rate. In Sudan, X = 0.31, that is, about 31% of foreign transactions are assumed to be priced at the official exchange rate (Albour, 2014).

(1-X) = is the share of foreign transactions priced at the weighted average of the black market exchange rate.

Financial analysis:

Local commercial inputs (with no international prices):

This type of input was calculated according to the following equation:

$$FPT_i = Fx_i \times TC \times AOER$$

Where:

FPti = the financial price of the i^{th} tradable input

Fxi = foreign component of the i^{th} tradable input (Appendix A).

TC=total cost (SDG/ton)

AOER = Average official exchange rate

Non-commercial inputs:

This was calculated according to the following equation:

$$FPn_i = (1 - Fx_i) \times TC \times AOER$$

Where:

FPni = financial price of the i^{th} non-tradable input.

Economic analysis:

For transferring the financial prices into economic prices, the following equations are used:

Economic analysis equations for tradable:

$$\mathbf{EPti = FPti \times SER \div AOER}$$

Where:

EPti = economic price of the i^{th} tradable input.

FPti = financial price of the same input

SER = shadow exchange rate.

Economic analysis non-tradable inputs (EPn_i):

$EPn_i$was calculated according to the following equation:

$$\boldsymbol{EPn_i = FPn_i \times O_i}$$

Where:

FPni = economic price of i^{th} non-tradable input.

Oi = conversion factor of i^{th} non-tradable input.

Shadow price of capital: It is the real interest rate (Ir).

It is calculated by modifying the nominal interest rate(In) taking into account the inflation rate (f).

$$\boldsymbol{Ir = \left(\frac{1+In}{1+f}\right) - 1}$$

3.2 Interpretation of policy analysis matrix results:

PAM is used to measure profitability, international competitiveness and incentives of the main crops grown on small-scale farms of the rain-fed sector of Gadarif State.

a- Social profit (H) = (E-F-G). All entries were evaluated in social prices to measure social profitability. For outputs (E) and input (F) that are traded

internationally, the appropriate social values are given by the world prices: CIF (costs insurance and freight) for importable and (FOB) for exportable. The social profit is an efficiency measure because outputs (E) and inputs (F+G) are valued in prices that reflect scarcity value or social opportunity costs.

b- Domestic Resource Cost (DRC):

$$DRC = \frac{G}{(E-F)}$$

c- Social Cost Benefit Ratio (SCB):

$$SCB = \frac{(F+G)}{E}$$

Condition of profitability (H>0, DRC< 1 and SCB<1)

d- Profitability Coefficient (PC)

$$\boldsymbol{PC = \frac{(A-B-C)}{(E-F-G)}\ OR\ \frac{D}{H}}$$

If (PC>1) it means that the private profit is more than economic profit, and farmers may get support from government.

3.2.1 Measure of protection Coefficient

a- Nominal Protection Coefficient for Outputs (NPCO)

$$NPCO = \frac{A}{E}$$

If (NPCO<1), it means that products are taxed

b- Nominal Protection Coefficient for input (NPCI):

$$NPCI = \frac{B}{F}$$

If NPCI <1, it means that input is subsidized.

c- Effective Protection Coefficient (EPC):

$$EPC = \frac{(A-B)}{(E-F)}$$

EPC <1, it means there is taxes on product.

3.2.2 Measures of international competitiveness

a- The international value added(IVA US$)

$$IVA(US\$) = \frac{(E-F)}{Exchange\ Rate}$$

Where:

(E-F)= the value added in economic price.

b- Coefficient of International Competitiveness (CIC): Measure the value of domestic resource necessary to earn one unit of foreign exchange rate. CIC is the ratio of domestic resource cost value in economic prices, expressed in foreign currency to international value added, it is compared with SER (shadow exchange rate): if (CIC <SER) it mean it have competitiveness.

$$CIC = \frac{G}{(E-F)}$$

3.3 Linear programming techniques

3.3.1 Prelude

Linear programming technique was used to determine the optimal cropping sequence of small-scale farms in the rain-fed sector of Gadarif state. Spread sheet of the excel solver was used to run the analysis.

3.4 The structure of the linear programming (LP) model

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

3.4.1 The objective function

The objective function of this model was to maximize framers' net returns from crop production. The mathematical form of the model followed the general maximization function (Dent et al. 1986; Hazel, 1986):

$$\textbf{Max} \quad Z = \sum_{t-1}^{n} R_j x_j$$

Subject to

1) Constrains of the form: $\sum_{t-1}^{n} a_{ij} x_j \leq b_i$

2) And non-negativity constrains: $X_j \geq 0$, j= 1, 2, …,n

Where:

Z= Objective function value

X_j = productivity of the main crops produced under the rain-fed sector of Gadarif state. The crops were (sorghum, millet, sesame and groundnuts).

R_j = net return/Feddan of the j activity,

n = number of restrictions in the model.

$a_{I\,j=}$ the cost of the i^{th} resource required to produce one unit of the j^{th} activity.

$b_{I=}$ vector of resources availability.

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

3.4.2 Technical coefficients of the model

A simplified tableau of the model technical coefficients is presented in 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 must be less than or equal to the average area/farmer (Feddan). The second row represents the productivity in Kg/Fed. The third row represents the price in SDG/Kg. The fourth row represents return per Feddan for each of the four crops under consideration. The fifth, sixth and seventh rows represent the costs of inputs. Row eight to twenty represents the labor man day hours/season which should be equal or less than the constraint of the right hand side. Row 21 to 24 represents the operational costs (land, labor and machine costs SDG), they should equal or less than their equivalent right hand side. Row 25 to 26 represents the capital at hand at the begging of the season, which should be equal or less than 500SDG.

