UNIVERSITI PUTRA MALAYSIA

TECHNICAL EFFICIENCY OF WHEAT PRODUCTION AMONG ADOPTERS AND NON-ADOPTERS OF NEW TECHNOLOGY IN FEZZAN REGION, LIBYA

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By

HANAN ALI MOHAMED ALI ALABASI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

May 2018

DEDICATION

TO

My mother

My father (May Allah be merciful to him)

My husband

&

My dear children

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

TECHNICAL EFFICIENCY OF WHEAT PRODUCTION AMONG ADOPTERS AND NON-ADOPTERS OF NEW TECHNOLOGY IN FEZZAN REGION, LIBYA

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May 2018

Chairman : Professor Zainal Abidin Mohamed, PhD
Faculty : Agriculture

Wheat is considered the most valuable food in Libya and as the main staple food in Libyan diet. Libyan consumes a large quantity of wheat; the average consumed quantity about 145 kg/ capita. However, the current wheat production in Libya is just covers about 27% of the needs of the population, in which, almost about 1.6 million MT and the average yield about 1.25 MT/ha and this level is low comparing with the global wheat yield which is about 4.6 MT/ha. Although the efforts to enhance the productivity of wheat in Libya, it is still low and there is no improvement in wheat yield over the last decade indicating the usage of inputs in process of production is not efficient. Though some farms adopted new technology of planting wheat, nevertheless a lot of respondents are still using the old technology of production. Thereby, it is inevitable to assess the technical efficiency of wheat production in the areas in term of technology adoption in wheat planting. Therefore, this study aims to estimate the technical efficiency and resources used as well as determine the sources of technical inefficiency among wheat producers in south-western Libya. The study also aims to evaluate the economic performance of wheat producers by profitability analysis.

Slack-based DEA model, fractional regression model as well as gross margin analysis applied in order to achieve the objectives of the study. The multistage cluster sampling method is used in order to select 225 respondents among adopters and non-adopters of new technology. The average technical efficiency for pooled sample farms is 76%, indicating that respondents can decrease their inputs on average by 24% and still produce the same level of output. Thereby, if all respondents work efficiently and have zero slack, input quantities can be reduced by 26.7%, 21.5%, 30.9%, 20.5,10.7% and 14.5% for DAP, seed, urea, organic fertilizers, size and labour. The average technical efficiency of non-adopters of new technology was 0.69 indicating that respondents were operating at a low level of technical efficiency while the mean efficiency estimated of adopters of new technology was 88%.

Six (6) factors that show significant relationships with the inefficiency: the technology adoption, the age of respondents, main occupation, farm size, seed type and education. On the other hand, non- adopters of new technology can increase the profit by 24% by better use of inputs. The cost of seed and the cost of labour found to have a significant effect on profitability level of both groups. The study concluded that, respondents have a great chance to enhance their performance by adopting the new technology. The study recommended that improvement productivity programs should be targeted toward older farmers to improve their performance by training them in modern mechanization in agriculture. Moreover, the agriculture bodies should establish soil laboratory to enable the respondents to know the adequate quantity of fertilizer required. The government bodies should make facilities to help farmers to access and use the improved seed to improve the production.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KECEKAPAN TEKNIKAL PENGELUARAN GANDUM DI KALANGAN PENGANGKUT DAN BUKAN PENERIMA TEKNOLOGI BARU DI RANTAU FEZZAN, LIBYA

Oleh

HANAN ALI MOHAMED ALI ALABASI

Mei 2018

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Gandum dianggap makanan yang paling berharga di Libya dan sebagai makanan ruji utama dalam diet Libya. Libya menggunakan sebilangan besar gandum; kuantiti purata yang digunakan kira-kira 145kg/kapita. Walau bagaimanapun, pengeluaran gandum semasa di Libya hanya mencakupi kira-kira 27% daripada keperluan penduduk, di mana, hampir kira-kira 1.6 juta MT dan hasil purata kira-kira 1.25MT/ha dan tahap ini adalah rendah berbanding dengan hasil gandum global yang kira-kira 4.6MT/ha. Walaupun usaha untuk meningkatkan produktiviti gandum di Libya, masih rendah dan tidak ada peningkatan dalam hasil gandum sepanjang dekad yang lalu yang menunjukkan penggunaan input dalam proses pengeluaran tidak cekap.

Walaupun sesetengah ladang mengamalkan teknologi baru untuk menanam gandum, namun banyak responden masih menggunakan teknologi lama pengeluaran. Oleh itu, tidak dapat dielakkan untuk menilai kecekapan teknikal pengeluaran gandum di beberapa-kawasan dari segi penggunaan teknologi iaitu teknologi baru yang diterima pakai dan tidak diterima pakai dalam penanaman gandum. Oleh itu, kajian ini bertujuan untuk menganggarkan kecekapan teknikal dan sumber yang digunakan serta menentukan sumber ketidakcekapan teknikal di kalangan pengeluar gandum di Barat Daya Libya. Kajian ini juga bertujuan untuk menilai prestasi ekonomi pengeluar gandum dengan analisis keuntungan.

Model DEA berasaskan Slack, model regresi pecahan serta analisa margin kasar yang digunakan untuk mencapai objektif kajian. Kaedah pensampelan kluster pelbagai digunakan untuk memilih 225 responden di kalangan pemakai dan bukan pemakai teknologi baru. Kecekapan teknikal purata bagi ladang sampel disatukan adalah76%, menunjukkan bahawa responden dapat menurunkan inputnya secara purata sebanyak 24% dan masih menghasilkan tahap output yang sama. Oleh itu, jika semua responden bekerja dengan cekap dan mempunyai senggaraan nol, kuantiti input dapat dikurangkan sebanyak 26.7%, 21.5%, 30.9%, 20.5,10.7% dan 14.5% untuk DAP, benih, urea, baja organik, saiz dan buruh. Sebaliknya, kecekapan teknikal purata bukan penerima teknologi baru adalah 0.69 yang menunjukkan responden beroperasi pada tahap kecekapan teknikal yang rendah manakala kecekapan min dianggarkan pengguna teknologi baru adalah 88%.

Enam (6) faktor yang menunjukkan hubungan yang signifikan dengan ketidakcekapan: penggunaan teknologi, umur responden, pekerjaan utama, saiz ladang, jenis benih dan pendidikan. Sebaliknya, bukan penerima teknologi baru boleh meningkatkan keuntungan sebanyak 24% dengan menggunakan input yang lebih baik. Kos benih dan kos buruh didapati memberi kesan yang signifikan ke atas tahap keuntungan kedua-dua kumpulan responden. Kajian ini menyimpulkan bahawa, secara umum, responden mempunyai peluang besar untuk meningkatkan prestasi mereka dengan menggunapakai teknologi baru. Kajian ini juga mencadangkan agar program peningkatan produktiviti patut disasarkan kepada petani tua untuk meningkatkan prestasi mereka dengan melatih mereka dalam mekanisasi moden dalam bidang pertanian. Tambahan pula, badan-badan pertanian perlu mewujudkan makmal tanah untuk membolehkan petani mengetahui jumlah baja yang mencukupi yang diperlukan. Badan-badan kerajaan harus membuat kemudahan untuk membantu petani mengakses dan menggunakan benih yang lebih baik untuk meningkatkan pengeluaran.

