Analysis of Economic Efficiency and Farm Size:

A Case Study of Wheat Farmers in Nakuru District, Kenya.

Research Thesis

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In Partial Fulfillment of the award of Master's Degree in Agricultural and Applied Economics, Department of Agricultural Economics, University of Nairobi.

2011.

DECLARATION

This thesis is my original work and has not, wholly or in part, been presented for an award of any degree in any institution or University.

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TABLE OF CONTENTS

DECLARATION i

LIST OF TABLES v

LIST OF FIGURES vi

LIST OF ACRONYMS vii

ACKNOWLEDGEMENT viii

ABSTRACT ix

CHAPTER ONE: INTRODUCTION 1

1.1 Global Wheat Outlook 1

1.2 Regional Wheat Outlook 5

1.3 Kenya's Wheat Production 8

1.4 Kenya's Wheat Consumption 12

1.5 The wheat value chain in Kenya 12

1.5.1 Milling Capacity and Wheat Types 13

1.5.2 Intra-regional Trade in Wheat Products 15

1.6 Problem statement 16

1.7 Objectives of the Study 18

1.7.1 Hypotheses tested 18

1.8 Justification of the Study 18

1.9 Limitations of the study 19

CHAPTER TWO: LITERATURE REVIEW 20

2.1 Wheat Marketing in Kenya Before and After Reforms 20

2.2 Productivity 24
2.3 Measurement of Efficiency 25
2.4 Application of Efficiency Analysis 25
CHAPTER THREE: METHODOLOGY 30
3.1 Theoretical Framework 30
3.2 Efficiency Models 31
3.2.1 Non-parametric Frontier model 32
3.2.2 Deterministic frontier Production Function 32
3.2.3 Stochastic frontier production function (SFPF) 33
3.3 Conceptual Framework 35
3.4 Empirical Framework: Stochastic Frontier Production and Cost Functions 36
3.4.1 The Production Function 38
3.4.2 The Cost Function 39
3.4.3 Determining factors influencing efficiency- The Tobit model 40
3.5 Area of Study 41
3.6 Data Sources and sampling procedure 42
3.7 Data Collection 44
3.8 Data Entry and Analysis 45
CHAPTER FOUR: RESULTS AND DISCUSSION 46
4.1 Household Characteristics 46
4.2 Wheat Production and Marketing 49
4.2.1 Land preparation and Planting 49
4.2.2 Wheat Yields 50
4.2.3 Production Costs 50

4.2.4 Gross Margins Analysis 51

4.2.5 Wheat Marketing 52

4.3 Extension Advice 52

4.4 Credit 54

4.5 Social capital 54

4.6 Distance to Social Amenities 55

4.7 Household Quality of Life Indicators 55

4.8 Efficiency Estimates 57

4.8.1 Technical, Allocative and Economic efficiencies. 57

4.8.2 Distributions of technical (TE), allocative (AE) and economic (EE) efficiency measures 59

4.8.3 Farm size and Efficiency 60

4.8.4 Factors influencing efficiency 62

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS 64

5.1 Summary 64

5.2 Production systems and farmers' profile 65

5.3 Findings on efficiency estimates 66

5.4 Findings on factors influencing efficiency 68

5.5 Policy Recommendations 69

5.5 Further Research 70

REFERENCES: 71

ANNEXES 75

LIST OF TABLES

Table 1.1: World Wheat Production Trends 2
Table 1.2: Wheat production trends in the US 4
Table 1.3: Proportion of total cost of wheat production in the US 5
Table 1.4: Wheat production trends in Egypt 6
Table 1.5: Proportion of different activities to total cost of wheat production in Egypt 7
Table 1.6: Regional Exports of Wheat Flour and Meal Wheat 1998-2002 for selected African countries 8
Table 17: Structure of wheat farming in Kenya 9
Table 1.8: Wheat production and demand trends in Kenya 10
Table 3.1: A Summary of Sampled households by Divisions 44
Table 4.1: Mean acres owned and cultivated in 2008 46
Table 4.2: Land Tenure by Farm Size 46
Table 4.3: Characteristics of Household Head 47
Table 4.4: Highest Level of Education level of Household head 48
Table 4.5: Main Occupation of the Household Head 48
Table 4.6: Main Seed varieties planted 49
Table 4.7: Type of seed used 49
Table 4.8a: Mean Cost of Production (KSh/Acre) 51
Table 4.8b Gross Margin Analysis of Wheat production in Nakuru District 2008 season (Kshs/acre) 51
Table 4.9: Buyer Type by Farm size 52
Table 4.10: Source of Extension Services 53
Table 4.11: Reasons for not seeking extension advice 53
Table 4.12: Proportion of Households that Sought and Received Cash Credit 54
Table 4.13: Services obtained from the Group 55
Table 4.14: Distance in Km. 55
Table 4.15: Building materials of the main house 56

Table 4.16: Type of toilet used 56

Table 4.17: Ordinary least squares (OLS) estimates of the average production function and ML estimates of the stochastic production frontier for the sampled wheat producers 58

Table 4.18: Mean TE, AE and EE scores by farm size 59

Table 4.19: A two sample t-test on the association between technical efficiency and farm size 60

Table 4.20: A two sample t-test on the association between allocative efficiency and farm size 61

Table 4.21: A two sample t-test on the association between economic efficiency and farm size 61

Table 4.22: Tobit model estimates for different efficiency measures 63

LIST OF FIGURES

Figure 1.1: The share of top ten wheat producers in the world (2002-2008) Sources: USDA, 2010; 2

Figure 1.2: The share of the annual world export by the top exporting countries (2002-2008) 3

Fig 1 3 Proportion of wheat imported into Kenya by country of origin Source: FAOSTAT 2008, ... 11

Figure 1.4: Wheat value chain in Kenya 14

Figure 3.1: Graphical Representation of Observed, Technically, and Economically Efficient Cost Measures 31

Figure 4.1 Conceptual framework 35

Figure 4.1: Frequency of Technical Efficiency by Farm Size 59

LIST OF ACRONYMS

ADC	Agricultural Development Corporation
AE	Allocative Efficiency
ANOVA	Analysis of Variance
CGA	Cereal Growers Association
CMA	Cereal Millers Association
COMESA	Common Market for East and Southern Africa
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
EE	Economic Efficiency
EU	European Union
FDH	Free Disposable Hull
FAO	Food and Agriculture Organization
GoK	Government of Kenya
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Health Inspectorate Service
MLE	Maximum Likelihood Estimates
MoA	Ministry of Agriculture
NCPB	National Cereals and Produce Board
OLS	Ordinary Least Squares
SFPF	Stochastic Frontier Production Function
SPSS	Statistical Package for Social Scientists
USDA	United States Development Agency
WTO	World Trade Organization

ACKNOWLEDGEMENT

The author thanks Professor Ackello Ogutu and Dr. Richard Mulwa (university supervisors) for their mentoring, guidance and useful comments throughout the completion of the work.

I thank CMAAE (Collaborative Masters in Applied Agricultural Economics) program for providing the financial assistance towards data collection and analysis without which this work would have been difficult to complete.

Special appreciation to Tegemeo Institute for their support in the course of my studies and for the assistance during data collection and analysis.

Sincere thanks to my loving Wife, Peninah and Son, Newton and other family members for their prayers, encouragement and support throughout the entire period of study.

Finally, I thank the Almighty God for giving me the strength and patience to go through the program.

ABSTRACT

The wheat sector in Kenya has been facing several challenges among them declining yields and while self-sufficiency in wheat remains a stated goal of the government, it has remained elusive over the years. The primary objective of this study is to examine the effect of farm size on economic efficiency among wheat producers and to suggest ways to improve wheat production in the country. Specifically the study attempts to estimate the levels of technical, allocative and economic efficiencies among the sampled 130 large and small scale wheat producers in Nakuru District. The social-economic factors that influence economic efficiency in wheat production have also been determined.

This study uses the parametric stochastic efficiency technique that follows the Kopp and Diewert (1982) cost decomposition procedure to estimate technical, allocative and economic efficiencies. Its advantage lies in the application of a stochastic frontier model with a disturbance term specification that captures noise, measurement error and exogenous shocks beyond the farm. The two-step regression model has been used to analyze the effects of the social-economic factors on economic efficiency using a censored tobit model. Results indicate that the mean technical, allocative and economic efficiency indices of small-scale wheat farmers are 85%, 96% and 84% respectively while for the large-scale farmers the mean technical, allocative and economic efficiency indices are 91%, 94% and 88%. Thus the results from both small and large scale farmers reveal some considerable levels of inefficiencies in wheat production in Nakuru District. The number of years of school the farmer has had in formal education, distance to extension advice and the size of the farm have strong influence on the efficiency levels. The relatively high levels of technical efficiencies among the small scale farmers defies the notion that wheat production in Kenya can only be efficiently produced by the large scale farmers. This study shows that it is possible for small-scale farmers to produce wheat efficiently.

The study recommends that to improve the farmer knowledge and skills there is need for public-private partnerships in the provision of extension services. Reduction in the cost on fuel and spare parts for farm machinery through reduction of taxes and tariffs is critical in increasing wheat production. In the medium/ long term there is need to invest in simple technology machineries to be used especially by the small scale wheat farmers.

CHAPTER ONE: INTRODUCTION

1.1 Global Wheat Outlook

Wheat is grown on more land area worldwide than any other crop and is a close third to rice and corn in total world production. Nearly 36% of the world's wheat production is in Asia, 17% is in Europe and 16% in North America.

Wheat provides 21% of the food calories and 20% of the proteins to more than 4.5 billion people in 94 developing countries. The 'miracle crop' of the 20th century, improved wheat varieties adopted during the green revolution saved millions of lives in South and West Asia, China and Latin America. Wheat's dramatic productivity growth – 3.6% per annum during the 1966-1979 (FAOSTAT, 2010) and production increases in developing countries came from creation and use of high yielding, semi-dwarf varieties and improved cropping practices, along with favourable policies and institutional support. Since then, productivity growth has slowed steadily in wheat slipping to 2.8% during the 1984-1994 and 1.1% during 1995-2005 period. Threatening food security in the many regions where wheat is the main staple, this scenario is worsened by farmers' increasing reliance on rain fed wheat cropping, escalating fertilizer costs, virulent diseases and pests and looming climate change impacts. In the absence of coordinated measures to raise wheat productivity, wheat consumers will pay more than double for the staple food (Rosegrant et al., 2010).

According to the Agriculture Outlook for FAOSTAT 2008, wheat production has increased over the years but it demand has also increased. During the close of season in 2008 wheat stocks were 109.7 million tons. This is the lowest opening stock for wheat recorded since 1982. The increase in demand of wheat resulted in a high unprecedented rise in the price of wheat. The price of average export price of hard winter wheat increased by 56% (from US $ 212 per ton to US $ 331) between 2006 and 2007 while soft red wheat price increased by 72 % (from US$ 176 to US $ 303 per ton) during the same period. Table 1.1 summarizes world demand trends of wheat. Between 2003 and 2009, area under wheat, production and yield per ton of wheat increased by 7.4%, 23% and 14% respectively. The trend from 2003 on area under wheat and yields was an increase up to 2009 while the trend for production indicated a mixed trend declining then increasing.

Table 1.1: World Wheat Production Trends

Year	Area (million Ha)	Production (million MT)	Yield (MT/ha)	Price (US $/ton) US hard wheat	Price (US $/ton) US soft wheat	Price (US $/ton) Argentina Trigo pan
2003	209.9	554.8	2.64	255	-	-
2004	217.6	626.7	2.88	280	-	-
2005	219.7	619.2	2.82	175	138	138
2006	213.3	596.1	2.8	212	176	188
2007	217.9	611.2	2.8	361	311	318
2008	225.6	683.3	3.03	270	201	234
2009	225.6	679.9	3.01	236	183	218

Source USDA FRS Wheat year book tables, International Grain Council 2009

On world supply and demand of wheat Figure 1.1 summarizes the top ten wheat producing countries and the proportion of wheat produced to the total world production. China leads the group followed by India and then USA. The top ten countries produces two third of the world wheat. China, India and the US are the three biggest producers of wheat. Though China and India are the leading producers of wheat due to their population size they are both net importer of wheat. China annual consumption of wheat averages 112,501 metric tons against an average production of 108,712 metric tons while India annual average annual consumption is 65,282 metric tons and produces 65,856 metric tons.