Table (3.2) Tableau of the linear programming model

Activity set	Crops						
	Sorghum (X_1)	Millet(X_2)	Sesame(X)	Groundnuts(X_4)			
Area							
Productivity (Kg/feddan)	Kg_1	Kg_2	Kg_3	Kg_4			
Price (SDG/Kg)	P_1	P_2	P_3	P_4			
Returns	P_1Kg_1	P_2Kg_2	P_3Kg_3	P_4Kg_4	P_1Kg_{1+} P_2Kg_{2+} P_3Kg_{3+} P_4Kg_4		
Input costs (SDG/feddan):							
Seed	5.9	20	10	20	$5.9Kg_{1+}20Kg_{2+}10Kg_{3+}20Kg_4$	≤	5000
Chemicals (Fertilizers and Pesticides)	16.53	20	27	0	$16.5Kg_{1+}20Kg_{2+}27Kg_{3+}$ $0Kg_4$	≤	
Labour constraints (man-day hours):							
16-30 July	600	360	600	360	$600Kg_{1+}$ $360Kg_{2+}$ $600Kg_{3+}$ $360Kg_4$	≤	2400
1-15 August	360	480	480	360	$360Kg_{1+}480Kg_{2+}480Kg_{3+}$ $360Kg_4$	≤	1800
16-31 August	240	360	480	240	$240Kg_{1+}$ $360Kg_{2+}480Kg_{3+}240Kg_4$	≤	1800
1-15 September	240	240	240	120	$240Kg_{1+}240Kg_{2+}240Kg_{3+}120Kg_4$	≤	960
16-30 September	120	120	120	120	$120Kg_{1+}120Kg_{2+}120Kg_{3+}$ $120Kg_4$	≤	1200
1-15 October	240	600	240	480	$240Kg_{1+}600Kg_{2+}240Kg_{3+}480Kg_4$	≤	1200
16-30 October	120	120	600	360	$120Kg_{1+}120Kg_{2+}600Kg_{3+}360Kg_4$	≤	1800
1-15 November	600	360	0	120	$600Kg_{1+}$ $360Kg_{2+}$ $0Kg_{3+}120Kg_4$	≤	1200
16-30 November	240	360	0	0	$240Kg_{1+}$ $360Kg_{2+}$ $0Kg_{3+}$ $0Kg_4$	≤	960
1-15 December	240	240	0	0	$240Kg_{1+}240Kg_{2+}$ $0Kg_{3+}$ $0Kg_4$	≤	960
16-30 December	240	360	0	0	$240Kg_{1+}$ $360Kg_{2+}$ $0Kg_{3+}$ $0Kg_4$	≤	960
Operational costs:							
Land preparations	43.67	62.08	65.36	43.7	$43.7Kg_{1+}62.08Kg_{2+}65.4Kg_{3+}43.7Kg_4$	≤	5000
Labour cost	170	117	123.8	174.8	$1700Kg_{1+}117Kg_{2+}123.8Kg_{3+}174.8Kg_4$	≤	885
Machine cost	63.44	59.5	35.8	93.84	$63.4Kg_{1+}59.5Kg_{2+}$ $35.8Kg_{3+}93.8Kg_4$	≤	600
Other constraints							
Capital at hand	1	1	1	1	$1Kg_{1+}1Kg_{2+}1Kg_{3+}1Kg_4$	≤	500

3.5 Policy analysis scenarios

Scenarios were developed from the technological improvement and changing its parameters. They were developed from the model in order to reflect a range of technological improvement (crop sequence) and policy choices (increasing microfinance accessibility and quantity). Increasing microfinance will increase farmer's ability to increase his limiting factors by various degrees.

The scenario is based on the crop sequences and provision of microfinance:

1. The first crop sequence: is the current agricultural practices of crop sequence in which sorghum did not come after sesame in the cropping rotation.
2. The second cropping sequences: Groundnuts– Sesame– Sorghum– Millet. Here sorghum comes after sesame. This sequence plays a great role in controlling the major pest threating sorghum (Striga) thus increases sorghum productivity by 150%.

Under each of these scenarios three level of technological improvement were used. These are:

a. Using the current agricultural practices and technological improvement

   For the first scenario: this is the first run of the model.

   For the second scenario: Adopting this sequence will increase sorghum yield by 100%, other crops remain unchanged.

b. Adoption of 50% of the technological improvement:

   For the first scenario: all crops increased by 50%.

   For the second scenario: Here it is assumed that the total returns of the sorghum crops increased by 200%, sesame increased by75%, groundnuts increased by 75% and millet increased by 75%.

c. Adoption of 100% of the technological improvement:

   For the first scenario: Here all crops are assumed to be increased by 200%.

   For the second scenario: Here it is assumed that the total returns of the sorghum crops increased by 400% (Yousif and Babiker, 2015), sesame increased by 150%, groundnuts increased by 150% and millet increased by 150%.

Sensitivity analyses was also carried out to assess farmers returns under adverse conditions for the optimal cropping sequence under different technological improvements:

1. Reducing crops-prices by 10%.
2. Reducing crops-prices by 25%.
3. Increasing input costs by 10%.
4. Increasing input costs by 25%

Chapter Four

Results and Discussion

Chapter Four

Results and discussion

This chapter discusses the results for the analysis of the socioeconomic characteristics of farmers in the study area, examining the social profitability and competitiveness of the main crops produced under the rain-fed area of Gadarif State and determining the optimal cropping pattern of small-scale farms under different scenarios of policy measures

4.1 Socioeconomic characteristics of farmers in the study area

This section gives the empirical results of the socioeconomics characteristics of the farmers which expected to have greater effects, direct or indirect, on productivity and competitiveness of crops produced in the study area. The socioeconomics characters studied here are (age, education level, experience, marital status, occupation, family members, source of income, family expenses, land tenure and source of fund).

4.1.1 Farmers' age

Results of the descriptive statistics revealed that, majority (92.57%) of the farmers in the study area are in the active age group (20-65years) with the bulk lies in the age group of (20-49) years old. According to Mustafa (2006) there is a negative relationship between age and technology adoption, that is, an increase age reduces the probability of technology adoption. Hence, it is expected that farmers in the study area are able to adopt new innovations.

Table (4.1): Distribution of small-scale farms household head in the rain-fed sector of Gadarif state according to their age

Age group	No. of farmers	%
20-29	22	12.57
30-39	44	25.14
40-49	52	29.71
50-59	33	18.86
60-69	11	6.29
70-79	8	4.57
80-90	5	2.86
Total	175	100.0

Source: Field survey, 2013

4.1.2 Education

Results revealed that the majority of the household head of small-scale farms in the rain-fed sector of Gadarif state have low education level or illiterate (96.57%),as indicated by the percentage of illiterate (10.86)formal education with six years as an average (85.71%.), (Table 4.2).