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I certify that a Thesis Examination Committee has met on 22 May 2018 to conduct the final examination of Hanan Ali Mohamed Ali Alabasi on her thesis entitled "Technical Efficiency of Wheat Production among Adopters and Non-Adopters of New Technology in Fezzan Region, Libya" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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Declaration by Members of Supervisory Committee

This is to confirm that:

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- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) were adhered to.

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Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr. Ismail AbduLatif

Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr. Amin Mahir Abdullah

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LIST OF ABBREVIATIONS

USDA	United States Department of Agriculture
GMMR	Great Man Mad River
NCISP	Libya's National Center for Improved Seed Production
ARC	Agricultural research center
GDP	Gross Domestic Product
DMU	Decision Making Unit
AE	Allocative efficiency
TE	Technical Efficiency
EE	Economic Efficiency
CRS	Constant Return to Scale
VRS	Variable Return to Scale
DEA	Data Envelopment Analysis
SFA	Stochastic Frontier Analysis
MVP	Marginal value production
MFC	Marginal Factor Cost
SBM	Slack Based Model
FRM	Fractional Regression Model
OLS	Ordinary Least Square
GM	Gross Margin

CHAPTER 1

INTRODUCTION

This chapter is shed light on the facts about the agriculture. information like consumption, production, productivity as well as importation of wheat all be mentioned in the chapter. The problem statement and the objectives of the study also Mentioned in the chapter.

1.1 Global Wheat Production

Wheat is considered one of the most important agricultural crops in the world. It is a strategic crop as it competes with both agricultural commodities and industrial products. The importance of wheat cannot be overemphasized, it is used mainly as human food in some countries and as animal feed in many nations around the world. Other than that, it also represents an input in the production of bio-fuel. Thus, wheat is a universal commodity with varieties of uses. Wheat is cultivated in all continents of the world. In 2017, China is the world's largest wheat producer, followed by India, Russia and United States of America. The world wheat production is estimated at about 739,530 million MT in 2017 (United States Department of Agriculture USDA, 2017). Figure1.1 represents the evaluation of the global wheat production. The global wheat production was about 692.9 million MT in 2010 and rose to around 750 million MT in 2017. However, global warming has a great impact on wheat production around the world as a 1°C rise in temperature can reduce wheat yield by 6% (Zhao et al, 2017).

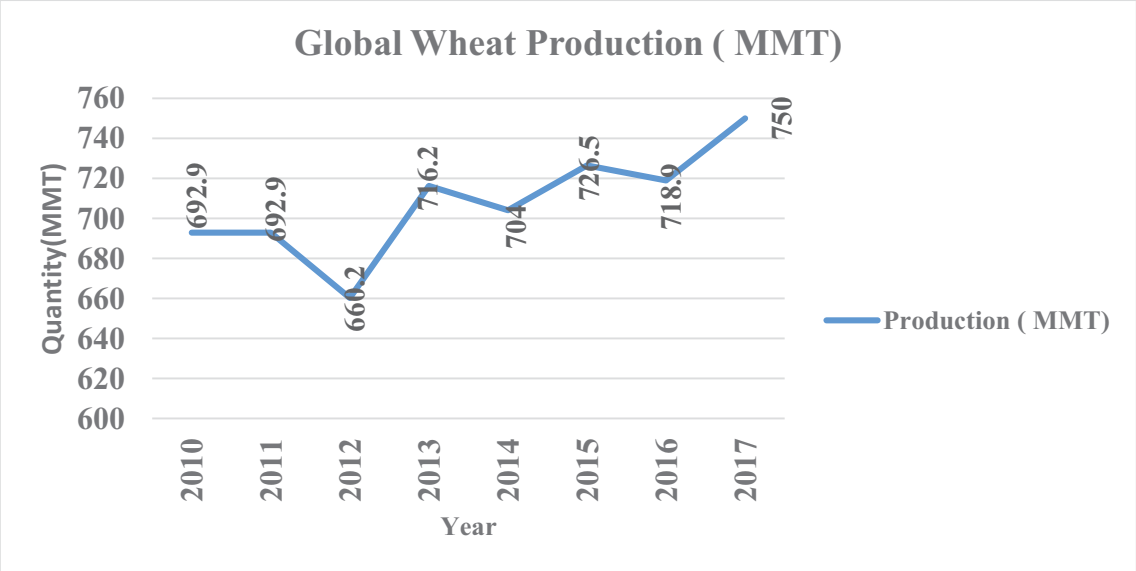

Figure 1.1 : Evaluation of Global Wheat Production
(Source : United States Department of Agriculture USDA, 2017)

Table 1.1 represents the production, area and yield of wheat in some countries. Even though wheat is a staple food for most Arab countries, they cannot be classified among the major wheat producers in the world. The largest producers of wheat in the Arab world are Egypt, Morocco, Iraq, Algeria and Syria. Libya is the eighth (8) largest wheat producer among the Arab countries. However, the yield of wheat is very low in the Arab world which consequently necessitate importation to meet the domestic demand.

Over the last few years, wheat production has declined significantly in many countries around the world. The decline in wheat production is a global phenomenon which is brought about by a number of reasons such as continuous decrease in the areas allocated for wheat cultivation, a steady rise in the emergence of cash crops competing with wheat, decrease in the productivity (per hectare) of wheat in some countries compared to others, and incessant exposure to environmental pressures that reduce the vitality of wheat at the International level. The continued decline in global wheat productivity will have a significant impact on countries that rely on wheat importation to meet domestic requirements. One of the most important impacts on the importing countries is the difficulty in obtaining the required quantities of wheat. Even if the needed quantity is obtained, it will often be at higher prices.

Table 1.1 : Production, Area and Yield of Wheat Crop in Some Countries 2017

Country	Production (1000MT)	Area (1000ha)	Yield (MT/ha)
China	131,000	24,200	5.4
India	96,000	30,715	3.12
Russia	69,000	27,500	3
United states	49,642	15,591	3.18
Canada	27,000	9,000	3
Ukraine	26,500	6,600	4
Pakistan	25,700	9,050	3
Australia	21,500	12,500	2
Turkey	21,000	7,800	3
Argentina	17,500	5,600	3
Egypt	8,100	1,260	6
Morocco	5,800	3,300	2
Iraq	4,025	2,225	2
Algeria	2,500	2,100	1.19
Syria	2,200	1,100	2
Tunisia	1,200	620	1.9
Sudan	400	235	1.7
Libya	**200**	**165**	**1.2**
Yemen	150	100	1.5

(Source : United States Department of Agriculture, 2017)

1.2 Introduction of Agriculture Sector in Libya

Libya is a North African country which covers an area of 177,700 km2 (equivalent to 17,770,000 ha). It is the fourth largest country in the Africa continent and has a population of about 6 million with more than half of the populace living in the northern part of Libya. Libya's economy depends primarily on the country's energy sector, which generates about 95% of export revenues, 80% of GDP and 99% of government income. The Sahara Desert covers more than 90% of the territory and only 2.2 million hectares is available as arable land representing about 12% of the country's total area. Furthermore, there are about 14 million hectares of forests and pastures (Arab Organization for Agricultural Development (AOAD), 2016).

Agriculture is the second most important sector in the Libyan national economy. It is one of the important sectors that can be relied upon in diversifying the structure of the national economy and reducing the high dependency on oil extraction. Thus, several investments have been directed towards improving the agricultural sector and increasing its contribution to the GDP. Table 1.2 represents the gross domestic product by sector. In 2016, the contributions of the agricultural, industry and services sectors to the GDP were 1.9%, 43.2% and 66.4% respectively (World Bank, 2017). This indicates that the agricultural sector does not respond to these investment flows and therefore has not achieved the desired objectives which are to improve the self-sufficiency level of the country with regards to food production and to increase the sector's contribution to the GDP.