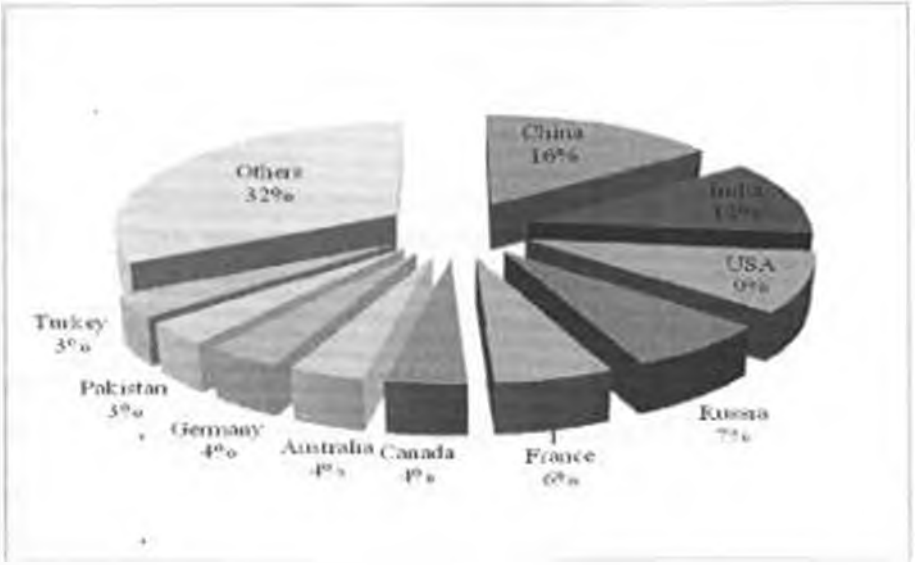

Figure 1.1: The share of top ten wheat producers in the world (2002-2008) Sources: USDA, 2010; International Grain Council, 2010

On the world wheat trade the USA is the country leading in wheat exports followed by Canada and Australia respectively. Based on annual average metric tons of wheat exported between 2002 and 2008 USA exported an annual average of 27.08 million metric tons, Canada exported 14.4 million metric tons while Australia exports were 15.2 metric tons (USDA, 2008). Figure 1.2 summarizes the average annual export from the leading exporters from 2002 and 2008.

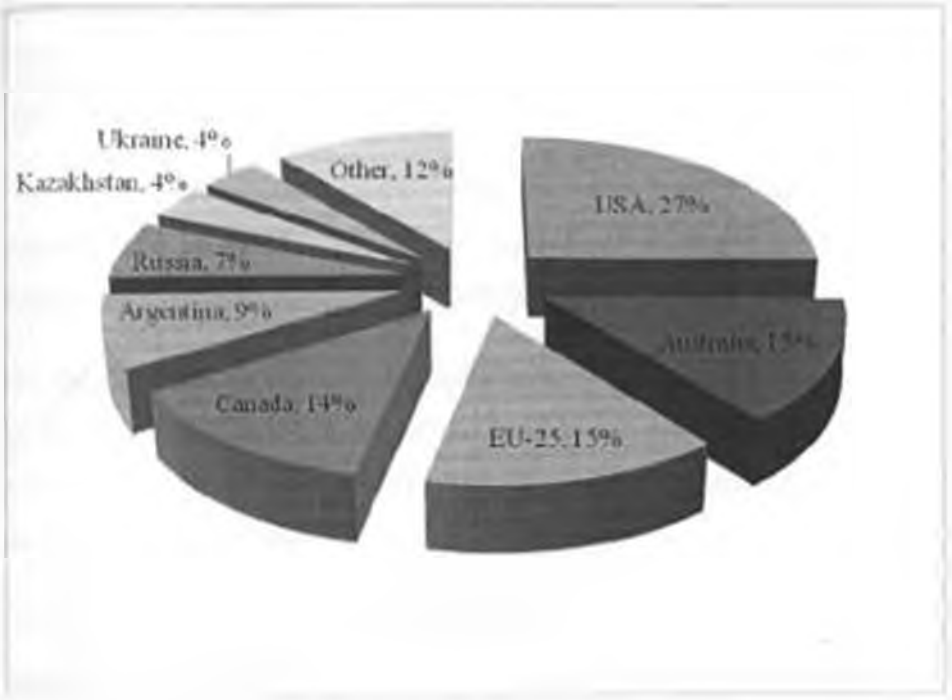

Figure 1.2: The share of the annual world export by the top exporting countries (2002-2008)
Sources: USDA, 2010; International Grain Council, 2010

As indicated on Figure 1.1 and 1.2 Russia is a key player in wheat trade, it's the world's fourth largest producer and the sixth largest exporter of wheat. Russia was affected by drought in 2010 which destroyed a substantial proportion of wheat in the field. It is estimated that the production will reduce by 38%, thus the Russian government imposed an export ban on wheat. The imposing on the export ban has had an effect in the world price of wheat which rose by 44% (from US$ 176 to US$ 254) and a five percent decline in world production. Though the import ban in Russia has affected the world prices it comes against the backdrop of two

bumper harvest that has resulted in an increase in world closing stocks. According to the International Grain Council and USDA the global stocks at end of the marketing year 2009/10 was 194 million metric tons, 70 million metric tons more than in 2007/08 during the high food prices crises. A supply response is expected for spring wheat in the South America in particular Brazil and also in Australia. There is also a shift from importing from the USA to Australia and Argentina by major importing countries such as Egypt. In the short run the price of wheat will continue to rise though steadily the increase are smaller compared to the increase during the food crises of 2007/08 when it picked to US$ 510 per ton. Though the global picture is not gloomy following the export ban this is not good news to countries that are net importers of wheat Kenya included as they will have to increase their import bill to meet their food requirements.

On average, each person in the world consumes 68.2 kilograms of wheat each year. This is equivalent to about 630 calories per day per person or one-third to half of the minimal energy requirements of most adults (FAO, 2007).

As shown earlier USA is the top of wheat exporter. Wheat plays an important role in the US as it's the fourth most produced commodity after maize, cow milk and soybeans. Between the period 2000/01 and 2009/10 both harvested and yield of wheat exhibited a mixed trend as summarized on Table 1.2.

Table 1.2: Wheat production trends in the US

Year	Planted area (million hectare)	Harvested area(million hectare)	Production million (MT)	Yield (MT/hectare)
2001/02	24.06	19.62	525.81	26.8
2002/03	24.42	18.55	433.59	23.37
2003/04	25.16	21.48	632.99	29.47
2004/05	24.15	20.23	582.33	28.79
2005/06	23.16	20.28	567.9	28
2006/07	23.21	18.95	488.27	25.77
2007/08	24.48	20.65	553.79	26.82
2008/09	25.58	22.55	674.77	29.92
2009/10	23.94	20.19	598.37	29.64

Source: USDA, 2010

The US government has spent US$ 22.5 billion in subsidy to wheat farmers between 1995 and 2006 this translate to an average of US$ 1.83 billion per year (US Farm Subsidy data base, 2008). In the US the agricultural policy has been focused mainly on the income support measure which affects consumers and producers prices and the level of production. These measures are influenced by the US Food and Agricultural Act. Through intervention measures such as flow of production across borders and price support programmes have resulted in surplus production in wheat, feed grains, dairy products, cotton and rice. US consume about half of the wheat produced and export the rest. The cost of production in the US is summarized on Table 1.3. Input costs (fertilizer and herbicide) consisted of half of the cost of wheat cultivation and levies were the least.

Table 1.3: Proportion of total cost of wheat production in the US

Item	Proportional cost (%)
Fertilizer	32
Contract Harvesting	20
Sowing	18
Herbicide	18
Crop Insurance	6
Levies	3
Cultivation	3

Source: USDA, 2008

1.2 Regional Wheat Outlook

Africa imports about 9 million tons of wheat a year (more than 80% of what it needs) and this gap is predicted to increase steadily in the future. Poor consumers in Africa and elsewhere are particularly vulnerable to price increases (FAO, 2007).

In Africa Egypt is the dominant country with respect to imports of wheat. The country has the highest per capita consumption of wheat in the world (180 Kgs). Wheat is a key staple food crop and it occupies 33% of total winter crop area, accounts for 9% of water resource and

[1] An example is the 1985 US farm bill that provides a $100 per ton subsidy to wheat farmers. In supporting the wheat farmers the US government has *provided fixed decoupled payments* (payment not tied to production or crop yield) and *counter-cyclic assistance payment* (payment tied to per-bushel pound target price). The subsidy given to the producers depends on their past production. The USDA Fact sheet of 2008 *fixed decoupled payment* was given at a rate of $0.52/bushel[2] while *counter cyclic payment* was $3.92/bushels.

contributes to 17% of total value added in Egyptian agriculture. It also provides 34% of total daily protein consumption and one-third of daily calories intake (Siam and Andre, 2007). According to the International Food Policy Research Institute (IFPRI) crop production and yields have recorded a significant growth in Egypt after the sub-sector was liberalized in 1987. Though the country has the highest per capita consumption of wheat it is not able to meet its consumption needs thus deficit met through imports. The area allocated to wheat

Production in the Nile valley and the delta is not adequate to produce for it population given that 90% of Egypt is a desert. Thus Irrigation plays an important role in the country's agriculture. Out of the 3.3 million hectare of arable land, a quarter has been reclaimed from the desert though the reclaimed land adds about 7% of the total value of agricultural production (Guven and Ibrahim, 2009). Between cropping years 2005/06 and 2008/09 the country produced an average of 8.1 million metric ton of wheat while consumption during the same period was 15.6 million metric tons. Thus Egypt imported 48% of its yearly requirements during this period. The annual cost of wheat exported were US$ 1.2 billion (USDA, 2009). Though the country imports almost half of the wheat produced, local production of wheat is still strategic to the Egyptian government. To encourage local wheat production the Egyptian government has undertaken several measures and these includes; provision of moderate subsidies on agricultural production that are below the level allowed by the World Trade Organization WTO; price control on a number of agricultural commodities including wheat; payment of high prices to local producer; and encouraging expansion of area under wheat and the growing of high yielding variety by the local producers[1]. The government efforts to increase local wheat production have been successful. Between 2002 and 2007 the acreage under wheat in Egypt increased by 11%, production rose by 24 % while yield per hectare averaged at 6.5 ton (Table 1.4).

Table 1.4: Wheat production trends in Egypt

YEAR	Area (ha) '000	Yield (MT/ha)	Production (MT)
2002	1030	6.4	6,564
2003	1053	6.5	6,254
2004	1095	6.6	6,624
2005	1254	6.5	6,844
2006	1287	6.4	7,177
2007	1139	6.5	8,140

Source: FAOSTAT and USDA, 2009

Though Egypt is a net importer of wheat, it is a major exporter of milled wheat in the COMESA region. Egypt is able to benefit from the Regional Trade Agreements (RTA) between the COMESA states that is discussed on the Rule of Origin[2]. The quantity of milled wheat imported from Egypt to COMESA region between 2003 and 2007 increased from 179 tons to 7,153 tons (FAOSTAT, 2008). The cost of production of wheat in Egypt is summarized on Table 1.5. Input costs comprise of the highest costs 46%. In Egypt unlike in the US cost of production included rental for equipment and land.

Table 1.5: Proportion of different activities to total cost of wheat production in Egypt

Item	Proportional cost (%)
Hired labor	27
Fertilizers	23
Equipment rental	20
Seeds	13
Land rental	7
Agro-chemicals	5
Other inputs	5

Source: IFPRI/MALR-EWFS (1999)

Table 1.6 shows the regional trade (exports) of wheat flour/meal and wheat Exports by COMESA member countries are shown in bold. From the table, COMESA member countries that have exported significant amounts of wheat flour and related products in recent years (from 2002) include Mauritius (the leading exporter), Egypt, Kenya, Zambia and Uganda. Kenya's exports were significant in 1998 valued at about US$ 16 million but this sharply declined to US$ 408,000 in 2002. On the other hand, exports from Mauritius have continued to increase from a value of US$ 4.5 million in 1998 to about US$ 7.2 million in 2002. Exports from Egypt show a mixed performance having risen from US$ 417,000 in 1998 to about US $ 4.4 million in 1999, dropped to only US $945,000 in the year 2000 but rose again in 2001 to a value of about US$ 4.4

[2] Under this rule goods eligible for duty-free treatment are those that meet the following requirements, goods are wholly produced or obtained in a member State; imported materials used in the production of the final good and does not exceed 60% of the total cost of all the material used in their production, a minimum of 35-40% domestic value added of the ex-factory cost of goods is achieved, if goods produced in member states are classified after the manufacturing process under a tariff heading other than the one under which they were imported, and a minimum of 25% domestic value added of the ex-factory cost of goods is achieved for goods of particular importance to the economic development of the member states

million. In the year 2002, Egyptian exports of wheat flour and related products remained significant at US $ 1.6 million. From the table, the rapid decline in Kenya's exports of wheat flour and related products indicates that the country has faced stiff competition and to some extent lost competitiveness in the products.