Table (4.2): Distribution of small-scale farms household head in the rain-fed sector of Gadarif state according to their education levels

Education	No. of tenants	Percentage
Illiterate	19	10.86%
Formal education years	150	85.71%
University	6	3.34%
Total	**175**	**100%**

Source: field survey, 2013.

Age and education level are used as indicators of farmers' level of awareness and their abilities of taking decisions on crop cultivation, marketing, finance, resources allocation, and new agricultural technologies adoption. High level of education insures farmers awareness of their business environment and ability to take right decisions to increase their productivity, (Mustafa, 2006).

On the other hand, the average years of farmers experience is very high for male (30 years) and reasonable for female (9 years), (Table 4.3). High experience in agricultural practices assumed to has significant effects on the output of the agricultural crops. Heibert (1974) found positive relation between the probability of adoption of new crop varieties and farmer expertise, Table (4.3).

Table (4.3): Average years of experience of small-scale farms household head (male and female) in the rain-fed sector of Gadarif state

Gender	Average (years)	Coefficient of variation
Male	30.26	54.49%
Female	9.29	82.99%

Source: Field survey 2013

4.1.3 Marital status

It is very clear from Table (4.4) that, the majorities of the respondents in the study area were married (86.3%), widow (4%) and/or divorced (1.7%), thus, they avoided risk in order to secure food for their families.

Table (4.4): Distribution of small-scale farms household head in the rain-fed sector of Gadarif state according to marital status

Marital status	No. of tenants	%
Married	151	86.3
Single	14	8.0
Divorced	3	1.7
Widowed	7	4.0
Total	**175**	**100.0**

Source: Field survey 2013

On the other hand, the average family members of small-scale farms are found to be relatively small, four members. This result indicates that farmers resort on hired labor in their agricultural operational. According to Musa (2000) farmer's family members are the main source of labor supply for various farm operation. Hired labors, if needed, are used in cases of seasonal bottleneck.

4.1.4 Farmers' main and secondary occupation according to sex

The main occupation of the majority of the respondents in the study area is agriculture. The off-farm activities are of great importance for the farmers in the region in providing alternative income sources when the agricultural activities fail. The trading business, for both male and female farmers, was very small. Accordingly, it is expected that farmers in the study area were not commercially oriented. (Table 4.5).

Table (4.5): Distribution of small-scale farms household head (male and female) in the rain-fed sector of Gadarif state according to their main and secondary occupation.

Occupation	Main	%	Secondary	%
Male:				
Farmer	47.0	82.4	31.0	58.5
Merchant	0.0	0.0	3.0	5.7
Employee	7.0	12.3	6.0	11.3
Labor	1.0	1.8	6.0	11.3
Other	2.0	3.5	7.0	13.2
Total	57.0	100	53.0	100
Female:				
Farmer	71.0	60.2	101.0	89.4
Merchant	0.0	0.0	1.0	0.9
Employee	6.0	5.1	0.0	0.0
Labor	5.0	4.2	1.0	0.9
Other	36.0	30.5	10.0	8.8
Total	118.0	100	113	100

Source: Field survey 2013

4.1.5 Small-scale farms yields

It is very clear from Table (4.6) that, the average yields of all produced crop in the study area are very poor compared with the research station [sorghum= 313 Kg/Ha, sesame= 96 Kg/Ha, millet= 234.78 Kg/Ha and groundnuts= 188Kg/Ha]. No wonder, all indicators proved that the small scale farmer used improper technique to produce their product.

Table (4.6). Distribution of small-scale farms yields in the rain-fed sector of Gadarif state according to sex (Kg/ha)

Crops	Male		Female	
	Average	**CV**	**Average**	**CV**
Sorghum	46.02	37.9	55.22	43.1
Sesame	28.9	30.9	16.27	67.6
Millet	37.8	66.3	52.59	39.3
Groundnuts	0	0	55.88	73.8

Sources: Field survey 2013

4.1.6 Sources of income

Farmers in the study area have two sources of income: on-farm and off-farm income. The average total income for both male and female in the last season was relatively high 24937.95 SDG/annum. The average male total income (10742.05 SDG/annum) is higher than female (7842.30 SDG). The coefficient of variation was high indicating that there are differences in farmers' total income (Table 4.7).

Table (4.7) Distribution of small-scale farms household head (male and female) in the rain-fed sector of Gadarif state according to their sources of income (SDG)

		On-farm income	Off-farm income	Total
Male	**Average**	4240.02	6502.04	10742.05
	CV	161.88	140.24	302.12
Female	**Average**	2113.58	5728.72	7842.30
	CV	372.50	121.49	487.24
Total	**Average**	6353.60	12230.76	24937.95
	CV	534.40	254.96	789.36

Source: Field survey, 2013

4.1.7 On-farm income

On-farm income was obtained from the sale of the planted crops. The average on-farm income gained by small-scale farms was so poor (6353.60 SDG/annum) with male farmers (4240.018 SDG/annum) gained more than female farmers (2113.581 SDG/annum). This result confirms the earlier finding that the average cultivated land for male farmers is much greater than female one. The coefficient of variation (CV) is relatively small indicating consistency among farmers of getting the same income. However, it is worth mentioning here that, the main crops produced by small-scale male farmers are sorghum, sesame and millet. On the other hand, the main crops produced by small-scale female farmers are groundnuts, sorghum and millet.

4.1.8 Off-farm income

The main source of off-farm incomes were: laborer work in others' farms, trade (village traders), relatives, seasonal laborer in cities during dry season, and/or wage and salaries. The average off-farm income for male 6502.04 SDG, was relatively high compared to female 5728.72 SDG.

The average off-farm income, for both male and female, exceed that of on-farm income by almost double. It is noticeable here that, farmers usually neglect household consumption in calculating their on-farm incomes.

4.1.9 Family expenditure

It is very clear from Table (4.8) that, the average farmer expenditure/ year was found to be 8766.5SDG which exceed farmers' income by 41.2%.This results reflects the farmers need for saving from off-farm income, support or borrowed money to enter the next season. The coefficient of variation is very small indicating consistency of farmers (both male and female) expenditures.