Table 1.2 : Gross Domestic Product Composition by Sector

	Sector		
Year	**Agriculture**	**Industry**	**Services**
2002	5.2	66.1	28.7
2005	2.3	75.5	22.2
2008	1.9	78.2	19.9
2011	3.2	49.5	47.3

(Source : World Bank,2016)

In general, the contribution of the agricultural sector is still below the required level which leaves the country dependence on both imported food commodities and raw materials. Libya currently imports 75% of its food needs. Approximately 17% of the population works in agriculture. This is reflected in the large import value, which led to a deficit trade balance in agricultural products on one hand, and increase in foreign exchange on the other hand.

The agriculture sector has been subjected to several challenges since the change of government in 2011. The sector witnessed drastic decline as many government agricultural projects were abandoned especially in south Libya. Furthermore, one of the aftermaths of the political event that occurred in Libya is the complete destruction of the agricultural data system. Thus, the reconstruction of the country's agricultural data system becomes a great challenge (Arhama, 2016).

1.3 Importance of Wheat in Libya

Wheat is a strategic crop in Libya due to its dual competing uses in human food and animal ingredient. It is called the first food crop as wheat flour represents the major ingredient in the manufacture of bread, pasta, biscuits and other industrial products. Due to the importance of wheat to the country, the government encouraged private sector involvement in its cultivation. Since the year 1970, farmers in the southern part of the country focused mainly on wheat cultivation (Elfagehia, 2014). Wheat is a winter crop and generally suited to two farming conditions in Libya which are; irrigated agriculture in the South and rainfed agriculture in the North. Wheat is usually planted in mid-November and harvested in the mid-May, indicating that the production cycle is about six months.

The total area planted (wheat) rose from 130,000 hectares in 2001 to 165,000 hectares in 2017. On the other hand, the level of production increased from 130,000 MT in 2001 to about 200,000 MT in 2017. Wheat is grown in different parts of Libya. Figure 1.2 represents the distribution of wheat production among the provinces in Libya. The Fezzan region which is located in South-West Libya supplied about 53%, followed by the Marj area which supplied about 16% of the total wheat produced in the country (Department of Statistics Libya, 2007).

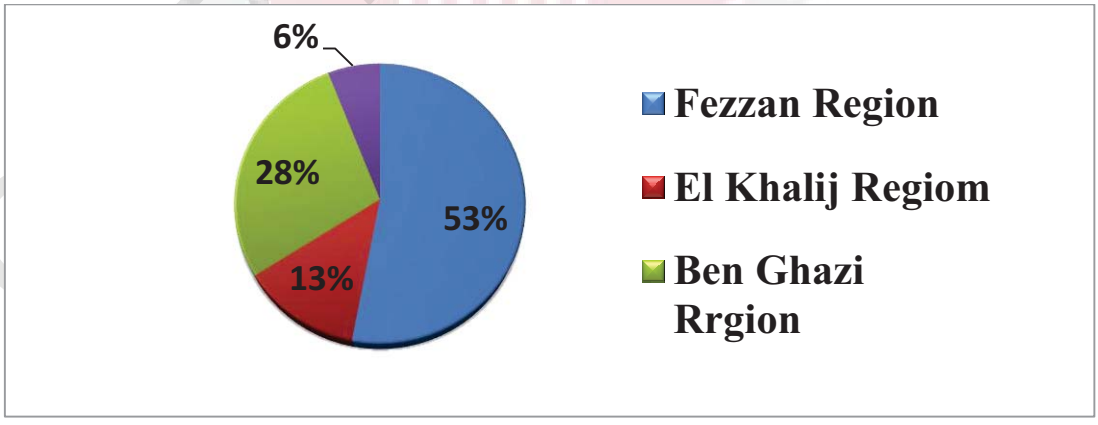

Figure 1.2 : Distribution of Wheat Production among Provinces in Libya
(Source : Department of Statistics Libya, 2007)

Even though Libya is a desert country with poor renewable waters sources, it has huge reservoir of underground water that can be utilized for irrigation purposes. Thus, 90% of the farmers practice irrigated agriculture.

As the largest wheat producing area in Libya, Fezzan is bestowed with abundant groundwater which is available in sufficient quantities and suitable natural conditions for the cultivation of agricultural crops. Thus, priority was given to this area in order to increase the productivity and efficiency of agricultural products such as (especially) wheat.

1.4 Evolution of Production and Productivity of Wheat in Libya

Low productivity is a clear phenomenon among cereal crops in Libya. In 2007, the productivity was about 0.7MT/ha and rose slightly by 0.8% through 2007-2017. The highest wheat yield obtained in Libya was about 1.25 MT/ha in 2013. Comparing this level of yield with neighbouring nations and countries with the same environmental conditions, it can be concluded that it is relatively low. For example, wheat yield in some countries is about 6 MT/ha. The productivity of wheat in Tunisia, Morocco and Algeria is around 2 MT/ha. Thus, the government encouraged farmers to grow wheat in their personal farms so as to improve the production level in the country.

At the beginning of the 1970s, the state embarked on the establishment of large central agricultural projects for the production of cereals, especially wheat and barley in the southern Libyan. In 1989, the state introduced policy which permitted the conversion of some public agricultural projects into private farms. These farms are a model of organized agriculture, where they followed the modern agricultural methods in tillage and sowing and use the latest irrigation machines for the extraction of faraway groundwater.

Despite the increased acreage and production level, the rise in the consumption of wheat exceed the quantity produced. Libya suffers from a chronic wheat deficit of about 800,000 MT annually. The average global per capita consumption of wheat ranges between 70-80 kg per year. In contrast to this measure, a Libyan citizen usually consumes more than 145 kg of wheat annually. At the level of production of about 200,000 MT in 2017, the local production of wheat can only provide about 17 kg of the per capita requirement. This necessitates the importation of wheat to meet domestic needs.

The high rate of consumption is not surprising as wheat is an important staple food for the citizens. The domestic production of wheat is very poor and cannot meet the demand as the population increases. Despite the improvement in productivity over the years, the local supply could not cover the quantity (1,494,000 MT) required in 2017. The increased volume of consumption reflects the demand for wheat products. It is noted that consumption is increasing despite the improved productivity achieved during the years of relative population stability. Table 1.3 illustrates the consumption and wheat gaps between 2007 and 2017. In 2017, domestic wheat production is about 200,000 MT, the consumption is about 1,600,000 MT and the wheat gap is about 194,400,000 MT (USDA, 2017).