Table 1.6: Regional Exports of Wheat Flour and Meal Wheat 1998-2002 for selected African countries

Country	1998 US$ '000	1999 US$ '000	2000 US$ '000	2001 US$ '000	2002 US$ '000
Mauritius	4,537	3,852	5,367	6,856	7,217
Egypt	417	4,375	945	4,366	1,614
Mozambique	-	33	-	425	-
Kenya	**16,058**	**6,060**	**2,632**	-	**408**
Guinea	-	-	-	573	383
Zambia	14,095	1,133	1,124	778	255
Zimbambwe	-	10,493	5,912	229	-
Botswana	-	-	61	151	-
Uganda	400	84	112	58	123
Ghana	2,560	390	16	13	-
Cameroon	-	-	167	173	9
Cent. Af.Republic	947	3	-	-	-
Malawi	-	341	8	1	-
Cote D'voire	1,352	646	164	-	0

Source ITC- International Trade Statistics http://www.intracen.org/tradestat/sitc3-3d/ep046.htm

1.3 Kenya's Wheat Production

The Kenyan wheat sector is unique in African agriculture. The Central and Rift Valley Provinces are perhaps the only areas in Africa which have the agro-climatic conditions necessary for successful use of modern, high-yielding, wheat varieties. Relatively large-scale farming and state-of-the-art techniques have been used throughout most of the twentieth century. Kenya has collaborated in scientific endeavors to invent and implement new mechanical, chemical and biological technology. Yet the green revolution, which transformed much of Latin-American and Asian wheat agriculture, has had a relatively minor effect on Kenyan wheat production. For example, Kenya was a net exporter of wheat throughout the late 1960's and early 1970's and currently Kenya is still importing wheat to meet domestic demand.

In Kenya, wheat is the second most important crop after maize with regards to both production and consumption. The wheat industry is made up of about 20 millers and supports about 9,000 farmers. It contributes 1.4% and 30% to overall and cereal GDP respectively (Barasa, 2004). It provides employment to over 500,000 people through linkages with several sectors such as transport, storage and the distribution services. The industry contributes over Ksh. 20 billion and supports about 11.3 % of the national population. Wheat production in Kenya is carried out by small, medium and large scale farmers. The country produces an average of about 300,000 metric tons annually. Out of the total wheat produced medium and large scale producers' accounts for 75% of total wheat produced (Table 1.7). The national average yield as shown on Table 2.8 stands at 10 bags per acre (2 tons/ha). These yields are quite low compared to Egypt whose productivity is three times higher (6.5 tons/ha).

Table 17: Structure of wheat farming in Kenya

Scale of operation	Yields(bags/acre)	Metric tons	% of total production
Small scale	6	75,000	25
Medium scale	9	90,000	30
Large scale	16	135,000	45
Total National	**10**	**300,000**	**100**

Source: Nyoro and Muyanga (2005)

Kenya is a high cost wheat producing country. It is under this condition that the country requested COMESA for wheat safeguard so that it could address competitiveness of the sub-sector and also challenges facing the sub-sector. The country was granted safeguard of up to May 30th 2005 which got extended to December of 2009. Under the safeguard regime imported wheat attracted 35% import duty while white flour attracted 65%. Import duty. With the lapse in safeguards and to be in line with the EAC agreement the Ministry of Finance during the 2010/11 budget speech announce a reduction of duty on imported wheat to from 35% to 10%.

The country is currently producing about 40% of its total requirements and the deficit is met through imports (Nyoro and Muyanga, 2005; Economic Review of Agriculture, 2010). Between 2003 and 2009 the area under wheat production and productivity has almost remained the same although consumption and importation has increased by 21% and 55% respectively. The country expenditure on imported unmilled wheat increased by 128% between

2003 and 2008 this was as a result of increase in the price of wheat in the global market (Table 1.8).

Table 1.8: Wheat production and demand trends in Kenya

Year	Area (Ha)	Production (tons)	Yield (bags/ha)	Price (Ksh/bag)	Consumption (tons)	Imports (tons)	Value imports (Ksh.billions)
2003	151,135	379,034	28	1,718	883,120	502,115	6.01
2004	145,359	397,005	29	1,995	889,020	404,060	6.75
2005	159,477	365,696	25	1,639	893,120	621,839	7.96
2006	150,488	358,061	26	1,714	903,120	650,400	8.02
2007	104,176	354,249	28	3,000	892,000	564,300	9.71
2008	130,273	336,688	11.3	2,600	853,000	538,500	13.94
2009*	131,594	219,301	18.5	3,571	1,072,000	781,700	

Source: Department of Land and Crops Development and Management 2010.NCPB. 2009.Statistical Abstract, 2010 Provisional*

According to the Ministry of Agriculture, Kenya has the potential to produce over 700,000 MT of wheat per year. This can be achieved through expansion into non-traditional wheat growing areas, substitution of competing enterprises such as maize and dairy by wheat, improved yields through adoption of higher yielding varieties and application of improved agronomic practices, among other factors. As shown on Table 1.8 the country imports increased by 55% between 2003 and 2009. Kenya has been mainly importing it wheat from Argentina, USA, Ukraine, Russia and other [1] countries. The proportions of wheat imports from the main countries have differed over the year. Figure 1.3 summarizes the proportion of imported wheat by countries to the total imported wheat between 2004 and 2007. Argentina was the main source imported wheat in 2004 and 2005 during 2006 imports declined but increased in 2007 although the proportion was smaller. From 2005 Russia and Ukraine emerged as a source of imported wheat and the proportion increased. Imports from the US were constant though increased from 2006.

[1] Iran, Romania, Canada, Uruguay, United Kingdom, Ethiopia, Tanzania, Antigua & Barbuda, Australia, Brazil, Bulgaria, CzechRepublic, Egypt, France, German Japan, Italy, Kazakhstan, Lithuania, Netherlands, Pakistan, Singapore, Slovakia, Swaziland, Uganda, UAE

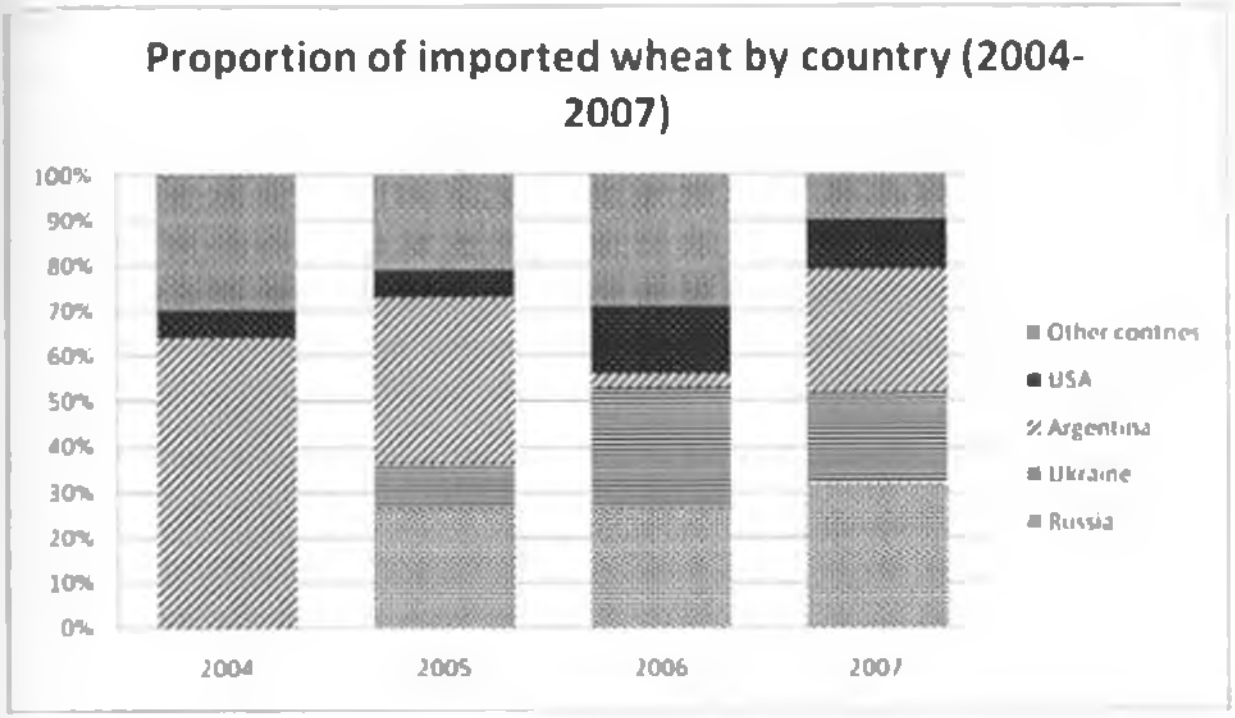

Fig 1.3 Proportion of wheat imported into Kenya by country of origin. Source: FAOSTAT 2008, Author's computations

With the export ban in Russia discussed earlier the country will have increase the shares from Argentina, Ukraine, USA and from other countries to be able to meet it requirements and the increase in the price will increase bill spent on imports. Table 1.8 shows that the country expenditure on imported wheat increased by 128%. With the export ban in Russia the increase in the world prices will further exacerbate the situation locally as the expenditure on imported unmilled wheat will have to increase and this has an implication on food security in the country.

1.4 Kenya's Wheat Consumption

Wheat is increasingly becoming an important source of food in Kenya. Increased demand is driven by a rapidly growing population, increased urbanization and rising incomes and a change in food preferences from traditional cereals towards wheat and wheat products (Government of Kenya, 2007).

Wheat and its by-product have gained importance in the households' consumption patterns in the last decade. In 2005 wheat and it by-products accounted for 44% of total expenditure of main staple in urban areas, up from 35% in 1995 (Muyanga, *et al* 2005).

Domestic demand is growing at the rate of 7 % per year, and even though production is increasing marginally, only about 40% of domestic consumption requirements are being met. The per capita wheat consumption in Kenya averages 27 kg per year per person. Despite the efforts made by the wheat breeders in developing new high yielding varieties during the past three decades, wheat production in Kenya remains short of demand and thus import has been the only alternative to fill the gap. Until 1974, Kenya was a net exporter of wheat but since then the country has had to import wheat to meet a high and rising local demand thus Kenya is a net importer (Hassan *et al.*, 1993). The most important type of imported wheat is the hard wheat, the type used for making bread or blending with the local soft types. The soft wheat is used mainly for home baking.

1.5 The wheat value chain in Kenya

The wheat industry has linkages to several sub-sectors including animal feed production for the dairy and poultry industries and service sectors of transport, storage, warehousing and distribution. The entire industry contributes over Ksh 20 billion and employs over 500,000 people in animal feed industry, transport sector, storage and distribution services. The entire wheat industry supports the livelihoods of about 3.5 million Kenyans or about 11.3 percent of the national population. Kenya's wheat farmers are entirely dependent on local millers as the only market for their produce (Nyoro *et al.* 2005)

The value chain in the wheat industry is made up of various players inter-linked as summarized on Figure 1.4. In Kenya the public institution mandated in the development of the seed is the Kenya Agricultural Institution (KARI) private seed companies also do develop their seed. Key institution mandate with regulating the seed sector is the Kenya Plant Health Inspectorate

Services (KEPHIS). Seeds produced have to meet requirements set by KEPHIS. Between 1985 and 2008 KARI has released 21 varieties for wheat. The distribution of the seeds and other inputs such us fertilizers and chemical are distributed to the farmers through input suppliers (agro-dealers) that are spread out in major & small towns and shopping centers in the rural areas.

There are various small scale traders operating in the region where wheat is grown. The small scale traders uses pick-up as the mode of transport to collect wheat from the producers. There are also large scale traders who also double as transporters along the chain. These large scale traders also double as transporters of wheat. Supermarkets have developed in the country and they have several chain, also wholesaler/distributors purchases milled wheat and sell it directly o the consumers while the bakeries does value addition to produce bread, cakes biscuits etc among other by-products. There are several major bakeries that purchase the wheat in order to manufacture bread, and other wheat products.

1.5.1 Milling Capacity and Wheat Types

According to Cereal Miller Association (CMA) there are 23 millers large scale miller and about 100 medium scale millers across the country. On average they mill 770,000 metric tons of wheat per year this comprise 270,000 metric tons of local and 500,000 ton of imported wheat. The installed milling capacity for large scale millers is estimated at 3,600 tons of wheat per day. At this rate capacity utilization is at of 59 percent. The average age of installed mills range between 10-15 years with a milling efficiency extraction rate averaged at 76 percent (Nyoro and Muyanga, 2005). The wheat milling industry contributes Ksh. 10 billion to GDP and employs over 5,000 people directly. The mills are situated in the major towns of the country (Nairobi, Mombasa, Nakuru and Kisumu). The utilization of the milling capacity is low (estimated at 30 to 60 percent). Most of these mills were established to mill maize and wheat as their core line of business. Over time, some have diversified into baking bread and cookies, and manufacturing of animal feeds from milling by-products.