Table (4.8): Distribution small-scale farms household head (male and female) in the rain-fed sector of Gadarif state according to their family expenditure (SDG)

	Mean	CV
Male	9150.3509	46.8
Female	8579.4872	47.2
Total	8766.4943	47

Source: Field survey, 2013

4.1.10 Land tenure

It is very clear from Table (4.9) that, the majority of the cultivated land (90%) was owned by the small-scale farms in the rain-fed sector of Gadarif State. Only small fraction of farmers used to rent a land (5.8%). In fact farmers neither rely much on sharing others nor on renting land.

Table (4.9): Land tenure system for small-scale farms in the rain-fed sector of Gadarif state

Crop	Own land	Rent	Sharing	Total
Sorghum	34.5	3.4	6.0	43.9
Millet	50.8	1.1	0.0	51.9
Sesame	58.2	5.1	0.6	63.9
Groundnuts	23.7	1.1	0.0	24.8
Total	167.2	10.7	6.6	184.5

Source: Field survey, 2013

4.1.11 Source of fund

Almost all small-scale farmers complained from their inability to finance their field operations. Even though, a good percentage of them depend on their own money (57%) Table (4.10) taking in mind the earlier findings that the small-scale farms' annual expenditure usually exceed their returns, this results justify the use of traditional methods and hence, poor productivity. On the other hands, about 42% of the farmers depended on financial institutions for finance. Types of official finance vary from kind to cash.

Table (4.10): Source of financing for small-scale farms in the rain-fed sector of Gadarif state

Source of Finance	Frequency	%
Bank	62	41.89
Relative	2	1.35
Own	84	56.76
Total	148	100

Source: Field survey, 2013

Loans usually acquired from the Sudanese Agricultural Bank, even though, there is other fourteen commercial banks spread in Gadarif state.

Generally, all banks work within the frame of the general policy set by the central bank of Sudan (CBOS) which implies the use of Islamic forms of Salam and Murabaha since 1990.

To cab it all, results of the socioeconomic characteristics of small-scale farms heads revealed that farmers will continue using the traditional methods of agricultural production, if not supported and encourage by the government. This expectation comes out from the results that the majority of them has low education level, enters the next season without enough money at hand and gained a relatively low income from different sources.

4.1.12 Small-scale famers' net profit

Budget analysis was used to determine the net profit of small-scale farmers from producing the main crops grown in the rain-fed sector of Gadarif state (Table 4.11).

It is very clear from Table 4.11 that, farmers gained a reasonable profit despite the fact that, the productivity per unit area for the four cultivated crops [sesame (1.7 sacks), sorghum (3.4 sacks), millet (2 sacks) and groundnuts (10 sacks)] in the rain-fed sector of Sudan, is very poor compared with the agricultural research stations (Ahmed and Elrasheed 2016). In the same veins, the net profit can be considered as acceptable. But still there is a wide room to improve the productivity if proper technological improvement is adopted. One of the striking results were only (1%) of the farmers used fertilizers and pesticides or both.

The main reason for the poor productivity can be linked to the high cost of inputs. Farmers generally entered the agricultural seasons with a huge debt and sometimes could not be able to finance the main agricultural practice despite the adoption of high technologies (Ahmed and Elrasheed, 2016). Accordingly to improve farmers' productivity it is very important to finance them at the beginning of the agricultural season. On the other hand, it is very

clear here that, sesame is a leading crop in terms of net profit followed by groundnuts, sorghum and millet.

Table (4.11) Productivity, returns and net profits of the main crops grown by small–scale farmers in the rain-fed sector of Gadarif State Sudan

	Sorghum	Sesame	Groundnuts	Millet
Yield (Sack*/feddan*)	3.4	1.7	10	2
Farm gate Price (SDG/sack*)	60	273.8	25	108
Returns	204	465.46	250	216
Returns from crop residues	80	-	90	40
Total returns (SDG/feddan*)	284.0	465.46	340	256
Total costs (SDG/feddan*)	228.5	340	250	210
Profit (SDG/feddan*)	55.5	115.46	90	46

Source: Field survey.

* sack=90Kg

** feddan=4200 m^2

4.2 Social profitability and competitiveness of the main crops grown in the rain-fed area of Gadarif State (PAM results)

The results of PAM analysis revealed that, the financial and economic profitability of the main crops grown in the rain-fed sector of Gadarif state (sorghum, millet, sesame and groundnuts) were positive, indicating that they were substantially profitable and have high comparative advantages (Table 4.12). Taking sesame in consideration this crop gained an outstanding economic (1174 SDG) and social profitability (714.30 SDG), compared with other crops, followed by millet. On the other hand, farmers continued cultivating groundnuts and sorghum despite their low private profits, because groundnut is the main cash crop for female-farmers and sorghum is a subsistence crop.

The positive output transfer (I) (positive divergence between the private (A) and economic revenue (E)) for sesame, sorghum and millet indicates that the applied policies for these crops caused an implicit subsidy or transfer of resources in favor of them. On the other hand, the negative output transfer for ground indicates that this used policy caused an implicit tax or transfer of resources away from the crop.

The negative divergence in tradable input prices (J) such as seeds, chemicals and fertilizers, (that caused private tradable input costs (B) to be less than social tradable input costs (F)) for the four crops under consideration, indicates that the policies used for these crops caused an implicit subsidy or transfer of resources in favor of the agricultural system. On the other hand, the positive sign of the factor transfers of all crops indicated that these crop are taxed or resources are transferred away from the agricultural system. Despite the facts that government encourage large scale farmers in rain-fed agricultural sector by long-leasing the agricultural land with cheap price, but small scale farms are not directly benefited from such subsidies. The most important source of divergence in domestic factors price lie in the machinery and capital charges. The distortions in the labor market were very small because labor cost was more or less correctly priced at social opportunity cost without government intervention.

The net transfer explains the difference between private and social profits. If efficient policies balance market failures and all distortion are removed, divergences disappear and the net transfer becomes equal to zero. Results revealed the presence of positive net transfers for all crops except groundnuts. This results indicate that sesame, sorghum and millet crops are subsidized and the negative sign of groundnuts indicates that the overall policy implication against this crop (groundnuts).