Table 1.3 : Consumption and Consumption Gap of Wheat during 2007 – 2017

Year	Population (million)	Production (1000 MT)	Consumption (1000 MT)	Wheat Consumption gap (1000 MT)	Imports (1000 MT)
2007	5.6	104	1,478	1,374	1,574
2008	5.7	104	1,793	1,689	1,689
2009	5.9	105	2,091	1,986	2,090
2010	5.9	106	1,680	1,574	1,474
2011	5.9	166	1,727	1,561	1,561
2012	5.8	200	2,015	1,815	1,815
2013	5.7	200	2,250	2,050	2,050
2014	5.8	200	1,676	1,476	1,326
2015	5.9	200	1,496	1,296	1,316
2016	5.9	200	1,600	1,400	1,450
2017	6.1	200	1,600	1,400	1,450

(Source : USDA, 2017)

Figure 1.3 shows the wheat consumption gap in Libya. As can be seen, the gap between production and consumption could not be covered by local supply. The reason for this large deficit is the increase in irrational wheat consumption, coupled with the fact that the production is seasonal while the demand is all through the year. Libya has to depend on wheat importation to meet the local demands. The Large volume of imported quantities (about 1,400,000 MT) shows the deficiency in local production. The decline in productivity per hectare illustrates the deterioration in the production of wheat and justifies the large volume of imports. On the other hand, the yield gap which is the difference between actual and potential yield reflects the efficiency in the use of resources and it is generally large in developing and transitional countries (Bai & Tao, 2017). Wheat production in Libya is characterized by fluctuations due to natural and technical factors. While the cultivated areas have increased over years, wheat yield is still low at an average of 1.2 MT/ha.

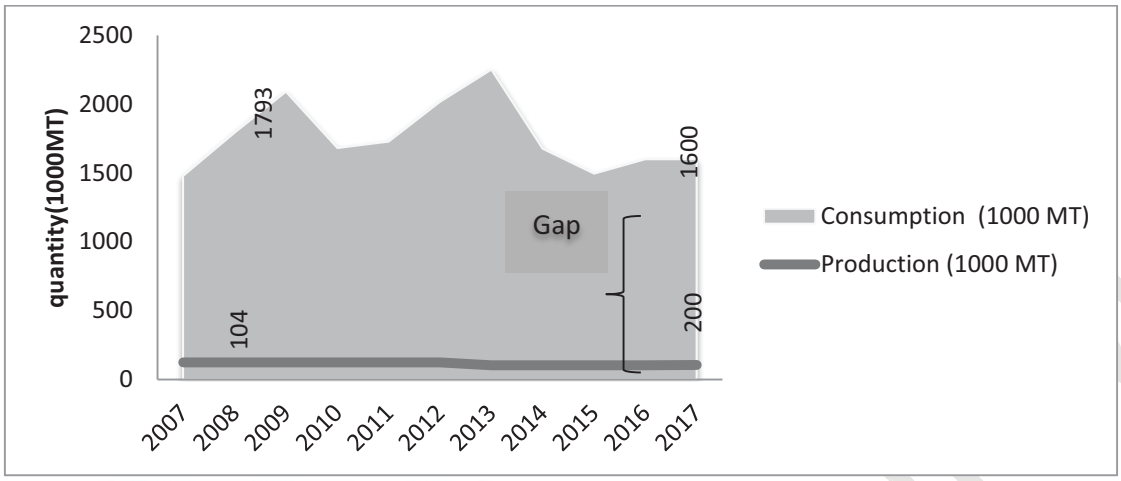

Figure 1.3 : Consumption Gap of Wheat in Libya
(Source : USDA, 2017)

During the last ten years, the production of wheat is convergent despite the differences in cultivated area. The average yield is about 0.7 MT/ha during this period.

Table1.4 represents production and yield of wheat in Libya. The productivity of wheat is low and does not commensurate with the required quantities of wheat. The stability of lower productivity reflects the inability to develop or improve wheat production. The production of wheat increased from 106,000 MT in 2010 to 200,000 MT in 2013. The yield also increased from 0.85MT/ha in 2010 to 1.2MT/ha in 2017. This shows a little improvement in wheat yield per hectare.

Table 1.4 : Wheat Area Harvested, Production and Yield in Libya (2007-2017)

Year	Area harvested(1000 ha)	Production(1000 MT)	Yield(MT/ha)
2007	132	104	0.7
2008	132	104	0.7
2009	133	105	0.8
2010	135	106	0.85
2011	150	166	1.106
2012	165	200	1.212
2013	160	200	1.25
2014	165	200	1.2
2015	165	200	1.2
2016	165	200	1.2
2017	165	200	1.2

(Source : USDA, 2017)

Low productivity, widening income and welfare gaps between urban and rural areas are the major issues facing the agricultural sector in Libya. The Libyan government prioritized sustainable agriculture by increasing agricultural productivity and competitiveness in order to respond to internal and external changes and to continuously advance the agricultural sector. The performance of the plant sector, especially in cereal production is poor and both production and productivity have declined in the past ten years due to the poor management, lack of resources and low level of technology with no improved seeds, fertilization and agricultural practices, and inadequate agricultural policies to encourage local production. In the same token, agricultural output has also declined drastically due to lack of arable land and counterproductive labour. These problems are further augmented by the government's push for the development of large state-owned farms, characterized by low productivity and production despite the improved agricultural technology provided to these farms.

1.5 Resources in Agricultural Production

1.5.1 Land

Libya is a desert country and 95% of the country's total land area is covered with sandy soil. About 2% of the area is available as arable land which is located in north Libya near the Mediterranean coast. The climate of Libya is influenced by the Mediterranean climate in the north and the desert climate in the middle and south part of the country. Therefore, the country is characterized by regular drought brought about by low and intermittent rainfall. In general, the soils in Libya are relatively shallow and coarse and are characterized by low organic matter content and water holding capacity (Markou and Stavri, 2006). Moreover, about 53.5% of the Libyan soils are estimated to be degraded by salinization, water erosion, and wind erosion (Aburas, 2008). Table 1.5 represents the pattern of land use in Libya between 2000 and 2015.

Table 1.5 : Land Use in Libya

Year	Agriculture land(ha)	Arable (ha)	Land under cereal production(ha)
2000	15,450,000	1,815,000	348,110 (19.2%)
2005	15,385,000	1,750,000	375,080 (21.4)
2010	15,351,000	1,716,000	364,677 (21.25)
2015	15,350,000	1,720,000	452,361(26.3%)

(Source : FAOSTAT, 2017)

As indicated in Table 1.5, Agricultural land declined by 100,000 ha between 2000 and 2015, while arable land falls by 95,000 ha during the same period. The area under cereal crops constituted about 19% and 26% of the total arable land in 2000 and 2015 respectively.

Furthermore, there are about 81% arable areas in North Libya, 52% in Northwest Libya and 29% in Northeast Libya, while more than 70% of the area in Southwest Libya is not suitable for farming (Lariel, 2015).

1.5.2 Water Resources in Libya

Water is considered one of the most important components of the agriculture. Figure 1.4 presents the percentage distribution of the available sources of water in Libya. The water resources in Libya can be represented by groundwater, surface water, water reclaimed by desalination, wastewater treatment, and the Great Man-Made River Project (**GMMR**). About 1,820 million m^3 available water is distributed annually in which around 79% are non-renewable and 17% are renewable water.