Figure 1.4: Wheat value chain in Kenya

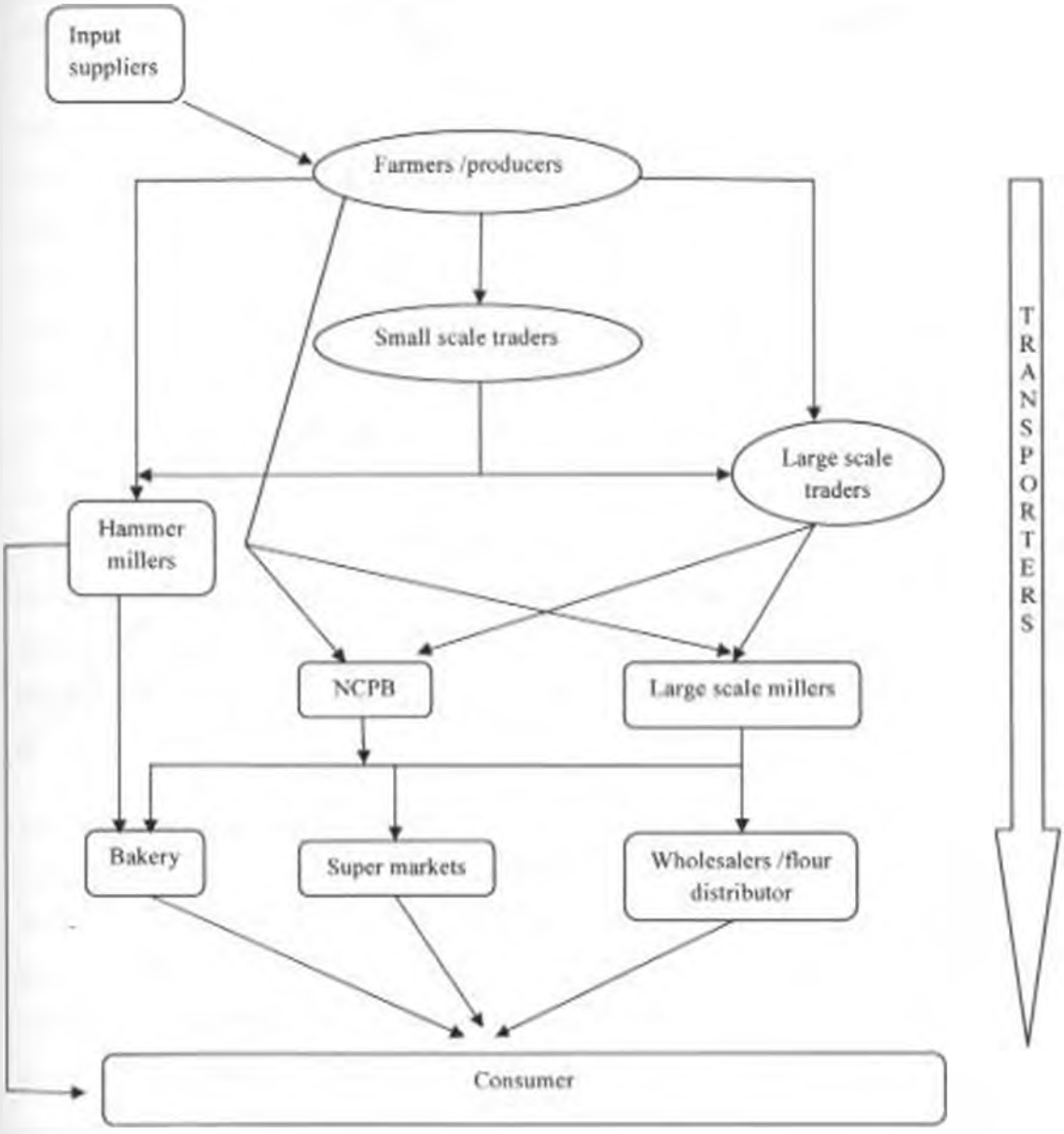

Figure 1.4: Wheat value chain in Kenya

Kenya domestic production consists of about 60 percent Soft wheat. The Wheat Millers Association (WMA) has made a commitment to buy all domestic wheat supplies before going into the import market to avoid government's imposition of suspended duties on wheat imports.

Therefore, for every miller there is a portion of domestic wheat that they have to buy from local farmers as a social obligation. The CMA negotiates with the Cereal Growers Association (CGA) with respect to the wheat producer price annually on the basis of quality (Nyoro *et al* . 2005)

Soft wheat has a very low level of gluten, a substance required to raise dough quality of flour. For this reason, Soft wheat is usually blended with hard wheat to produce quality flour. In addition, Soft wheat has a very low extraction/conversion rate of around 40 percent. For commercially viable wheat, the extraction rate should be around 70-80 percent. Therefore, locally grown soft wheat is blended with hard wheat at a ratio of 40:60 percent to make quality flour. Millers access soft wheat locally from Kenyan farmers and normally import hard wheat as it is produced in very small quantities domestically. However, some Soft wheat is also imported.

To avoid tying a lot of funds in raw material stocks (hence affecting cash flow and building large storage facilities), most millers import wheat on a quarterly basis. Most wheat importers prefer negotiating for credit with exporters and other offshore financiers and paying back after selling the wheat. This makes imports more attractive than domestically sourced wheat. The differences in prices, freight costs, quality and government policy in these countries can be used to explain the relative differences in the amounts of wheat imports (Nyoro *et al* . 2005).

1.5.2 Intra-regional Trade in Wheat Products

Compared to other countries in the region, Kenya has an edge in the supply of wheat products because the country has a relatively well-developed domestic milling industry for wheat and manufacturing industries for wheat products. Thus, the country has a reasonable competitive advantage in supplying the region with wheat products. However, since production of wheat grain in the region is very low, the region will to a large extent depend on wheat imports.

Despite the advantage Kenya has in manufacturing wheat products and the potential large market for wheat products in the COMESA region (350 million people) the country has the highest duties on wheat compared to other countries in the COMESA region such Egypt and Mauritius (zero duties on wheat imports) (Nyagito,2002).

The duties on wheat imports have made Kenyan wheat products less competitive in the regional markets and thus leading to reduced growth of demand for local wheat products. With low

relative duties on imported wheat products (currently at 10 percent with no suspended duty), traders have increased imports of finished wheat products (flour and biscuits) from Europe and Asia. However, since Kenya is a member of the World Trade Organization (WTO) and has trade agreements with the European Union under the African Caribbean Pacific (ACP)-European Union (EU) Cotonou Agreement, the imposition of duties on wheat imports will diminish in the long run since these agreements require lowering of tariffs (Nyoro *et al* , 2005).

1.6 Problem statement

Though the country has a potential of increasing the production of wheat, the industry lacks competitiveness as it is faced by several challenges. A study by Nyoro *et al.*, (2005) identified some of the problems facing the wheat industry in Kenya that includes the following:

Farm inputs- after liberalization, the cost of farm inputs has been going up pushing up the cost of production. Stagnation in production technology, lack of high quality seeds in the market and inadequate information on newly released varieties has contributed to the low yields and poor quality wheat produce. Further, the cost of inputs has led to declining use of farm, especially fertilizers and agro-chemicals that in turn has led to stagnation in yields.

Expensive farm machinery- Inadequate land preparation and lack of sufficient farm machinery particularly for harvesting among the small-scale farmers has been a major constraint. There is also unavailability of timely machinery services at the harvesting time problem. Hired farm machinery is expensive.

Poor marketing infrastructure- Inadequate infrastructure development such as roads, railway, storage and inputs supply increasing post harvest costs.

Lack of affordable credit- one of the main problems facing the private sector that has hindered its intervention in the wheat industry has been the high cost of investment capital due to high interest rates charged by commercial banks on loans. The private sector could not easily invest in sectors such as transport, drying, milling, etc as the profitability of such business ventures was not assured.

Land subdivision- inadequate size of holdings to accommodate wheat and other competing farm enterprises such as maize and dairy farming leading to subdivision of land beyond economical units. Other problems include insecurity of land tenure in wheat producing areas due to un-adjudicated land, soil deterioration as a result of monoculture.

Producer price instability- producer price instability and uncertainty following the reduced government intervention in wheat marketing followed by a malfunctioning deregulated cereals' market.

Government policy and low government investment- the government expenditure on the agricultural sector has declined to a low of about 2.5 percent of the total government investment. The producers have also been subjected to high and double fees by the local authorities.

While self-sufficiency in wheat remains a stated goal of the government, it has remained elusive over the years. The average national yields range between 2.0 tons per ha to 2.2 tons per ha which is much lower than the actual potential yield of over 3.0 tons per ha (MoA, 2008). Finding ways of producing wheat in a more competitive manner will reduce the levels of imports and this will release the foreign exchange for use of other essential imports which cannot be produced locally and the fact that only 40% being met from domestic production and with increased demand for wheat products globally this situation could worsen further if Kenya fails to achieve a higher level of growth rate in wheat production and sustain it.

Wheat production is carried out by small, medium and large scale farmers. The small scale farmers are the majority of the producers though they differ in use of inputs, agronomic practices and productivity from the large scale farmers (Nyoro *et al*, 2005). In order to maximize productivity, wheat farmers have to utilize resources efficiently through achieving potential maximum production from available resources, or to achieve a certain level of production through an optimal mix of resources that could help in closing the gap between supply and demand. However, the levels of efficiency among wheat producers and sources of inefficiencies are not known especially among small scale and large scale farmers. Nakuru District being one of the leading wheat growing districts in the country was used as a case study to assess the levels of efficiency among the different wheat producers. The analysis of economic efficiency provides

a researchable problem for wheat farming in the district. There is a shortage of information in this area and there is need to provide baseline results, findings and implications.

1.7 Objectives of the Study

The general objective of this study is to examine the effect of farm size on economic efficiency among wheat producers in Nakuru District and to suggest ways to improve wheat production in the country.

The specific objectives are:-

- To estimate the levels of technical, allocative and economic efficiencies among the large and small scale wheat producers in Nakuru district.
- To assess the effect of farm size on technical, allocative and economic efficiency
- To determine socio-economic factors influencing efficiency among small and large scale wheat producers.

1.7.1 Hypotheses tested

The following null hypotheses will be tested;

H_0: Farm size has no effect on economic efficiency

H_0: None of the identified socio-economic factors influence efficiency

1.8 Justification of the Study

Measuring economic efficiency in wheat production is important for a number of reasons. First, the wheat sub-sector is important in terms of farm incomes to the rural economy. With the growing demand for wheat and increasing prices the farmers stand a better chance to raise their incomes. The higher prices should reward farmers with greater profits and better livelihoods.

Second, the wheat sector is under increasing regional and international competition, which is a major concern, for only efficient farms are likely to stand the competitive pressure from the efficient producers. In view of growing competition and high production costs, production efficiency and profitability will become increasingly important determinants affecting the future of wheat industry in the country.

Third, in addition to developing and adopting new production technologies, the wheat industry can maintain its economic viability by improving the efficiency of existing operations with given technology. The study will provide information to help producers utilize resources more efficiently and to assist the industry becoming more competitive.

Finally, a study that addresses issues on economic efficiency in wheat production in Nakuru District is important because, to the author's knowledge, limited studies have investigated these issues. By providing empirical evidence, this study will serve to fill the knowledge gap that exists today, regarding the levels of economic efficiency among different wheat farmers in the District.

1.9 Limitations of the study

Due to the limitations of time and finances, the study was carried out in Rongai and Ngata divisions instead of all the wheat growing divisions in the District.

This thesis is organized into chapters. Chapter two provides a review of the relevant literature. Chapter three presents the empirical models utilized. Chapter four presents the data, and provides statistical results and discussions of the dependent and independent variables used in the analysis. Chapter five discusses the summary, conclusions and policy implications of the research.

CHAPTER TWO: LITERATURE REVIEW

2.1 Wheat Marketing in Kenya Before and After Reforms

This first section discusses the wheat marketing before and after liberalization and how this has affected wheat production.

The pre-liberalization period

Kenya was among African countries that believed right at independence that the most effective way of modernizing agriculture and improving the welfare of producers and consumers was through direct state intervention. Thus, in most of the 1960's and up to the mid 1980s the government maintained its presence in agriculture through controls on marketing, credit and inputs. The marketing of essential staple food items, especially wheat, maize, beans, milk and sugar was tightly regulated by the government. By controlling the marketing of these crops, the government sought to protect consumers, especially in urban areas and producers from exploitation by middlemen. The government also sought through price controls to stabilise the prices of agricultural commodities and farm inputs (Makanda *et al* , 1993).

The cereals market in Kenya was controlled by the government through a host of state regulations and controls introduced over time. These included restrictions on movement of produce across districts, price controls and more importantly the requirement that the produce be sold directly to the state marketing boards. In the case of wheat, all produce was to be sold to the National Cereals and Produce Board (NCPB).