The high and positive value of the financial and social profitability for the four crops indicated that the applied price policies encouraged efficient utilization of resources. This result confirms the first hypothesis which state that, all crops produced under rain-fed sector of Gadarif state are of high social profitability, competitive and comparative advantages. In the same trend, the positive sign of the profitability transfer for all crops, except groundnut, means that the overall effects of the government intervention policies on each of these crops systems, which in turn affects the inputs and out prices and exchange rate, were in favor of the producers in the short-run. And the negative value of the groundnut revenue transfer indicated that producers of this crop are highly taxed. The tax effect can be from the government intervention or market imperfection or both. Surely, if incentives are given to groundnut farmers, they can link to a high value international market thus improving their private revenue. But, the negative divergence between social and private output prices for groundnut was attributed to internal market failure. This result suggests the existence of market imperfection in output markets.

4.2.1 Policy implication of the results

PAM results showed that, the role of government intervention was inadequate. Despite the fact that all crops proved to be financially and socially profitable (has positive sign), therefore, they should be promoted and encouraged. But farmers producing sorghum, sesame and millet in the area were still taxed in factor transfers (the divergence between the financial and economic price is lower than social price). The situation was worse for groundnut production as small-scale farms were taxed in out-puts transfer, factor transfer and overall transfer as indicated by the negative values of the divergence between the financial price and the economic price for the revenue, cost of tradable inputs and profits. Results of these policies proved to

discourage farmers from producing socially profitable crops like groundnuts. However it's worse to be mentioned here that all crop are subsidized in the tradable inputs (the divergence between financial and economic price for the tradable input got negative sign).

The problems facing crops production in the rain-fed sector of Gadarif state are related to management, output market, input markets and agronomic improvement of the crops. Farmers were complaining from inadequate finance, unavailability of inputs at right time, marketing problems, high taxes, and inadequate extension services. Policy-wise, government should reduce taxes and provide incentives for farmers participating and adopting extension programs. It should also invest on the infrastructure to link small-scale farmers to a high value markets. Likewise, they should expand microfinance to cover all farmers.

Table (4.12): PAM of the main crops grown in the rain fed sector of Gadarif state Sudan (sorghum, millet, sesame and groundnut) SDG/ton

	Revenue	Costs		Profit
Indicator		**Tradable input**	**Domestic input**	
Sorghum				
Financial Price	450.00	200.57	117.54	131.89
Economic Price	318.81	233.02	70.74	15.06
Divergence	131.19	-32.44	46.80	116.83
Millet				
Financial Price	560.00	214.16	126.80	219.05
Economic Price	413.19	248.79	85.55	78.85
Divergence	146.81	-34.64	41.25	140.20
Sesame				
Financial Price	1579.80	100.64	305.26	1173.91
Economic Price	1073.41	116.91	242.20	714.30
Divergence	506.39	-16.28	63.05	459.61
Groundnuts				
Financial Price	462.14	82.56	285.04	94.54
Economic Price	768.84	95.91	240.73	432.19
Divergence	-306.70	-13.35	44.30	-337.65

Source: Field survey, 2013

4.2.3 Measures of Profitability, Competitiveness and Protection Coefficient of the main crops grown in Gadarif state

Four types of measures were used in analyzing and comparing policies used in the development of the rain-fed sector of Gadarif state, these were: measures of private profitability, measures of social profitability, measures of international competitiveness and measures of protection coefficient (Table4.13). The net economic profitability (H) is called the efficiency measures because both output (E) and input (F+G) were valued in price that reflects scarcity or social opportunity cost. If the value of economic profitability is positive and greater than unity it indicates that the crop produced in the area has a comparative advantage under the prevailing conditions. The net private profitability reflected that sesame was the most profitable crop grown in the study area under the available financial prices, policy measures, technology, costs and returns of the product at season 2013. Other profitable crops in chronological order were millet, sorghum and groundnuts.

Private cost (PRC) and Private cost benefit ratio (PCB) should be less than one to be both privately and socially profitable. PRC can be defined as the numbers of units of domestic resource cost spent to save unity value added. The PCB means that the costs needed to save a unit pound revenue. In ranking the crops according to their profitability, sesame occupied the first position (got the least value compared with others crop) and groundnut is the last. Generally, all crops are socially and financially profitable. But when taking economic profitability in consideration groundnuts moved to the second position after sesame according to domestic resource cost ratio (DRC). Domestic resource cost for any crop is the measure of comparative advantage and means the opportunity cost of using domestic resources is lower than international value added at world prices. Accordingly, for the crop to be

economically profitable its DRC should be less the one. Results revealed that all crop grown in the rain-fed sector of Gadarif state had comparative advantage. In other words, each of the four crops grown in study area produce more than enough international value added to compensate for domestic factors used.

As for profitability coefficient, the concerned should be on the positive numbers only. If this ratio is greater than one, farmers are subsidized and if it is less than one, farmers are taxed. Our findings confirmed the earlier results that all crops were subsidized except groundnuts which were taxed.

In assessing the international competitiveness of the four crops, two measures were used these are international value added and coefficient of international competitiveness. Results of these two measures indicate that the four crops were internationally competitive. The amazing thing is that, despite the high taxes imposed on groundnut this crop occupied the second position, after sesame, in terms of it is international competitiveness. The coefficient of international competitiveness revealed that sesame, groundnuts, millet and sorghum used 1.34, 1.89, 2.75 and 4.35 SDG of the domestic resources, respectively, to gain one US$. (US$= 6.189SDG).

Measures of protection incentives were also studied. Results of the ratio of the effective protection coefficient of less than one indicate a tax on producers and of more than one indicate a subsidy for the crop. Results of this measure proved the earlier findings that all crops were somehow supported by the government except groundnuts. Nevertheless, results of the Nominal Protection Coefficient for outputs for all crops, except groundnuts, were greater than one indicating that the producers of these crops were subsidized. Likewise, results of the nominal protection coefficient for tradable inputs for all crops, which equals to 0.86 each, that is less than one, reflects that the production inputs for all crops subsidized. However, it is worth mentioning

here that, small scale farmers complaining from receiving any kind of subsidies. Accordingly, it is very important to analyze the value chain of the four crops under consideration.