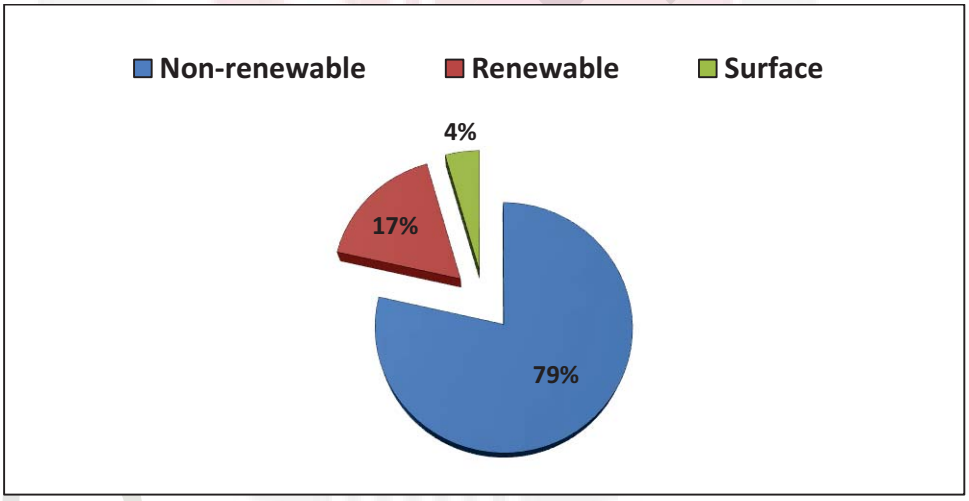

Figure 1.4 : Percentage Distribution of Water Available in Libya
(Source : FAO, 2015)

The rainfall pattern in Libya is erratic and cannot be relied upon for crop production. The groundwater is the main source of water that provides about 95% of the total volume of water used in the country. Recently, the Libyan government is focused on initiating agricultural projects in the non-arable land in south Libya due the huge groundwater reservoir in these areas.

The GMMRP transfers about 7.1 million m3 of water per day from the Fezzan and Kufrah aquifers to the coastal areas through a system of pipes traversed along 4,500 km. The GMMRP offers water for irrigation and other purposes in these areas. The Murzuq Basin is the second largest aquifer in Libya after the Al Sarir-Al Kufrah basin and both of them are located in the southern part of the country. The Great Man-Made River Project transfers water from these aquifers to the coastal areas for domestic, industrial, and agricultural purposes. Even though Libya has the largest fossil water reserves in the world, the country still appeared among the list of the water-scarce nations. The main reasons for this are the excessive use of the water by the populace; the demand for urban uses increased from 3.637 million in 1984 to about 6 million in 2017 as the population increased during these periods. The other important reason is the excessive use of water for agricultural purposes where more than 95% of the available water is drained annually for agricultural activities. The excessive use of water for agricultural activities is brought about by natural factors, the dominance of unsuitable agricultural pattern, the increase in the number of small farm holdings, ignorance pertaining to irrigation requirements and lack of agricultural extension (Alabasi, 2011)

In summary, Libya relies heavy on the unrenewable groundwater for irrigation purposes, and this will have a great impact on the availability of water for future agricultural production.

1.5.3 Agricultural Technology Adoption in Libya

Technology is considered one of resources for agricultural production. In order to cover the demand from consumers on food, the agricultural sector has to accept evolving technologies and farm practices across many different farming systems and structures. Using the improved technology lead to higher incomes and low-cost of farmers. Furthermore, technical progress leads to increased productivity of resources; capital, land and also leads to improved production with the available resource used.

The improved agricultural technology adoption, such as using improved seed varieties, chemical fertilizers and modern technology could make the changeover from the current low productivity and subsistence farming to commercial farming which is lead to increase the production. Improved agricultural technology adoption has the possibility to enhance the market share of agricultural output through which the farmers' resource use could be guided increasingly by their objective of profit maximization.

In Libya, the new technology or modern technology is available, but not adopted by all farmers. The underlying reasons for non-adoption of modern technologies in the farms are not understood, however, the adoption of modern technology depends on the availability of technology. e.g., technology related to seeding, fertilizing, irrigation, agricultural practices, hybrids and certified seeds, harvest and storage and using agricultural research results. Some of the small and median scale farms use the simple and old machines in agriculture. They rely on surface water and some use primitive agricultural machines for their operation (Afhimh & Saad, 2012).

The farmers use Aquarius, and the machines have developed into diesel engines to extract water from the wells. These farms usually use the broadcaster way to distribute seed as well as fertilizers in the agriculture. Generally, this way is an inefficient way because more seeds are used then more seed wastage. Moreover, there is no uniformity in the land which leads to uneven planting depth, uneven germination and uneven growth. all these factors will affect the output. The modern machine used to add the seed is seed drill machine. By using the seed drill machine, farmers can avoid the problem linked with traditional methods of adding the seed; by this method, the seeds are sowed at equal distances and proper depth, ensuring that the seeds get covered with soil and saved from being eaten by birds. the most important case that the use of seed drill can improve the ratio of crop yield. Recently, farmers tend to adopt the new technology in the agriculture.

On the other hand, the improved varieties of wheat offer new opportunities for farmers because of their unique characteristics, such as a higher yield and shorter period of growth better than the traditional cultivars/varieties (Almahale variation). The adoption of these improved varieties is very important to improve the production and cover the demand for wheat. However, the high number of farmers are still depending on the no-improved wheat seed.

Modern farms which depend on the new technology have been widely appearing in Libya with an area on average about 15 ha for irrigated farms and 50 ha for rainfed farms. These farms rely on deep groundwater wells ranging from 40 to 100 meters. They also employed efficient agricultural techniques as the irrigation systems used in these farms are modern and sophisticated. The sprinkler irrigation is a popular method, which pipes with a set amount of water to the fields and then sprays it directly over the crops. The benefit is that the amounts of water can be controlled. The modern irrigation system represents by center pivot. It involves a self-propelled system in which a single pipeline moves on wheeled towers in a circular pattern. It used in agriculture to make better use of water resources, it can also be used to apply types of fertilizers and pesticides. A small amount of work is required and the device works automatically and maintenance is low, hence low amount of labour costs. Technology adoption is influenced by education, training, information which form the basis of farmers' knowledge. It also affected by the development, dissemination and application at the farm level of existing and new biological, chemical and mechanical techniques.

In the same token, the modern and tradition farms also differ based on the extent of cultivation in the winter and summer seasons. In the winter, the cropped area in traditional farms ranged between 17% and 35% while those of modern farms ranged between 27% and 62%. Unlike the winter period, the difference in the extent of cultivation between the two system in the summer was not significant as the cropped area in the traditional farms ranged between 11% and 46% while those of modern farms ranged between 21% and 47 % (Allan *et al.*, 2015).

1.5.4 Labour

Apart from land and water, labour is also one of the most important factors affecting agricultural production in Libya. The country's population increased from 1.88 million persons in 1967 to 6.375 million persons in 2017, indicating an average annual growth rate of 2.51 % (FAOSTAT, 2017). Libya has a very low population density of 4 people per square km. Furthermore, individuals aged between 15-64 years represent about 67.2 % of the total population. The urban population increased from 39.8% in 1967 to 79% in 2017, indicating an average annual growth rate of 1.42%. The rural population refers to the people living in rural areas in Libya and they constitute about 21% of the total population in 2017 (FAOSTAT, 2017).

Libya is one of the oil producing countries that rely on oil as the major source of national income. The country's dependence on oil has reduced the importance of other sectors, especially the agricultural sector which contributes only about 1.9% of the Libyan gross domestic product (GDP) in 2017. Also, the number of individuals who rely on farm labour as the basic source of income dropped from 33.7% in 2001 to about 23.4% in 2011 (DOSL, 2007). This shows that the dependence on the oil sector has led to drastic reduction in the number of agricultural workers as they can earn better incomes in the services and industrial sectors.