The National Cereals and Produce Board (NCPB)

The NCPB was charged with the function of marketing and distribution of cereals as a monopoly. The specific objectives of NCPB were:

- To improve the economic position of agricultural producers by ensuring that they received fair prices for their produce;

- To protect consumers especially those in urban centres;
- To raise the bargaining power of producers in both domestic and export markets;
- To shelter producers and consumers from price instability;
- To improve market organization through quality regulation, packaging standards, acceptable market conduct (rules of the game); and
- To obtain funds for research, sales promotion, extension and other services.

The NCPB operated through numerous depots and buying agents spread all over the country. The agents were paid a commission on each bag of wheat or maize they purchased to cover the costs of collection, storage, hulking, payments to the farmers and transportation. In some regions, NCPB used cooperative institutions and especially the giant Kenya Grain Growers Cooperative Union (KGGCU). Large farmers were also in some cases allowed to sell directly to the NCPB with the board reimbursing transport and related costs. The board bought the wheat from farmers at prices announced by the government. This price was established annually before the planting season by a price review team led by Ministry of Agriculture, which collected, collated and analyzed the data and information on the cost of production all over the country as a basis for determining the price for the next season.

NCPB was authorized by law to sell its grains to traders, institutional consumers (including schools and hospitals) and to large millers at officially controlled prices. The millers processed and sold the flour to wholesalers and retailers all over the country. It was illegal for private traders and millers to purchase wheat or maize directly from farmers. Whenever there was not enough domestic wheat or maize production to meet national needs, NCPB was mandated to import. Other parastatal organizations such as the Kenya National Trading Corporation (KNTC) and private firms could also import wheat or maize after acquiring import licenses and authorization from NCPB.

The overall objectives of the NCPB were in many ways noble and largely farmer-centred. The NCPB emphasised measures that guaranteed farm gate prices rather than intervening directly to reduce consumer prices. Farmers were assured of market for their crop and at a guaranteed price.

There was also a government subsidy on transport and farmers did not worry too much about storage as NCPB bought their crop upon being harvested. Thus at the national level, the government core objective was realization of food self sufficiency at the pan seasonal and pan territorial pricing level, at all seasons all over the country.

However, having acquired monopoly status in food procurement, distribution and pricing, the NCPB generally was faced with serious management problems, which partly led to offering services at high costs to the treasury. The Board's management problems contributed to frequent food shortages, inefficiency, and low farm gate producer prices (Makanda *et al*, 1993). Pan-territorial pricing that was widely practised created a number of problems in the economy including reduced incentives for the private sector to invest in marketing. These weaknesses prompted the IMF/World Bank to agitate for the liberalization of the domestic food marketing system. Poor prices brought about by low global prices which impact on the entire marketing chain may have contributed to low investment in the sector. At the national level, low investment in wheat and other cereals' marketing is partly due to poor physical infrastructure, especially the road network, which raises the cost of transportation, the high cost of utilities such as telephone and electrical power (for storage and drying), and insecurity in some parts of the country, as well as the high cost of credit from commercial banks. All these render trade in wheat and other cereals not only unprofitable but also highly risky.

The Post liberalization period

A wave of substantial implementation of agricultural reforms started in 1993. In wheat and other grain marketing, the reforms emphasized restructuring of the NCPB to confine its role to being a buyer and seller of last resort. A combination of three major reform programmes resulted in major changes in the operation of the NCPB. These were:

(i) The removal of the monopoly status of the NCPB in the marketing of cereals

(ii) The removal of control and regulation of movement, purchasing, storage, distribution importation and exportation of wheat and maize by the NCPB

(iii) Relaxation of imports and export controls, depending on surplus and deficit situations. NCPB was no longer the sole importer by law. The private sector was now allowed to be involved independently in imports and exports of grains.

The role of the NCPB has now been reduced to:

- Procurement, maintenance and distribution of strategic grain reserves under agency contract with government
- Undertaking stabilization of the market through purchases and sales of wheat and other cereals in the market on commercial terms.

Under the new regime, farmers are free to sell their wheat to traders or millers directly. The option of selling to the NCPB still remains although farmers have to take the Board's buying price and meet the set quality standards. The challenge, particularly to the Government of Kenya, is how to make the NCPB a more effective player as an independent and commercial organization in the wheat sector as an efficient alternative market outlet for wheat which runs its business with minimum government support. The NCPB like other state trading enterprises, may also fall under scrutiny by the World Trade Organization where trade distorting support by State Trading Enterprises (STEs) is prohibited. However, Kenya being a Net Food Importing Developing Country (NFIDC) should argue for the exemption of the NCPB from since the role of the parastatal goes beyond commercial activities to also ensure food security through enhanced availability of food in marginal areas of the country.

To guard domestic wheat producers against competition from imports, the government has used variable import duties that have ranged between 25 percent and 35 percent. The duties are reviewed after every three months to offer producers protection, for example to discourage imports when domestic production is high, or to increase imports when domestic production is low.

Local producers when bargaining for producer price with NCPB consider the import price inclusive of the import duty as the benchmark. Use of expensive wheat by the millers has led to increased wheat products prices to local consumers and reducing export competitiveness (Nyoro *et al.*, 1995).

This second section describes the concepts of productivity and efficiency variables that can be used to explain changes in productivity and efficiency in a firm.

2.2 Productivity

Productivity is typically measured in discrete units of outputs and inputs. Kumar and Russell (2002) decomposed labor productivity growth into three components: technological change, technological catch-up, and capital accumulation. They measured productivity growth with respect to labor for 57 countries. Technological change refers to a shift in the world production frontier, determined conceptually by potentially transferable technologies.

Technological catch-up refers to movements closer to (or away from) the production frontier as countries adopt the "best practice" technologies and reduce technical and allocative inefficiencies. Capital accumulation refers to movements along the frontier. They found there was substantial evidence of technological catch-up, countries have moved toward the production frontier. Technological change was decidedly non neutral, which made the rich countries richer as compared to the poor countries. Finally, the most substantial finding was that productivity growth was primarily linked to capital deepening, which reflects the tendency to use relatively more capital in the production process.

Willis and Wroblewski (2007) describe a standard Cobb-Douglas model to illustrate the relationship between productivity and compensation:

$Y = A K^{1-\alpha} L^{\alpha}$

where (Y) is the amount of real output, expressed as a multiplicative function of the amount of labor (L) and physical capital (K) inputs. This equation suggests that labor is defined broadly to include the total number of hours worked for everyone in the economy. Capital represents the entire economy's capital resources. The variable (A) refers to a measure of total productivity that makes the inputs of the production process (K & L) more productive. The variable (α) represents the elasticity of the output with respect to labor, which is assumed to be less than 1.In this study the Cobb-Douglas production function is applied for where quantity of wheat harvested is the dependent variable while the input (independent) variables includes quantity of seeds, fertilizers, chemicals and labour used.

2.3 Measurement of Efficiency

The performance of a farm can be measured using the concept of economic efficiency, which is assumed to be made up of two components technical efficiency and allocative efficiency (Kalirajan and Shand, 1999; Bravo-Ureta *et al.*, 1997). Technical efficiency is the ability of a farm to obtain maximum output from a given set of inputs (Ajibefun and Daramola, 2003; Bravo-Ureta *et al.*, 1997; Banker *et al.*, 1984; Charnes *et al.*, 1978; Aigner, *et al.* 1977; Farrell, 1957). Allocative efficiency reflects the ability of a farm to use inputs in optimal proportions given their respective prices. A production process is said to be allocatively efficient if it equates the marginal rate of substitution between each pair of inputs with the input price ratio (Ajibefun and Daramola, 2003; Bravo-Ureta *et al.*, 1997; Farrell, 1957). Neoclassical production theory presupposes full technical efficiency (Tietenberg, 2006; Kalirajan and Shand, 1999). However, it has been acknowledged that there exists a gap between the theoretical assumption of full technical efficiency and empirical reality (Leibenstein, 1966). There is a high likelihood that, where technical inefficiency exists, it will exert influence on allocative efficiency and that there will be a cumulative negative effect on economic efficiency (Kalirajan and Shand, 1999). Following this logic, economic efficiency becomes central to the achievement of high levels of economic performance at the farm level. Since the publication of Farell's (1957) pioneering article on measuring productive efficiency, there have been numerous subsequent studies on the development of approaches to efficiency measurement. The most popular and perhaps the most utilized approaches are the deterministic and stochastic parametric frontiers and the mathematical non-parametric frontiers. The stochastic and deterministic parametric frontiers constitute measures that account for random errors using parametric estimation methods while non-parametric frontiers are non-stochastic utilizing mathematical linear programming estimation techniques.

2.4 Application of Efficiency Analysis

Several studies have investigated the levels of technical and allocative efficiencies on various farm enterprises with different findings as discussed below.

Obare *et al.*, 2010 applied a dual stochastic efficiency technique and a two-limit Tobit model to analyze resource allocative efficiency in irish potato production in Kenya. The paper established

that irish potato production in Nyandarua North district is characterized by decreasing returns to scale with a mean allocative efficiency of 0.57. The paper further established that farming experience, access to extension and credit and membership in a farmers' association positively and significantly influenced allocative efficiency.

Mulwa *et al.*, (2009) used a two-step estimation technique (DEA meta-frontier and Tobit Regression) to highlight the inefficiencies in maize cultivation and their causes in Western Kenya. The study found out that farmers could reduce their input use by about 20-30% and still achieve their current production level. Allocatively, the costs could be reduced by over 50% without affecting production. This input cost saving measures could indirectly increase the farmers' incomes.

Ahmed *et al.* (2002) did a study aimed at determining the sources of technical efficiency in wheat production in Ethiopia. The study used stochastic frontier model to estimate technical efficiency. Variables included in the model were tenure (whether owned or rented), age of household head, education status of the head of household (either literate or illiterate), main occupation of the household head (farming or non-farm activities), size of cultivated land and labour distribution in wheat production. The study found that tenure status significantly influences technical efficiency. More than half of the farmers cultivating wheat on their own plots operate above the average efficiency level compared to less than one quarter for those cultivating on borrowed plots. Beside land tenure systems, several other social economic and resource factors were identified to have an influence on technical efficiency. Technical efficiency was higher for older farmers this was associated with the accumulation of experience over time. Male headed households were found to be more efficient than female headed households and households with more educated heads were found to be more efficient. This study however had its emphasis on wheat production and the results would not be generalized to other enterprises.

Kolawole and Ojo (2007) examined the overall efficiency of smallholder crop farmers in Nigeria. The study used Cobb Douglas production and cost functions to estimate technical and allocative efficiency. The dependent variable was the total value of production and total costs respectively. The finding of the study was that farmers operated under increasing returns to scale

and therefore had the potential of improving their efficiency. The education level of the head of farmer (schooling years), farm size, quantity of fertilizer, age of farmer, credit availability and farming experience of the farmer were found to be significantly influencing technical efficiency.

Off farm income is an important determinant of efficiency. According to Rahman 2003, households who have higher opportunity to engage in off-farm work fail to pay much attention to their crops relative to other farmers and will operate at lower levels of efficiency. However Diao *et al.*, 2006 disagrees with the notion and instead argues that households with more off farm income are able to purchase farm inputs and are therefore more productive. Group membership increases the information flow into the household and also provides access to credit to farmers (Hazarika and Alwang, 2003). This would lead to increased farm efficiency. Access to extension services would enable farmers improve on their farming systems resulting in efficiency in production (Amaza and Maurice, 2005; Battese, 1992). Karagianis and Sarris, (2005), noted that when farmers are using irrigation in crop production, they have higher chances of increasing efficiency. The main reason for this is that they are able to schedule planting and harvesting time and are therefore less vulnerable to crop loss. Parikh *et al* (1995) estimated wheat technical inefficiency in Northwestern Pakistan at 11.3%. He attributed the inefficiency to underuse of hired labour, fertilizer, manure as well as the overuse of animal labour. Azhar, (1991) estimated that one additional year of schooling leads to a 1.28% increase in wheat output of farmers using modern varieties.Bedassa and Krishnamoorthy (1997) used a two-step approach to estimate technical efficiency in paddy farms of Tamil Nadu in India. They concluded that mean technical efficiency was 83 percent. Small and medium-scale farmers were more efficient than large-scale farmers. Battese *et al.*, (1996) used a single stage stochastic frontier model to estimate technical efficiencies in the production of wheat farmers in four districts of Pakistan ranging between 57 and 79 percent. The older farmers had smaller technical inefficiencies. In a study by Wilson *et al.*, (2001) a translog stochastic frontier and joint estimate technical efficiency was used to assess efficiency. The estimated technical efficiency among wheat farmers in Eastern England ranged between 62 and 98 percent and found farmers who sought information, and had more years of managerial and had large farm, were associated with higher levels of technical efficiency.Coelli & Battese (1996) estimated stochastic frontier production functions using panel data from three villages with diverse agro-climatic characteristics in the semi-arid tropics of India. The technical

inefficiency effects in the stochastic frontiers were modelled in terms of farm size, age and education of the farmers and the year of observation. The results indicated a significant inverse relationship between farm size and the level of the technical inefficiency effects in two of the three villages.