Table (4.13): Measures of Profitability Competitiveness and Protection Coefficient for sorghum, millet, sesame, groundnut grown under the rain-fed sector of Gadarif state.

Measures/ crops	Sorghum	Millet	Sesame	Groundnuts
Measures of Private Profitability (Profitability):				
Net private profitability (D)= A-B-C	131.89	219.05	1173.91	94.54
Private Resource Cost (PRC)= C/(A-B)	0.47	0.37	0.21	0.75
Private Cost Benefit Ratio (PCB)= (B+C)/A	0.71	0.61	0.26	0.80
Measures of Social Profitability (Comparative Advantage or Efficiency):				
Net Economic Profitability (H)= E-F-G	15.06	78.85	714.30	432.19
Domestic Resource Cost (DRC)= G/(E-F)	0.82	0.52	0.25	0.36
Social Cost Benefit Ratio (SCB)= (F+G)/E	0.95	0.81	0.33	0.44
Profitability Coefficient (PC)= D/H	8.76	2.78	1.64	0.22
Measures of International Competitiveness:				
International Value Added (IVA US$)=(E-F)/exch	16.25	31.14	181.16	127.45
Coefficient of International Competitiveness (CIC)=G/IVA	4.35	2.75	1.34	1.89
Measures of Protection Incentives:				
Nominal Protection Coefficient for tradable outputs (NPCo)=A/E	1.41	1.36	1.47	0.60
Nominal protection coefficient for tradable inputs (NPCi)=B/F	0.86	0.86	0.86	0.86
Effective Protection Coefficient (EPC)= (A-B)/ (E-F)	2.91	2.10	1.55	0.56

Source: Field survey, 2013

4.2.4 Sensitivity analysis

PAM results were further subjected to three scenarios to assess the reliability accuracy and precision. These scenarios were: decrease in FOB price by 10%, decrease in farm gate price by 20% and increase in shadow price by 5%. Results of the sensitivity analysis revealed that sesame was not affected under

all scenarios. This crop proved to be of high private, social and international competitiveness. Other crops were sensitive to these scenarios by various degrees and shows fragile situation of some crops (Table 4.14).

4.2.4.1 Sensitivity analysis of sorghum

Different measures were used in the sensitivity analysis of sorghum with the results presented in Table 4.14.

It is very clear from Table 4.14 that, sorghum-crop is greatly affected by the adverse conditions. The social profit, the domestic recourse cost (DRC) and the Social Cost Benefit Ratio were highly affected by the decrease in FOB price by 10% (-131, 2.01 and 1.13, respectively). Accordingly the profitability of sorghum doesn't withstand the adverse condition of the decrease in FOB price by 10%.

Table (4.14): Results of the sensitivity analysis of sorghum-crop produced by small-scale farmers in the rain-fed sector of Gadarif State, Sudan.

	Decrease in FOB price by 10%	Decrease in farm gate price by 20%	Increase in shadow price by 5%
Private profit (D)	131.89	41.89	131.89
PRC	0.47	0.74	0.47
PCB	0.71	0.88	0.71
Social profit (H)	-35.63	15.06	24.49
DRC	2.01	0.82	0.74
SCB	1.13	0.95	0.93
PC	-3.70	2.78	5.38
IVA (US$)	6.65	16.25	18.04
CIC	10.64	4.35	3.92
NPCo	1.68	1.13	1.32
NPCi	0.86	0.86	0.82
EPC	7.10	1.86	2.62

Source: Field Survey

4.2.4.2 Sensitivity analysis of millet

Different measures were used in the sensitivity analysis of millet with the results presented in Table (4.15).

It is very clear from Table (4.15) that, under all variable and adverse condition millet still profitable.

Table (4.15): Results of the sensitivity analysis of millet-crop produced by small-scale farmers in the rain-fed sector of Gadarif State, Sudan.

	Decrease in FOB price by 10%	**Decrease in farm gate price by 20%**	**Increase in shadow price by 5%**
Private profit (D)	219.05	107.05	107.05
PRC	0.37	0.54	0.54
PCB	0.61	0.76	0.76
Social profit (H)	31.54	78.85	78.85
DRC	0.73	0.52	0.52
SCB	0.91	0.81	0.81
PC	6.94	1.36	1.36
IVA (US$)	22.18	31.14	31.14
CIC	3.86	2.75	2.75
NPCo	1.53	1.08	1.08
NPCi	0.86	0.86	0.86
EPC	2.95	1.42	1.42

Source: Field Survey

4.2.4.3 Sensitivity analysis of sesame

Different measures were used in the sensitivity analysis of sesame with the results presented in Table 4.16.

It is very clear from Table 4.16 that, under all studied adverse condition sesame still has a high profitability.

Table (4.16) Results of the sensitivity analysis of sesame-crop produced by small-scale farmers in the rain-fed sector of Gadarif State, Sudan.

	Decrease in FOB price by 10%	Decrease in farm gate price by 20%	Increase in shadow price by 5%
Private profit (D)	1173.91	857.95	1173.91
PRC	0.21	0.26	0.21
PCB	0.26	0.32	0.26
Social profit (H)	599.38	714.30	763.75
DRC	0.29	0.25	0.24
SCB	0.37	0.33	0.32
PC	1.96	1.20	1.54
IVA (US$)	159.39	181.16	190.52
CIC	1.52	1.34	1.27
NPCo	1.65	1.18	1.40
NPCi	0.86	0.86	0.82
EPC	1.76	1.22	1.47

Source: Field Survey

4.2.4.4 Sensitivity analysis of groundnuts

Different measures were used in the sensitivity analysis of groundnuts with the results presented in Table (4.17).

Table (4.17): Results of the sensitivity analysis of groundnuts-crop produced by small-scale farmers in the rain-fed sector of Gadarif State, Sudan.