Agricultural jobs account for 19% of the total employment in Libya. Recently, the agricultural labour force experienced a noticeable decreasing trend. Furthermore, the declining involvement of Libyans in the agricultural sector has attracted large numbers of foreign workers from neighbouring countries such as Tunisia, Morocco, Egypt and other African nations (Laytimi, 2002). Brink (1991) mentioned that most of the Egyptian migrates are working in the agricultural sector due to the high wages but lacked the required skills to effectively conduct the farming operations. Also, the UN embargoes (1992-2000) prompted the Libyan government to intensify its relations with sub-Saharan countries, the Immigrants from these nations were often openly welcomed due to the shortage of the local labour and as a policy to revitalize the underpopulated desert regions (McGovern, 2007). Most of these foreign labourers work in the agricultural sector. For instance, the foreign agricultural labourers constitute about 32% of the total agricultural workforce in Fezzan region (Alabasi, 2011).

Figure 1.5 shows the labour force and the agricultural labour force in Libya. As indicated, the agricultural labour has declined over the years. The agricultural workers decreased by 36.16 thousand persons between 2004 and 2015. However, it increased from 54,000 persons in 2014 to 57,000 persons in 2015 (Arab Organization of Agricultural Development, 2017).

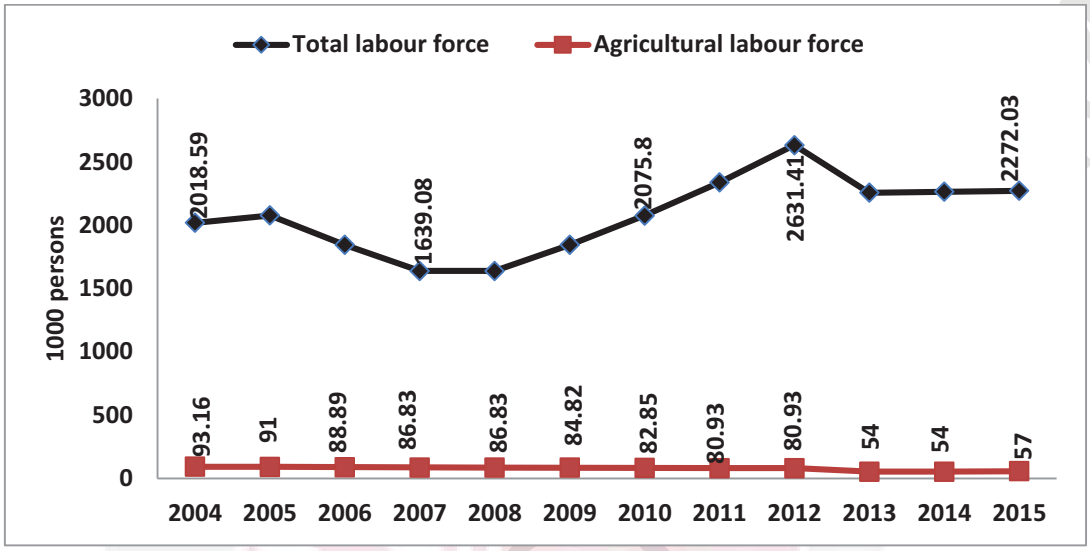

Figure 1.5 : Total and Agricultural Labour Force in Libya
(Source : AOAD, 2017)

1.5.5 Seed and Fertilizers

One of the ways that can be employed to enhance the productivity of crops is the use improved seed and fertilizers. As discussed earlier, most of the soil in Libya is sandy soil and needs adequate application of fertilizers, usually organic fertilizers, to improve the fertility. Recently, fertilizers are applied at an average rate of 4.6 kg/ha and this level is far lower than those of other countries (FAOSTAT, 2015). The popular forms of fertilizers used are urea and phosphate fertilizers such as Diammonium phosphate 18-46. Figure 1.6 highlights the imported quantity of fertilizers. The quantity of fertilizer imported decreased by 29,440 MT Di-Ammonium Phosphate (DAP) and 1,120 MT (Urea) between 2007 and 2014 (FAOSTAT, 2015). Also, fertilizer application also declined by 40,560 MT between 2005 and 2015 (Figure 1.6).

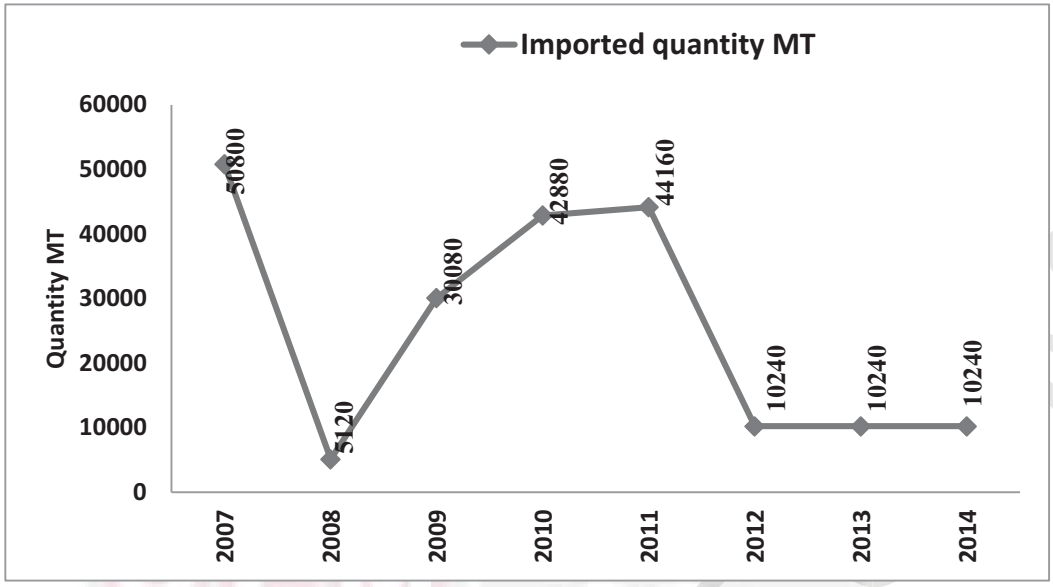

Figure 1.6 : Imported Quantity of Fertilizers since 2007-2014
(Source : FAOSTATA, 2015)

Furthermore, farmers have emphasized the lack of adequate pesticides and fertilizers needed for specific purposes and are forced to use the ones available in the market which may not suit their requirements (Faris, 2004).

In 2008, the government established the Libyan fertilizer company which introduced the country to the global fertilizer market and reduced fertilizer importation. The fertilizer company is located in west of Tripoli and has a combined daily production capacity of 2,200 MT of liquid ammonia and 2,750 MT of urea. However, the company ceased operations due to the recent unrest in the country (Park, 2016).

In term of seeds, Libya faces challenges in seed production, quality and supply due to limited technical capacities and quarantine measures, and new strains of plant and animal pests and diseases. Additionally, Libya depends on the importation of improved seed varieties which may not be well suited to the country's soil and environmental conditions. This situation directly affects the level of production and productivity (Lariel, 2015). In general, seed supply is of two sources: 1) the seeds produced by the farmers in southern Libya (government projects); and 2) imported seeds from Tunisia (Al-Idrissi et al., 1996). However, the majority of the farmers in Libya usually prefer the home-saved seeds rather than the fresh processed seeds and this can have a direct consequence on production and productivity. This is because the quality of the seeds usually reduces due to the poor storage conditions and can subsequently influence the level of production and productivity of the resultant product (Attitalla et al., 2010).