Hussain, (1989) estimated wheat technical inefficiency at 31% in Nothern Pakistan noting that efficiency was mainly influenced by factors such as new seed, seed treatment, density and knowledge score. Butt, (1981) estimated that primary education increased wheat productivity by 7% and secondary education by 10.7%. There was strong positive interaction of education and fertilizer use. A major conclusion stemming from these efficiency measures is that there is considerable room to increase agricultural output without increasing input levels and without requiring the introduction of new technology.

Several studies have evaluated the relationship between technical efficiency and socio-economic characteristics of farming households. Older household heads are associated with higher technical efficiency (Kolawole and Ojo, 2007; Amaza and Maurice, 2005; Ahmed, *et al*, 2002; Bravo-Ureta and Pinairo, 1997). Education level of the household head also strongly influences technical efficiency of farms (Kolawole and Ojo, 2007; Amaza and Maurice, 2005; Bravo-Ureta and Pinairo, 1997). Male headed households are more efficient than female headed households (Ahmed, *et al*, 2002; Bravo-Ureta and Pinairo, 1997). The size of the household unit significantly influences technical efficiency. Larger households are associated with higher efficiency than smaller households (Amaza and Maurice, 2005; Bravo-Ureta and Pinairo, 1997). Distance from the household to the access road and to market centers also affects the level of efficiency of farms. According to Binam *et al* 2004, farmers who are nearer to motorable roads are able to purchase inputs and therefore increase their production efficiency. At the same time, they have better flow of information about emerging technologies.

A World Bank (1983) study of the efficiency of small versus large farms in Kenya, using 1973/74 data, found that output per hectare was 19 times higher and employment per hectare was 30 times higher on holdings under 0.5 hectares than on holdings over 8 hectares.

Bagi (1982) estimated stochastic frontier production functions for both small and large farms in West Tennessee. He found that both small and large crop farms had almost equal technical efficiency, but large mixed farms were technically more efficient than small mixed farms.

Berry & Cline (1979) found that the value added per unit of invested capital for the second smallest farm-size group (10 to 50 ha) in the Muda River region of Malaysia exceeded that of the largest farm group (200 to 500 ha) by 65 per cent. Lau & Yotopoulos (1971) applied the profit function approach in their analysis of relative efficiency in Indian agriculture. Profit functions for small and large farms were compared for a given amount of output and input prices with fixed quantities of land and capital. They found that smaller farms had higher profits per unit of land than large farms and concluded that small farms attained higher levels of technical efficiency.

Conclusions from other studies

The evidence on the farm-size efficiency relationship is mixed. It is important to clearly define the terms and methodologies adopted in investigating the relationship between farm size and the efficiency of farms based on the particular region. This study focuses on Nakuru District where small scale farmers are defined as farmers who grow wheat on less than 20 acres and large scale growing over 20 acres as defined by the Ministry of Agriculture in the District .

It is interesting to note that most frontier studies have focused only on technical efficiency, even though it is by improving overall economic efficiency that major gains in output could be achieved. This suggests that additional efforts should be devoted to examining the impact of both allocative and technical efficiency on performance. This paper attempts to fill the gap by examining overall efficiency on wheat production. A notable fact that emerges from this review of the literature is the limited number of studies reporting an analysis between farm size and efficiency. This study will make a substantial contribution on this debate by examining the efficiencies between different wheat farm sizes. In general, most of the efficiency studies on wheat conclude that lack of technical knowledge and education are primary sources of technical and allocative inefficiencies, which implies that increasing the efficiency of input use by improving the farmer knowledge and skills provides a potential for productivity growth in the medium to long term. With studies based on cross-sectional data, however, the estimated effects on the efficiency of wheat production may vary widely depending on the location and time of study Rejesus *et al.*, (2005).

CHAPTER THREE: METHODOLOGY

3.1 Theoretical Framework

Over fifty years ago, Michael Farrell (1957) introduced a methodology to measure economic efficiency *(EE)*, technical efficiency *(TE)*, and allocative efficiency *(AE)*. In this methodology, *EE* is equal to the product of *TE* and *AE*. According to Farrell, *TE* is associated with the ability to produce on the frontier isoquant, while *AE* refers to the ability to produce at a given level of output using the cost-minimizing input ratios (see Figure 3.1). Alternatively, technical inefficiency is related to deviations from the frontier isoquant, and allocative inefficiency reflects deviations from the minimum cost input ratios. Thus, *EE* is defined as the capacity of a firm to produce a predetermined quantity of output at minimum cost for a given level of technology (Farrell 1957; Kopp and Diewert 1982).

Productive units can be inefficient either by obtaining less than the maximum output available from a determined set of inputs (technical inefficiency) or by not purchasing the lowest priced package of inputs given their respective prices and marginal productivities (allocative efficiency). Efficiency measurement can be categorized as either input or output oriented. Input-oriented technical efficiency evaluates how much input quantities can be reduced without changing the quantities produced. The output oriented measures of efficiency estimates the extent to which output quantities can be expanded without altering the input quantities used (Coelli, 1994). Efficiency estimation can best be demonstrated by relating both allocative and technical efficiency for ease of conceptualization. Over the last three decades, Farrell's methodology has been applied widely, while undergoing many refinements and improvements. The model used in this study is based on an extension advanced by Kopp and Diewert (1982) and further modified by Bravo-Ureta and Rieger (1990).

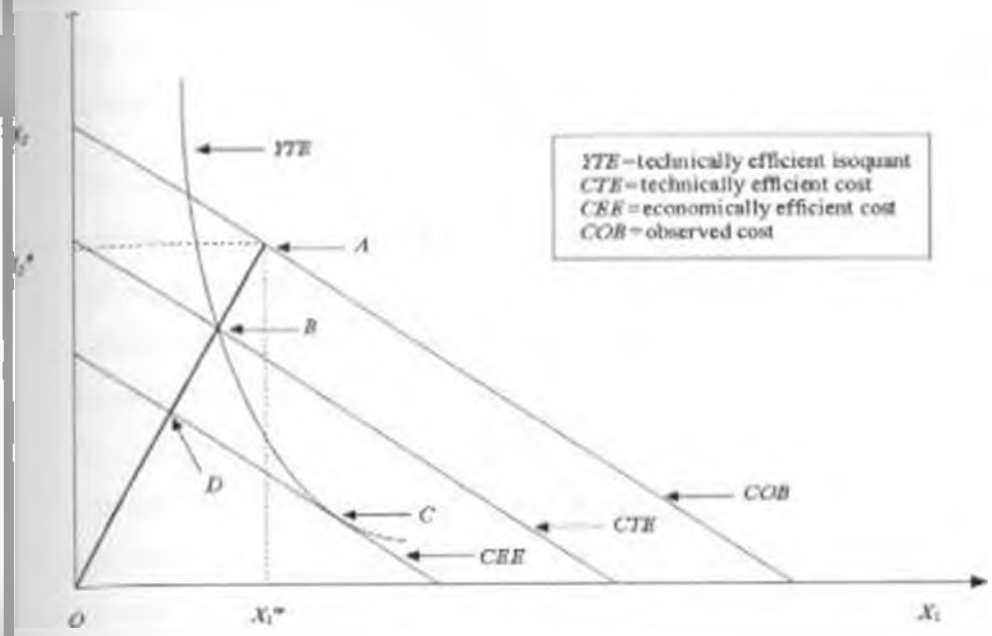

Figure 3.1: Graphical Representation of Observed, Technically, and Economically Efficient Cost Measures

TE, *EE*, and *AE* are equal to:

$TE=OB/OA=CTE/COB$,

$AE=OD/OB=CEE/CTE$, and

$EE=TE*AE=OD/OA=CEE/COB$.

3.2 Efficiency Models

Different models have been used in efficiency analysis. These models can be categorized as non-parametric or parametric approaches. The non-parametric includes the Data Envelopment Analysis (DEA).The parametric approaches include the deterministic and stochastic frontier production functions.

3.2.1 Non-parametric Frontier model

The most popular models under the non-parametric analysis are DEA (Data Envelopment Analysis) and Free Disposable Hull (FDH). In this paper, we will explore the DEA model.

Data Envelopment Analysis (DEA) is a common non-parametric mathematical programming method. This technique uses linear programming to determine the efficiency of each decision-making unit (DMU) and non-parametric because it imposes no functional form on the data. This method seeks to identify those decision-making units that determine an envelope surface hence the term data envelopment analysis. This frontier envelops the efficient units while units below are considered inefficient (Khem *et al.*, 1998). DEA can be either input-oriented or output-oriented. In the input-oriented case, the DEA method defines the frontier by seeking the maximum possible proportional reduction in input usage, with output levels maintained constant for each firm while in output oriented the method seeks the maximum proportional increase in output with input levels fixed (Mulwa *et al.* 2009).

DEA suffers the criticism that it does not account for possible influence from measurement error and other noise in the data. However it has the advantage of removing the necessity to make arbitrary assumptions regarding the functional form of the frontier and the ditributional form of the u_i (Khem *et al.*, 1998).

3.2.2 Deterministic frontier Production Function

The deterministic frontier production function recognizes the existence of technical efficiency by the inclusion of non-negative random errors that account for individual firms not attaining maximum production efficiency. These errors are considered internal to the firm and are therefore representative of any inefficiency within the production system. The deterministic frontier therefore represents maximum output given the current state of technology, and observed outputs for inefficient firms lie below the frontier i.e bounded from above and hence the term deterministic frontier.

$$Y_i = f(X_i, \beta) \quad i=1, 2.....N \qquad \textit{(Equation 3.1)}$$

Where possible production Yi is bounded above by the stochastic quantity $f(x_i; \beta)$.

It was later acknowledged that not all inefficiencies are due to internal random errors but there also exists external influences due to external factors which are beyond the control of the farm. These influences contribute to deviations of frontier output from the estimated deterministic frontier. This is the basis for the stochastic parametric frontier that was later developed to account for these external influences. Further extensions of the deterministic function were required to capture random factors not under the control of the farm (Ilatunga, 2002).

3.2.3 Stochastic frontier production function (SFPF)

The SFPF recognizes the existence of external random errors in addition to non-negative farm specific random errors. This is done by including another error term in the deterministic production function, as independently proposed by Aigner *et al*, (1977) and Meeusen and van den Broeck (1977). They defined the stochastic production function as;

$$Y_i = f(X_i, \beta)\exp(V_i - U_i) \quad i=1, 2.....N \qquad \textit{(Equation 3.2)}$$

Where V_i is a random error having zero mean, which is associated with random factors not under the control of the farm. Possible production Yi is bounded above by the stochastic quantity f (x_i; β) exp (V_i) hence the term stochastic frontier.

The random error V_i is assumed to be random, independent of U_i and identically distributed. U_i is technical inefficient effect, which is assumed to be non-negative random variables, independently (but not identically) distributed.

Aigner, *et al*, (1977) stated that, an important feature of the stochastic frontier production model is the decomposition of the error term e into two independent components. The components are: the traditional random term V_i and the random variable U_i which is associated with the technical inefficiency, as shown:

$$e_i = (V_i - U_i) \qquad \textit{(Equation 3.3)}$$

The component V_i assumed to be normally distributed with zero mean. The component U_i is one-sided and independent of V_i. U_i represents the shortfall in actual output from its maximum possible value, given by the stochastic frontier. In other words, it is distributed half normal or

follows an exponential distribution. U_i is equal to zero for any production unit whose output lies on the frontier and it is greater than zero for any output lying below the frontier. The distribution of the inefficiency components can assume different forms, but it is normally assumed to be distributed asymmetrically.

Several functional forms can be used in the estimation of the stochastic frontiers. Among the commonly used forms are the translog and the Cobb Douglas forms. The translog form allows for variations of output elasticities which avoids the problems associated with constant elasticities (Miller *et al*., 2005; Felmingham and Gang 2004). The Cobb Douglas form is preferred because it is easily interpreted in relation to the production technology (Binam *et al*., 2004) and has been widely used in efficiency estimation studies (Amaza and Maurice, 2005; Asadullah and Rahman, 2005; Baccouche and Mokhtar, 2003; Amara *et al*, 1999). This study uses this stochastic approach to estimates directly the efficiency effects from the functional form.

Estimation of stochastic frontiers can be done using ordinary least square estimation (OLS), generalized least square (GLS) or Maximum likelihood (ML) estimation methods. According to Greene (1980), MLE makes use of the specific distribution of the disturbance term and the estimates are more efficient than OLS estimates The ML estimation method is preferred because of its desirable asymptotic properties of consistency, normality and efficiency. This means that these properties have been proven to hold as the sample size approaches infinity (Long, 1997). MLE was used in this study because of the afore-mentioned merits. The two error terms were assumed to be independent of each other and with the input variables.