	Decrease in FOB price by 10%	Decrease in farm gate price by 20%	Increase in shadow price by 5%
Private profit (D)	94.54	2.12	219.05
PRC	0.75	0.99	0.37
PCB	0.80	0.99	0.61
Social profit (H)	352.08	432.19	88.33
DRC	0.41	0.36	0.49
SCB	0.49	0.44	0.80
PC	0.27	0.00	2.48
IVA (US$)	112.27	127.45	32.93
CIC	2.14	1.89	2.60
NPCo	0.67	0.48	1.29
NPCi	0.86	0.86	0.82
EPC	0.64	0.43	1.99

Source: Field Survey

It is very clear from Table 4.17 that, the PRC (0.99) and Domestic Resource Cost (DRC) (0.99) of the groundnuts under the adverse condition of the decrease in farm gate price by 20% critically affected the profitability of the crop. And as well-known for the crop to be profitable both it is PRC and DRC should be greater than one. Likewise, the results of the profitability coefficient (PC) and indicates that groundnuts crop is seriously affected by the adverse condition of the decrease in FOB price by 10% and the decrease in farm gate price by 20%. On the other hand, the economic profitability of the crop is totally changed from profitable crop to in-profitable crop under the conditions of decreasing in FOB price by 10% and decreasing in farm gate price by 20%.

4.3 Optimal cropping pattern of the small-scale farms in the rain-fed sector of Gadarif State

Results of the linear programming model, which was used to determine the optimal cropping sequences of the small-scale farms in rain-fed sector of Gadarif state, were validated by comparing them with the current net returns/ crops in season 12/2013 and presented hereafter:

4.3.1 Current agricultural practices and crop sequences (sorghum not come after sesame)

Net returns and optimal cropping pattern under the current agricultural practices of the small-scale farms in the rain-fed sector of Gadarif state are discussed here.

4.3.1.1 Net returns under the current and optimal agricultural practices and crop sequences (Sorghum not come after sesame).

The result of the linear programming net returns is presented in Table (4.18).

It is clear from Table (4.18) that, the optimal net return from the main crops produced under the current farmers practices (crop sequence) were greater than the actual one by 110.7%.However it is worth mentioning here that, farmers used three quarters of their land only. But in case of the relaxation of

the binding constraints farmers net returns reached up to SDG 4244, that is increase by more than 117%. This variation could be attributed to the fact that producers actually prefer to assign most of their area to sorghum cultivation.

Table (4.18) Farmer's net returns (optimal and actual value) under the current agricultural practices and technological improvement (SDG/ Feddan)

	Net Returns under the current agricultural practices
Initial value	3619.40
Optimal	4005.13
% Increase	110.70

Source: field survey.

4.3.1.2 Optimum cropping pattern for the rain-fed sector of Gadarif State (under the current agricultural practices and crop sequences)

The optimum cropping pattern (current agricultural practices) of the rain-fed sector of Gadarif State, compared to the actual one are presented in Table (4.19).

Table (4.19): Cropping pattern for the rain-fed sector of Gadarif State (actual and optimal) (%)

Crops	**Actual**	**Optimum**
Sorghum	1.39	0.00
Millet	1.00	0.13
Groundnuts	0.40	2.00
Sesame	1.17	0.77

Source: field survey.

From Table (4.19), it is very clear that sorghum did not enter the optimum cropping under the current cultural practices, crop sequence and technological improvement. On the other hand, groundnuts dominated the area.

4.3.2 Net returns and optimal cropping patterns under the recommended crop sequences (Sorghum come after sesame).

The optimum net returns and cropping pattern of the recommended crop sequence is presented in Table (4.20).

Table (4.20) Farmer's net returns: optimal and actual value (SDG/ Feddan) under the current agricultural practices and technological improvement

	Net Returns under the current agricultural practices
Initial value	3619.4
Optimal	4296.75
% increase	119%

Source: field survey

It is clear that the optimal crop plan under the current agricultural practices (crop sequence) increase small-scale farm net returns by more than 119%. Accordingly, it is very important to enlighten the small-scale farms about the optimal crop plan. This result confirms the second hypothesis which state that, the introduced crop sequence in which sorghum come after sesame substantially improves small-scale farms returns.

4.3.2.1 Recommended crop sequence: Net returns and optimal cropping pattern of small-scale farms under the different technological improvements

Here two level of technological improvement were tested: 50% and 100% adoption of technological improvement. The basic idea of these scenarios is based on the provision of microfinance for small-scale farmers coupled with strong extension programs.

Results revealed that, the four main crops, produced under the rain-fed sector of Gadarif state (sorghum, sesame, millet and groundnuts), enter the optimal cropping pattern under optimum crop sequences. The area allotted for the four crops are almost equal. On the other hand, small-scale farms returns increased substantially, by more than 131%, 214% and 369% %, from the actual farmer

returns, if they used the recommended crop sequences, adopt technological improvement by 50% and 100%, respectively.

Results also revealed that food crops, both sorghum and millet, dominated the area in case of 50% adoption of technology. But in case of 100% adoption of technology, millet alone occupied the largest land. These results confirm the finding of farmers used improper cultural production and used traditional methods. It also showed the importance of microfinance in solving farmers' problems poor savings table (4.21).

Table (4.21): Farmer's net returns (SDG/Feddan) and optimal cropping pattern of the recommended crop sequence under different scenario of technological improvement (50% and 100% technology adoption)

	Optimal crop sequence: recommended practices		**50% adoption of technological improve**		**100% adoption of technological improve**	
	Area	**Net returns**	**Area**	**Net returns**	**Area**	**Net returns**
Sorghum	1.00	**4738.16**	1.50	**7760.77**	0.19	**13359.03**
Sesame	0.90		0.30		0.54	
Millet	1.00		1.30		1.81	
Groundnuts	1.00		0.40		0.76	
Total	3.90		3.50		3.80	
% increase from actual farmers returns		**131%**		**214%**		**369%**

Source: field survey.