The wheat seed varieties usually grown in Libya is the durum wheat such as Karim, Marjawi etc. The Karim is mostly grown in southwest Libya by farmers in the government irrigated projects. The Marjawi is another variety of durum (hard) wheat developed by the International Maize and Wheat Improvement Center (CIMMYT) in order to increase the yield of wheat. The Fazan variety was improved to resists wheat rust. On the other hand, the bread wheat and Salambo are mostly planted in the coastal area of Libya. The Mahale variety is another local variety of wheat which is presumed to originate from Libya and has been planted for several years due to its ability to withstand water stress, high temperature, and certain insects. However, the productivity of these local varieties is not as high as some of the improved imported varieties (Lariel, 2015). Majbari (2009) found that 81% of wheat and barley farmers in Libya depend on the seeds saved from the previous cropping season especially those with high productivity and the stored seeds are usually planted in the following/new season.

The efforts to improve the level of productivity can be traced back to the 1950s when the Libyan government created plans to enhance and increase crop seeds. The government initiated training to educate farmers on the handing and planting of seeds. In 1958, a policy which entailed the plan to enhance and produce seeds in southern (Fezzan Region) and eastern Libya was formulated (Al-Shreidi, 2010). In addition to that, the government has been distributing high quality seeds to the farmers since the periods (1664-1966) due to the need to improve the productivity of wheat in the country. This policy was especially focused on the private farmers in order to assess the impact of the improved seeds on their productivity (Majbari, 2009). Another effort to increase wheat production was the initiation of different government agricultural projects in the eastern area and in the southern desert area of Fezzan during the 1970s. Finally, the Agricultural Research Centre (ARC) was instituted in the 1980s to promote crop production through improving seeds quality. The research centre developed different varieties of durum and bread wheat, barley and food legumes which are currently grown by the farmers (Lariel, 2015).

1.6 Agricultural Policy in Libya

In order to improve the contribution of the agriculture sector to the gross domestic product, the governments of Libya initiated a number of policies to support investments in the sector. The government introduced incentives such as the Price Stabilization Fund (PSF) to provide price support and also to subsidise some important agricultural inputs. This also enables the farmers to have easy access to credit facility through the agricultural investment bank. In addition to that, water is sold at very low prices through the great man-made river project (GMMR) programmer (Heemskerk and Koopmanschap, 2012). For instance, Public farms can pay as low as USD $0.03/m3 for irrigation water while the government completes it by paying USD $0.90/m3. The Agricultural Bank of Libya also plays significant roles in supporting the farmers and the agricultural sector in general. To ensure effective results, the loan applicants must be full-time farmers with duly signed farm deeds and the size of the farm should be more than ten (10) hectares.

Furthermore, the seeds are also being subsidized by the Libya's National Centre for Improved Seed Production (NCISP) through providing low priced foundation seed. The subsidies motivated more farmers to participate in the program and also encourage them to buy new modern irrigation technology to increase their production (Lariel, 2015).

Due to the need to ensure food security, the Ministry of Agriculture, Animal and Marine Wealth also directed more efforts towards improving agricultural production. About 25,000 target group with prior agricultural background were trained and introduced to agribusiness opportunities. To further encourage the farmers, the new government through the Ministry of Employment and Vocational Training allocated about 3 billion Libyan dinars (2 billion USD) for investment in a small and medium scale enterprise development programme (Heemskerk and Koopmanschap, 2012).

Given the importance of wheat in Libya, the government prioritized the crop in most of its programmes to encourage the wheat farmers and to enhance the production level. For instance, in the price support policy, the government initiated a programme aimed at purchasing the farmers' surplus in wheat, barley, and olive oil. These commodities are usually purchased from the farmers at prices which are above their respective market prices. However, this programme is not effective in recent years due to the delay in payment to the farmers (Araar et al 2017).

1.7 Technical Efficiency of Cereal Crops in Libya

One of the major challenges to sustainable the agriculture production in Libya is the limited resource. Although Libya has a large land area, water represents a major challenge to agricultural production and needs to be used efficiently. on the other hand, although Libya is the fourth large country in Africa, the agricultural land represents only 2% of this area The response of agricultural crops to different agricultural processes and obtaining the highest productivity and high quality is only due to the interplay of many factors of production such as climatic factors, genetic and physiological characteristics of the crop itself, and the characteristics of the natural and chemical soil that the farmer can control. Through the combination of these factors, the productivity of different crops can be improved by peaceful management, which includes good knowledge of the efficient use of inputs. Some of the farms producing wheat and barley are subject to some production constraints (irrigation related constraints, grain-related constraints, agricultural machinery constraints, chemical fertilizers and agricultural employment constraints), while marketing constraints are (relatively low selling prices), lack of a regular market for crops, increased losses during marketing, high marketing costs).

However, some facilities provided to the farmers led to the inverse effects in case of using the inputs. the low of the water pumped cost as well as electricity led to the inefficient to use this inputs. Thereby, to make the efforts of the government to improve the crop production is effective, it is essential to know some information the performance of farmers in case of using the inputs in process of production. Thereby measuring the overall technical efficiency and determine the source of inefficiency is considered the first step to set the effective policies based on the current situation of farmers. On the other hand, there is extensive use of pesticides between farmers which lead to soil pollution resulting from heavy pesticide usage (Laytimi 2005). However, soil solarization has been implemented by some farmers to decrease risks from such chemicals. (Dabaj 2003).

Elbeydi and Kashim (2016) explained in a study aimed to determine the optimal mix of urea fertilizer in wheat production that the average rates achieved higher grain productivity compared to other levels of urea levels while achieving higher net revenue than other levels. Thereby, the optimal fertilizer which maximizes profits rates according to the current price level of about is 163 kg /ha. On the other hand, the higher rates are uneconomical and unsafe On the environmental by the conditions of the experiment.

In the study of Saad et al (2012), about the efficiency of wheat production, the economic efficiency of phosphate fertilizer amounted to about 2.31, nitrogen fertilizer was estimated at 5.67, the composite fertilizer was 16.91, the seed quantity was 1.21 and the human labour was estimated at 17.98. This indicates the ratio of the value of the marginal product to the cost of the alternative (the price of the resource) for these variables is greater than one. This means that the efficiency of using these resources is high, allowing respondents the opportunity to increase their profits by producing the wheat crop so that its marginal production value is equal to the opportunity cost (supplier price).

While the water efficiency of the water component used in irrigation, which is represented by variable X7, is about 0.105. This is because the economic rate of return of this component is less than the correct one, indicating that this element is used at a higher rate than the optimum. While reducing the use of this item (resource) until the marginal productivity value is equal to its price. On the other hand, level of rainfall, number of human working hours, number of cultivars, seed type and seed quantity were identified as the main determinants of wheat production in mountain green area in Libya. The optimum volume of production was about (1.8) MT/ha which is more than the actual production by (0.97) MT/ ha. This is due to the inefficient use of the inputs. The problems of irrigation, fertilization, marketing, seed varieties, and the problem of harvesting were the most important problems faced by farmers in the region (Othman (2007).

While Mahmoud (2008) explained that the inputs that affected the production of barley crop are cultivated area, cultivated variety, quantity of manure, amount of pedometer, automatic working hours and rainfall rates. He explained that the problem of irrigation, marketing the crop, labour, the lack of Agricultural Extension and the use of non-improved varieties of the most important problems facing the cultivation of barley. Aqeel (2008) explained that the agricultural projects face a problem in the efficiency of the use of inputs in wheat planting which led to an increase in the average cost of labor due to the increase in the number of workers in the project as well as an increase in the average cost of electricity due to the increase in irrigation rates and the increase in the average cost of seeds. Therefore, it is necessary to pay attention to increasing the efficiency of the human element in the project as well as the interest in agricultural mechanization, especially harvesting machines.