3.3 Conceptual Framework

Production is the transformation of inputs into outputs and this occurs in a production process. The process of wheat production occurs within an environment comprising various factors such as the biophysical environment (climate, soils), institutional environment (laws, policies), household use of inputs, farmers' attributes and the economic environment. All these factors define the production potential and determine the maximum possible output from the production process.

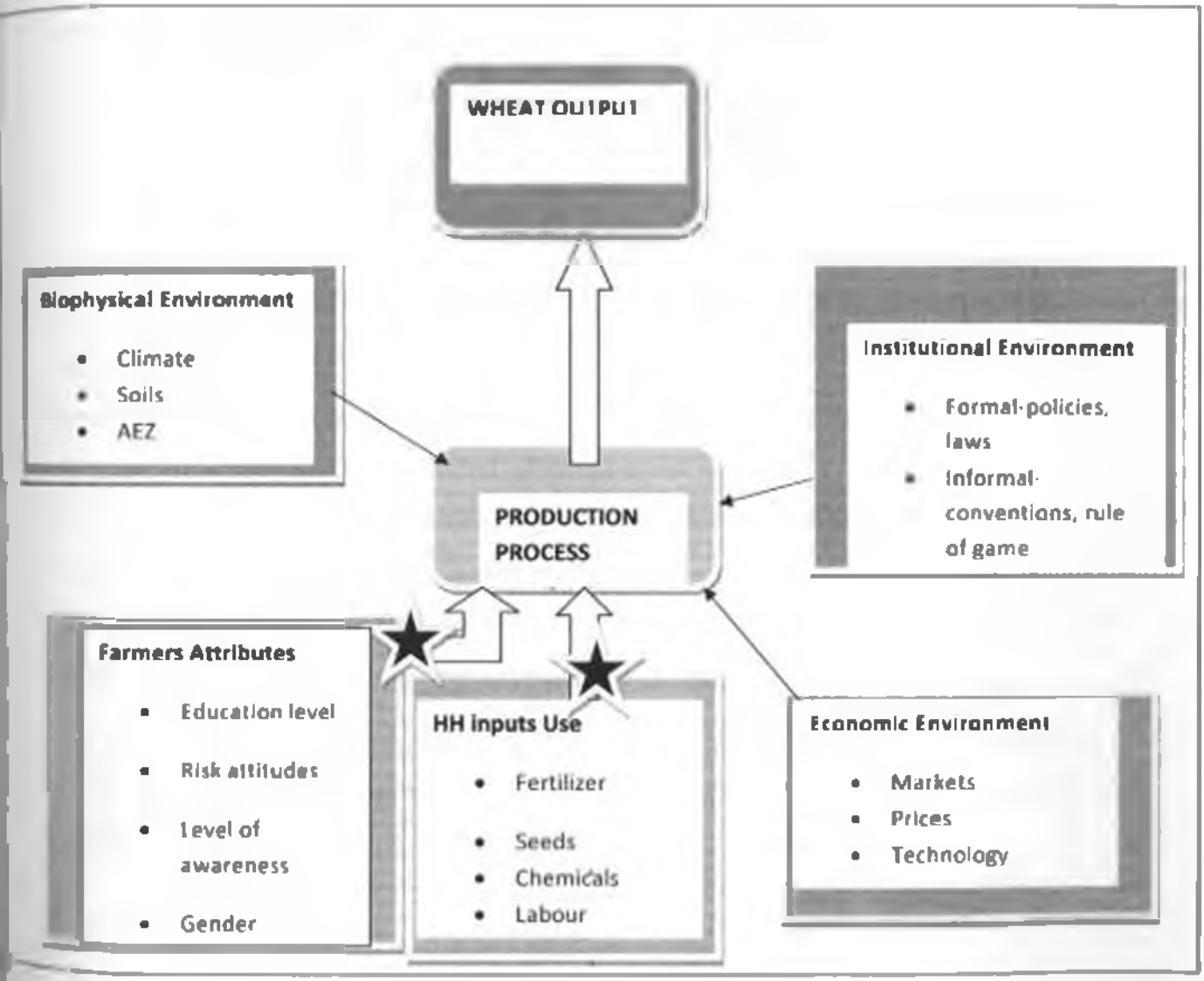

Figure 4.1 Conceptual framework

3.4 Empirical Framework: Stochastic Frontier Production and Cost Functions

As in Bravo-Ureta and Evenson (1994) and bravo-Ureta and Rieger (1991), the parametric technique used in this study follows the Kopp and Diewert (1982) cost decomposition procedure to estimate technical, allocative and economic efficiencies.

The firm's technology is represented by the stochastic frontier production function as follows;

$Y_i = f(X_i;\beta) + e_i$ *(Equation 3.4)*

Where Y_i is the output of the i^{th} farmer

X_i is a vector of input quantities of the i^{th} farmer

β is a vector of unknown parameters to be estimated.

$e_i = (V_i - U_i)$ *(Equation 3.5)*

V are assumed to be independent and identically distributed $N(0, \sigma^2_v)$ random errors independent of the U_i.

U_i are non-negative technical inefficiency effects representing management factors and are assumed to be independently distributed with mean u_i and variance σ^2.

The ith farm exploits the full technological production potential when the value of U_i comes out to be equal to zero, and the farmer is then producing at the production frontier beyond which he cannot produce. The greater the magnitude of U_i far away from the production frontier will the farmer be operating more inefficiently Drysdale *et al.*, (1995).

The maximum likelihood estimation of Eq. (3.4) provides estimators for the betas. The variances of the random errors σ^2_v and that of the technical and allocative inefficiency effects σ^2_u and overall variance of the model σ^2 are related thus:

$\sigma^2 = \sigma^2_v + \sigma^2_u$ *(Equation 3.6)*

The ratio $\gamma = \sigma^2_u / \sigma^2$, measures the total variation of output from the frontier which can be attributed to technical or allocative inefficiency (Battese and Corra, 1977).

Subtracting v_i from both sides of eq.(1) yields;

$$Y^*_i = y_i - v_i = f(X_i;\beta) - U_i) \qquad \textit{(Equation 3.7)}$$

Where Y^*_i is the observed output of the i^{th} firm, adjusted for the stochastic noise captured by v_i.

Equation (3.7) is the basis for deriving the technically efficient input vectors and for analytically deriving the dual cost frontier of the production function represented by Equation (3.4). For a given level of output Y^*_i, the technically efficient input vector for the i^{th} firm, X^t_i is derived by simultaneously solving Equation (3.7) and the ratios $X_1/X_i = k_i$ (i>1) where k_i is the ratio of observed inputs X_1 and X_i. Assuming that the production function in Equation (3.4) is self dual, the dual cost frontier can be derived algebraically and written in a general form as;

$$C_i = f(P_i;\ \alpha, Y^*_i;\alpha) \qquad \textit{(Equation 3.8)}$$

Where C_i is the minimum cost of the i^{th} firm associated with output Y^*_i, P_i is a vector of input prices for the i^{th} firm and α is a vector of parameters.

The economically efficient input vector for the i^{th} firm, X^e_i is derived by applying Shephard's lemma and substituting the firm's input prices and output level into the resulting system of input demand equations;

$$\partial C_i / \partial P_i = X^e_i\ (P_i, Y_i^*\ ;\beta) \qquad i=1,2\ldots..m \text{ inputs} \qquad \textit{(Equation 3.9)}$$

Where β is a vector of estimated parameters. The observed, technically efficient and economically efficient costs of production of the i^{th} firm are equal to $P_i'X_i$, $P_i'X^t_i$, and $P_i'X^e_i$, respectively. These cost measures are used to compute technical (TE) and economic (EE) efficiency indices for the i^{th} firm as follows;

$$TE_i = P_i'X^t_i / P_i'X_i \qquad \textit{(Equation 3.10a)}.$$

$$EE_i = P_i'X^t_i / P_i'X_i \qquad \textit{(Equation 3.10b)}$$

Following Farell (1957), the allocative efficiency (AE) index can be derived from Eqns (3.10a) and (3.10b) as follows;

$$AE_i = P_i'X_i^a / P_i'X_i^t \qquad \textit{(Equation 3.11)}$$

Thus the total cost or economic efficiency of the i[th] firm $(P_i'X_i - P_i'X_i^e)$ can be decomposed into its technical $(P_i'X_i - P_i'X_i^t)$ and allocative $(P_i'X_i^t - P_i'X_i^a)$ components.

3.4.1 The Production Function

The specific Cobb-Douglas[4] stochastic frontier model used in the analysis is defined in Equation (3.12) as follows.

$$\ln Y_i = \beta_0 + \beta_1 \ln fert_1 + \beta_2 \ln seed_2 + \beta_3 \ln chem_3 + \beta_4 \ln foliar_4 + \beta_5 \ln hlab_5 + \beta_6 \ln flab_6 + V_i - U_i$$

(Equation 3.12)

Where ln represents the natural logarithm

Y_i represents the wheat output (in kg) of the i[th] farmer per acre

$fert_1$ represents the quantity of fertilizer used in kg per acre

$seed_2$ represents the quantity of seeds used in kg per acre

$chem_3$ represents the quantity chemicals used in kg per acre

$foliar_4$ represents the quantity of foliar used in litres per acre

$hlab_5$ represents cost of hired labour per acre

$flab_6$ represents the imputed cost of family labour per acre

β_i represents parameters to be estimated

V_i is the random error

U_i is inefficiency measure.

U_i is the non-negative truncation (at zero) of the normal distribution with mean, μ_i and variance σ^2

[4] *The Cobb-Douglas form is chosen because the methodology used requires that the production function be self-dual. Despite its limitations, the Cobb-Douglas is found to be an adequate representation of data*

The variables specified in the model were subjected to a correlation test that showed that all the variables were not highly correlated (see annex 1). This validated the production model specified as proper and reliable.

3.4.2 The Cost Function

The corresponding dual stochastic frontier cost function which is the basis of estimating the allocative efficiencies of the farmers is specified as follows;

$$C_i = f(P_i; \alpha, Y^* + U_i) \quad i=1, 2, 3,\ldots\ldots\ldots\ldots N \qquad \textit{(Equation 3.13)}$$

Where;

C_i= is the minimum cost of the i^{th} firm associated with output, Y,

f= Cobb-Douglas functional form

P_i= represents input prices employed by i^{th} farm in wheat production

α = parameter to be estimated

Y^*_i=Observed wheat output per acre of the i^{th} firm adjusted for the statistical noise captured by V_i

U_i =provides information on the levels of allocative efficiency of the i^{th} farm.

The Cobb-Douglas cost frontier function for the wheat farmers is specified as follows;

$$\ln C_i = \alpha_0 + \alpha_1 \ln y^*_1 + \alpha_2 \ln pfert_2 + \alpha_3 \ln pseed_3 + \alpha_4 \ln pchem_4 + \alpha_5 \ln pfoliar_5 + \alpha_6 \ln phlab_6 + \alpha_7 pflab_7 + U_i$$

(Equation 3.14)

Where;

C_i= total cost of production of i^{th} farm per acre

Y^*_i= Observed wheat output per acre adjusted for statistical noise

$pfert_2$= Price of fertilizer per kg

$pseed_3$= Price of seeds per kg

$pchem_4$= Price per litre of chemical

$pfoliar_5$= Price per litre of chemical

$phlab_6$=Wage rate per day

$pflab_7$= Imputed family labour per day.

3.4.3 Determining factors influencing efficiency- The Tobit model

Analysis of the effects of firm-specific factors on economic efficiency has generated considerable debate in frontier studies. The most popular procedure is to first estimate efficiency scores and then regress them against a set of social-economic factors or to use nonparametric or analysis of variance (ANOVA) tests. While Kalirajan (1991) and Ray (1988) defend this two-step procedure, other authors (Kumbhakar *et al.*, 1991; Battese and Coelli, 1995) challenge this approach by arguing that firm-specific factors should be incorporated directly in the estimation of the production frontier because such factors may have a direct impact on efficiency.

Despite such criticism, the two-step procedure is still quite popular and has been adopted in this study to analyze the effects of socio-economic factors in the economic efficiency of the wheat producers.

The economic efficiency estimates obtained are regressed on some socio-economic factors using the tobit model. This use of a second stage regression model of determining the socio-economic attributes in explaining inefficiency has been suggested in a number of studies (Sharma *et al.*, 1999; Dunghana et at., 2004)

Assume the theoretical Tobit model, which takes the form;

$$y_i^* = x_i\beta + u_i \qquad \textit{(Equation 3.15)}$$

Where y_i^* the latent (hidden) independent variable for the kth is farm; x_i is the vector of independent variables which have been postulated to affect efficiency. β's are the unknown parameter vectors associated with the independent variables for the k^{th} farm, and u_i is an independently distributed error term assumed to be normally distributed with zero mean and constant variance.