Table (4.22): Sensitivity analysis for the recommended crop sequence under different scenarios of technological improvements and adverse condition

		Adoption of 50% technological improvements					Adoption of 100% technological improvements				
			Price	Price	Costs	Costs		Price	Price	Costs	Costs
	Optimal	Optimal	10% Decrease	25% Decrease	10% Increase	25% Increase	Optimal	10% Decrease	25% Decrease	10% Increase	25% increase
Sorghum Areas	1.14	1.50	0.70	1.14	0.186	0.86	0.50	1.01	0.50	0.00	1.50
Sesame Areas	0.80	0.30	0.50	0.80	0.54	1.00	0.70	0.00	0.70	0.00	0.30
Millet Areas	1.09	1.30	1.20	1.09	1.81	1.10	1.46	1.20	1.46	1.70	1.30
Groundnuts Areas	0.90	0.40	0.97	1.80	0.70	0.50	0.86	0.90	0.86	0.90	0.40
Net returns	4244.	7760.78	4452.93	3536.76	13339.13	4386.6	11109.25	12993.82	9547.3	11163.19	7760.78
% changes				-25.35	181.50	-7.42	134.46	17423	101.49	135.58	63.79

Source: field survey.

4.3.3 Sensitivity analysis

Test of sensitivity analysis was carried out to assess small-scale farms returns under adverse conditions by reducing crops-prices by 10% and 25% from one hand and increasing input costs by 10% and 25% on the other hand. Results of the sensitivity analysis are presented in Table (4.22).

Results revealed that, if small-scale farms adopt the improved technologies, their net returns would be far greater than the current practices, under all adverse conditions. The sensitivity analysis revealed that all crops are very sensitive to variation in input and output prices, except millet.

Chapter five

Summary, Conclusions and Recommendations

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5.1 Summary and conclusions

The importance of this study arises from the vital roles the rain-fed sector playing in the development of the Sudanese economy in terms of food security and foreign exchange earnings. Likewise, it arises from the necessity for providing policy makers and decision takers with concrete findings and recommendations that help in formulating appropriate policies for the development of the competitiveness and yields and returns of small-scale farms in the rain fed sector of Gadarif state, taking in mind the high risk surrounding this sector (environmental, marketing, prices, input, output…etc).

The objectives of this study concentrated on: study the socio-economic characteristics of small-scale farmers in the study area, investigate the competitiveness and social profitability of the main crops grown in the rain-fed sector of Gadarif state and determine the optimal cropping pattern (crop sequence) based on different scenarios of policy measure.

The study depended on both primary and secondary data. Primary data were collected from small-scale farms in Gadarif state of Sudan by means of questionnaire. Multistage random sampling techniques were used to collect data from 175 respondents from three villages of the study area. The collected data were validated by comparing it with the unpublished records on small intermediate and large scale farmers which was collected from the Ministry of Agriculture and Forestry Gadarif State and National Agency for Exports and General Administration of Customs Planning Department. Secondary data were collected from Central Bureau of Statistics, Federal Ministry of Agriculture, published papers and references related to the study.

In attempt to achieve the objectives of the study four types of analytical techniques were used these are; descriptive statistics to analyze the

socioeconomics characteristics of the farmers, F-test to test the significant indicators of socio-economic factors of farmers in the study area, Policy Analysis Matrix (PAM) to examine the competitiveness and social profitability of the crops produced in the study area and the linear Programming (LP) approach to determine optimal cropping pattern (sequence). The study reached to the following findings:

- Crops yields of small-scale farms in the rain-fed sector of Gadarif State are far below the research station, this particularly true if known that, the majority of them had low education level or illiterate and enter the agricultural season with minute amount of money. It worth mentioning here that, the majority of them are in the active age group with a reasonable family member, and has long experience in agricultural practices.
- Both on-farm and off-farm small-scale farm's returns were so poor, with annual expenditure exceeding their returns by more than 41%.
- Sesame, groundnuts, millet and sorghum produced by small-scale farms in rain-fed sector of Gadarif state had high profitability and comparative advantages, their international competitiveness revealed that they used 1.34, 1.89, 2.75 and 4.35 SDG of the domestic resources, respectively, to gain one US$. (US$= 6.189SDG).The net private profitability reflected that sesame was the most profitable crop grown in the study area under the available financial prices, policy measures, technology, costs and returns. Other profitable crops in chronological order were millet, sorghum and groundnuts.
- Sesame, sorghum and millet produced in the rain-fed sector of Gadarif state by small-scale farms were supported by the government in terms of their domestic inputs, revenue transfer and total transfer. On the other hand, the groundnuts was supported in tradable-inputs only. However, all small-scale farms complains from not getting any kind of subsidies.

- Government intervention in the rain-fed sector of Gadarif state is still less of optimum, despite the fact that, all studied crops proved to be socially and financially profitable. Sesame, sorghum, and millet produced by small-scale farms were taxed in terms of their domestic transfer, the situation is worth for groundnuts which was highly taxed in terms of domestic inputs, output transfer and total transfer. This policy discourages female-farmers, the main producers of groundnuts in the study area, from cultivating this crop.
- Sensitivity analysis revealed that, sesame was an outstanding crops in terms of profitability and international competitiveness, under all unexpected conditions. Other crops, sorghum, millet and groundnuts give slight results under adverse conditions.
- The crop sequence in which sorghum come after sesame substantially increase farmers returns. If this sequence is used with the recommended full package of technological improvement, then farmer's net returns will increase three times than the current practices.
- The sensitivity analysis revealed that sorghum was very sensitive to increase the costs of inputs and sesame is very sensitive to change in output prices.

5.2 Recommendations

- It is very important to facilitate the provision of microfinance to small-scale farms. This policy should be linked with extension programs to ensure that small-scale farmers adopt technologies.
- It is very important to link small-scale farms with the financial institutions.
- It is very important to encourage researchers to find solution on how to improve small-scale farms' yields, profitability and marketability of products, that is, integrating small-scale farms into high value markets.
- Government should support the domestic inputs such as land and invest in infrastructure. The support could be in the form of long leasing the agricultural land with cheaper prices.
- Provision of extension services coupled with demonstration farms is very essential to improve yields.
- The government should remove the taxes on agricultural inputs (both domestic and tradable) and outputs.
- It is very important to link small-scale farms with insurance program. This policy would encourage them to adopt the new technology.
- It is very necessary to encourage small-scale farms to join cooperative groups. These methods will increase their ability to market their products and reduce their cost.
- Small-scale farmers should be encouraged to adopt the crop sequence in which sorghum come after sesame. They should also be encouraged to change their mind to become commercially oriented. This could be done through provision of microfinance, extension programs and subsidized inputs. Likewise, the government should purchase their products during adverse conditions of price drop.

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