In summary, the improvement of the level of production and productivity can be only by using the input in process of production efficiently. Thereby measuring the technical efficiency of the wheat crop is the first step in order to enhance the production and the productivity. Therefore, is essential to use the modern methods to measure the technical efficiency and make accurate recommendations can be used to improve the performance of wheat producers.

1.8 Problem Statement

Even though the Libyan government has made several efforts to enhance the domestic wheat supply in the country, the productivity still remains very low at about 1.25 MT/ha. The little or no improvements in wheat yield per hectare over the last decade indicate inefficiencies in production inputs. In 2007, productivity was about 0.7 MT/ha, and this increased slightly by 0.8% through 2007-2017.

The Department of Agriculture and Libya Grains Organization initiated several policies to increase wheat production. The seed subsidies initiative through the National Center for Improved Seed Production (NCISP) enhanced the farmers' access to improved seeds and modern mechanization. Furthermore, the Ministry of Agriculture, Animal and Marine Wealth also provides avenues where both intending and existing farmers can secure loans that can be utilized in establishing new farms and improving production levels respectively.

The wheat planted area increased from 132,000 hectares in 2007 to 165,000 hectares in 2017, while the domestic production also rises from 104,000 MT to 200,000 MT during the same period. The introduction of new technologies has led to improved wheat yield in some neighbouring countries. For instance, the wheat yield in Egypt reached 6 MT/ha in 2017, and this is greater than the average global wheat yield estimated at 4.6 MT/ha. This huge improvement in the Egyptian wheat yield is brought about by the adoption of high-yielding varieties and modern technologies in wheat planting (Mansour, 2015). This improvement will contribute to containing food

insecurity in Egypt in the near future. Similarly, the Libyan government also encouraged the adoption of modern agricultural equipment and practices to improve wheat production and productivity. This is an important step in enhancing domestic supply and reducing the reliance on wheat importation.

While some of the respondents have embraced the modern farming systems, majority are still stuck with the traditional method of wheat production. One of the features of the traditional farms is the associated low crop yield as they are based on rudimentary farm management system and obsolete traditional experience. The level of wheat production is very low and way below the optimal level required to achieve economic efficiency. The factors responsible for the inadequate level of production are related to the low use of the available economic resources and the difficulty in accessing other necessary economic resources (Elfagehia, 2014).

While it is obvious that the wheat production system in Libya is not efficient. Thereby knowledge about the level of efficiency, land, fertilizers use and labour is important to enhance the production of wheat. On the other hand, it is not obvious what is the impediments and their effect on wheat production. Investigating the technical efficiency of wheat production is considered the most effective short-term solution that can be adopted to increase wheat productivity. In addition, determining the factors responsible for the inefficiency will provide important information that can be employed to improve the wheat yield which has remained relatively low since the last the decade. Even though the government has directed several efforts towards the wheat industry, the yield is still low and this necessitates the measure of technical efficiency. Measuring the technical efficiency of wheat production is essential in determining the factors hindering the improvement in yield and also in understanding the suitable amount of seed and other inputs required in the production process. In the same token, exploring the social environment of the wheat producers will assist in formulating polices which can be more accurate in alleviating the low productivity condition.

Measuring technical efficiency by using the frontier approach has a significant contraption in the existing study of technical efficiency in Libya. The results of this study will give information about the overall technical efficiency of wheat producers instead of estimated the partial efficiency by using the traditional methods (econometrics method) as the majority of the applied Libyan studies about the efficiency. This study will be of great scientific interest especially to the Libyan universities. Even though this topic is not new to the scientific world, it specific contribution on the performance of wheat producers in developing country like Libya will provide important information that can serve as the basis for comparison in other similar setting. The in-depth evaluation of the performance of respondents which involves estimating the technical efficiency and input slacks, and linking the socioeconomic factors is probably the first effort in the southwest Libya.

Most of the literature reviews on wheat crop in Libya focused on the government projects while studies that deal with the private farmers are very rare. This is due to the difficulty in obtaining data from the farmers. Thus, this study will provide considerable data about private wheat farmers in Libya.

Methodologically, several studies in Libyan Universities have employed traditional techniques such as productivity metrics (macro and micro), and statistical standards, this research represent a new dimension as it adopts the frontier methods (Slack-based DEA model) in measuring the technical efficiency. The conduct of slack analysis set this research apart from other related studies.

Moreover, this study shows how the technical efficiency, production, and profit can be improved by removing the values of input slacks. This analysis can be used to make important recommendations with regards to the result of the research. This study intends to determine the technical efficiency of wheat production using slack based DEA model. The findings from this research will have important implications on the society, farmers, and consumer.

1.9 Objectives of the Study

The main object of this study is to measure the technical efficiency of wheat production in Fezzan Region in Libya.

The specific objectives of this study are:

1) To present and analyze the socio-economic profile of wheat respondents in Fezzan Region, Libya.
2) To measure the technical efficiency and the input use among the wheat respondents in Fezzan Region, Libya.
3) To determine factors responsible for the technical inefficiency of wheat production in Fezzan Region, Libya.
4) To determine factors affecting gross income across the farming systems.

1.10 Significance of the Study

The importance of wheat to the Libyan population reflects the significance of this study. Wheat is one of the major food commodities around the world. Despite the efforts of the government in encouraging wheat cultivation, the production is still very low and importation becomes necessary to meet domestic demand. To ensure the effectiveness of the government efforts, optimal use of production resources need to be ensured. That is, productivity could be improved through efficient use of inputs.

As mentioned earlier, this study intends to measure the efficiency and identifies the factors responsible for the inefficiency in wheat production. This will reveal important information which can be employed in increasing wheat yield over time. Thus, the result of this study will be essential in enhancing the level of production and subsequently, the self-sufficiency level. This will enable the state to save some of the foreign exchange used in wheat importation. This study will also help in developing sustainable policies which can be adopted in ensuring optimum resources utilization and improving wheat production level in Libya. This is particularly important due to the increasing level of consumption and the need to reduce the country's dependence on wheat importation.

Furthermore, investigating the technical efficiency can help the respondents to increase their production capabilities which will consequently enhance their income generating potentials. Increase in income can be of immense benefits to the farmers especially those who depends on farm activities for their survival.

1.11 Thesis Organization

The study is divided into five chapters; introduction, literature review, methodology, results and conclusion. Chapter one presents the information about wheat production in the world. It illustrates wheat production, consumption, yield and imports in Libya. The important agricultural inputs in the country were also discussed. Lastly, the problem statement, objectives and the importance of the study were highlighted.

Chapter two comprised of two sections; the first section describes the theoretical framework and highlights the necessary improvements in the DEA model. The second section which includes the empirical literature reviews was divided into three subsections; the first subsection discussed the findings of several studies that have measured the efficiency of wheat production in the different countries. The second subsection highlighted the results of studies that have employed different forms of DEA to measure efficiency in the production of several crops. Lastly, the third subsection reviews the inefficiency studies with particular focus on those related to this study.

Chapter three presents the sampling procedure, the area of study and the detailed discussion of the empirical models. Chapter four presents and discusses the result of the study. It explains the efficiency estimates of the sample farms as well as the input slacks of the farms. It also reveals the different determinants of inefficiency and the result of the profitability analysis.

Chapter five presents the summary, recommendations and the limitations of the study.

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