Dummy variable represents the various socio-economic variables such as age, gender and level of education of the head of household among others. Because the dependent variable in Equation (11) is a measure of efficiency, the variables with a negative (positive) coefficient will have a positive (negative) effect on efficiency levels.

3.5 Area of Study

The study was carried out in Rongai and Ngata divisions in the New Nakuru district where a representative sample of wheat farmers was randomly selected. Seventy five percent (75%) of all wheat produced in Nakuru district comes from large-scale and small-scale farms in Rongai Division while the newly created Ngata division accounts for 25% (MoA, 2007).

Nakuru District covers an area of 1484.1 km^2 where 796.23km^2 is arable land, 45 km^2 is water mass, forests 7 km^2 and national parks covers 188km^2. The district is located in the high potential (over 1,800 metres above sea level) and low potential (less than1, 800 metres above sea level) agro ecological zones. The high potential zone generally receives more rainfall over a longer period of time than the low potential zone.

According to 1999 population census, the district population was 396,560 persons with growth rate of 3.4%. The 2009 projected population is 471,514. There are 126,037 farm families with an average farm size of 5 persons. The average farm size for small scale is 2.5 acres while for large scale is 200 acres. The district has three districts Agro-ecological zones; Lower Highland (LH3-LH4) mainly the wheat/maize/barley zone, the Lower Midland (LM3) zone and the Upper Midland (UM2-5) which is the upper sisal zone.

Rainfall ranges from 500 mm to 1,000mm in low potential zones and 1,200mm to 1,800mm in high potential zones. Rainfall is unimodal with distinct peaks in April and August. The mean maximum temperature is 29.3 ^{0}c and mean minimum temperature 24.0 ^{0}c. The wheat season stretches from June to November, sufficient time for the wheat crop to mature, given varying planting dates. The district mainly has soils developed from volcanic ashes that are generally deep and well drained (see annex 2 and 3).

Ngata division has an altitude of 1800-2400 metres above sea level with an annual rainfall of 760-1270 milllimetres. The mean temperatures range between 7^{0}c to 15^{0}c and soils are mollic andosol lying in the Agro-Ecological Zone of LH2 and LH3.

Rongai division has an altitude of 1520-1890 metres above sea level with annual rainfall of less than 760 millimetres and maximum temperature of 30^{0}c in December. July is cold with 23.9^{0}c. Soils are andosols except in Menengai which are nitisols.

The two divisions have been selected because they are major wheat growing areas in the district with both small and large-scale farmers. In 2007, the wheat production in the two divisions was 114,275 bags[3] in 2865 hectares with an average productivity of 40 bags per hectare (MoA, 2007).

3.6 Data Sources and sampling procedure

This study uses cross-sectional farm household data on wheat production, inputs and their prices, wheat output and prices, farm sizes, credit, extension and level of education of head. To fulfill the objective of the study primary data was collected using a structured questionnaire. A number of households were sampled and an adult member of the household interviewed using the questionnaire.

The population of the study comprised the wheat farmers in the two divisions namely Rongai and Ngata divisions. These are the only major wheat growing divisions in the district. The sampling procedure used was stratified proportional sampling method since the population of wheat farmers is not homogenous but divided into large and small scale farmers. The sampling frame comprised all wheat farmers in Ngata and Rongai divisions. A separate list of farmers who grow wheat on more than twenty (>20) acres was compiled to form the first strata and the second strata will comprise all the farmers growing wheat on twenty acres and less (20 and less) of land. Farmers were then randomly selected from each stratum using a stratified proportionate random sampling to form the study sample.

The data on the number of farmers who planted wheat from the two divisions was obtained from the divisional offices of the Ministry of Agriculture in both Ngata and Rongai divisions. The ministry officials reported that there was a decline of 10% in the number of farmers who planted wheat in 2008 season. This was mainly due to the post-election violence that rocked the country in 2008 that resulted in the displacement; farmers thus did not participate in the long-rain season. There was also the problem of high cost of inputs where for instance the cost of fertilizer went up to Kshs 6,200 per bag and the cost of chemicals was also high. The cost of land preparation was also high and the shortage of tractors that saw the cost of hiring a tractor for old land going up to Kshs 3,500 per acre.

[3] One bag=90 kg

According to the Ministry of Agriculture statistics, the population of farmers in the two divisions that planted wheat in the 2008 season was approximated at 180 both large scale and small-scale farmers in the two divisions. This was a decline from the previous years due to the displacement of farmers and the high cost of inputs such as chemicals and fertilizers that forced some farmers to abandon growing wheat. The ministry categorizes large-scale wheat farmers as those who plant wheat from twenty (20) acres and above while small scale wheat farmers plant in less than 20 acres.

The population of small-scale wheat farmers was 150 in both divisions while for large scale farmers were 30 farmers in the two divisions.

The sample size was determined using a formula developed by Krejcie and Morgan (1970) which is shown below.

$$S = \frac{x^2 NP(1-P)}{d^2 (N-1)} + x^2 P(1-P)$$

(Equation 3.16)

Where,

S=required sample size

χ^2=the table value of chi-square for 1 degree of freedom at the desired confidence level which is 3.841 for 95% confidence level.

P the population proportion assumed to be 0.5 since this would provide the maximum sample size.

d the degree of accuracy expressed as a proportion (0.05)

N population of wheat farmers in the division

Using the above formula the sample size computed for a population of 150 small scale farmers was 108 farmers while the sample size for the 30 large-scale farmers was 28 farmers. Ngata division had more large-scale and small-scale farmers that Rongai division. Therefore, to determine the sample size for each division for the small scale farmers the sampling was proportional to size at 60% for Ngata division and 40% for Rongai Division. For the large scale farmers the proportion was 57% in Ngata division and 43 % in Rongai division.

A list of farmers in the district was provided by the Ministry of Agriculture at the divisional offices that was used to select the sampled farmers.

Simple random sampling was used to select farmers from each stratum and random numbers were used to get the required number. The table below gives a summary of the sampled famers.

Table 3.1: A Summary of Sampled households by Divisions

	Small-scale wheat Farmers			Large-scale wheat Farmers		
Division	**Sample frame**	**Sampled**	**Interviewed**	**Sample frame**	**Sampled**	**Interviewed**
Ngata	90	65	64	17	16	15
Rongai	60	43	40	13	12	10
Total	**150**	**108**	**104**	**30**	**28**	**25**

As the table above shows there were 108 small-scale farmers sampled but 104 farmers were interviewed while 28 large scale farmers were sampled but 25 farmers were interviewed. The reasons for the missed households were; non-contact (3 households), 1 household moved away for small scale farmers while for large-scale farmers; 2 farmers could not be contacted and 1 farmer refused to be interviewed. A total number of 129 wheat farmers were interviewed in the two divisions.

3.7 Data Collection

A structured questionnaire was developed and pretested in Njoro Division, in Molo District where 15 farmers were interviewed. Necessary adjustments made before using it for data collection. The questionnaire captured household information on wheat cropping activities, inputs used, labor activities farmer training and extension, household demographics including education, access to productive resources, infrastructure, and quality of life indicators.

A team of 4 enumerators with qualifications in bachelor's degree in agricultural related field were hired and trained for data collection. The interviews were done at the farm and the respondents were notified prior to the day of interview. The surveys were done at a rate of 3 questionnaires per enumerator per day and one interview took an average of one hour to finish.

The field work survey was conducted between 6th April to 17th April 2009 for 11 days. The fieldwork was successful and there was no major difficulties apart from the expected normal field work minor inconveniences like extreme weather conditions on some days. The team members were cooperative. There was not any incident of serious misunderstanding amongst any of the team members. Everyone was committed to his/her work and as much as possible the team helped whoever amongst the members needed help.

3.8 Data Entry and Analysis

Data entry was done using SPSS data entry builder (version 2.0) and the analysis was done using SPSS, Frontier 4.0 and STATA statistical packages. *FRONTIER 4.0* was selected because of its ability to handle stochastic frontiers analysis while STATA handled the regression models. SPSS software was mainly used for data manipulation. Descriptive statistics were used to augment the findings from the model, for instance, in characterization of farmers operating under different farming sizes in the sampled areas. Stochastic frontier model was used to predict technical and economic efficiencies for each farm.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Household Characteristics

The average land owned was 273 acres and 9 acres for the large scale farmers and small scale farmers respectively. The acres under wheat in 2008 season averaged 190 acres and 5 acres for the large scale and small-scale farmers respectively as presented in Table 4.1.

Table 4.1: Mean acres owned and cultivated in 2008

Land (acres)	Large scale	Small scale	Overall
Land owned	273.6	8.9	60.2
Acres cultivated	235.9	9.0	52.9
Acres under wheat	190.8	5.0	41.0

About 57 % of the sampled farmers rented land to grow wheat. The mean acres rented were 108 acres and 5 acres for large and small scale farmers respectively. The amount paid for renting averaged Kshs 3,300 per acre.

About 56% of large scale farmers cultivated wheat on their own farms that have title deeds while for the small-scale farmers 58% cultivated wheat on rented farms as shown in Table 4.2 below. The cost of renting has implications on the levels of production in addition to the high cost of inputs.

Table 4.2: Land Tenure by Farm Size

Tenure	Large Scale (%)	Small Scale (%)	Overall (%)
Rented land	40	57.7	54.3
Owned with deed	56	28.8	34.1
Owned without deed	-	10.6	8.5
Owned by parent/relative	4	2.9	3.1
Total	100	100	100

About 84% and 98% of the large scale and small-scale respectively reported that they planted other crops besides wheat; an indication that majority of the farmers practiced mixed farming. For the large scale farmers wheat gave the highest crop income (56%) while maize accounted for 36% of the crop income. For the small-scale farmers maize accounted for the largest share of crop income at 72% while wheat contributed 23% of the crop income. Other crops that earned some income included beans, cabbages and Irish potatoes. Over 50% of the households reported that they started growing wheat since 1996 and more farmers have started growing wheat as the years progressed.

The average age of the household head was 56 years and 50 years for large-scale and small-scale farmers respectively as shown in Table 4.3. Male-headed households accounted for 88% and 87.5% for large-scale and small-scale farmers respectively. The results shows that on average 12% of the household heads had been trained on wheat production in the past year. The heads were living at home in most of the months in the last one year.

Table 4.3: Characteristics of Household Head

Household characteristics	Large Scale	Small Scale	Overall
Age in years	56.6	50.3	51.5
Male (%)	88.0	87.5	87.6
Female (%)	12.0	12.5	12.4
Trained on wheat production (%)	24.0	13.5	15.5
Months living at home	10.9	11.5	11.4

The results on the marital status indicate that majority of the household heads were monogamous. This accounted for 72% and 80% for the large-scale and small-scale farmers respectively. About 6.2% were polygamous, 10% widowed, 4.7% single and 0.8 % were divorced.

Education plays an important role in increasing the adoption of technologies. In addition, it increases the opportunities of participating in formal income earning activities among rural families. Results on the level of education completed by the head of the household are presented in Table 4.4. The results show that the majority of the heads were well educated especially large-scale farmers. About 60% of the heads had completed secondary education among the large-

scale farmers while 38% of the heads among small-scale farmers had completed secondary education. Overall 25.6% of the farmers had completed secondary education.

Table 4.4: Highest Level of Education level of Household head

Level of education	Large Scale (%)	Small Scale (%)	Overall (%)
Completed primary	12	29.8	26.4
Completed secondary	24	26	25.6
Some primary	8	14.4	13.2
Attended college	16	10.6	11.6
Some secondary	12	8.7	9.3
Pre-school	8	8.7	8.5
Attended university	20	1.9	5.4
Total	100	100	100

Household members engage in different income-earning activities; some are engaged in farm activities while others are involved in off-farm activities. The main activities engaged by the head of the households are presented in Table 4.5. Majority were engaged in self-employment in agriculture (59%) followed by salaried employment (18%). Among the large scale farmers, 56% were self-employed in agriculture, 16% were self-employed in non-farm enterprises while among the small scale farmers 59.6% were self-employed in agriculture and 20% were in salaried employment. About 8.5% of the heads were retired while 0.8 % were handicapped.

Table 4.5: Main Occupation of the Household Head

Occupation	Large Scale (%)	Small Scale (%)	Overall (%)
Self-employed in agriculture	56	59.6	58.9
Salaried worker	8	20.2	17.8
Self-employed on non-farm enterprise	16	11.5	12.4
Retired	16	6.7	8.5
Student	4	1	1.6
Not able to work (handicapped)	-	1	0.8
Total	100	100	100

4.2 Wheat Production and Marketing

4.2.1 Land preparation and Planting

Wheat farming is mainly mechanized with minimum human labour for the various activities involved. The results indicate that mainly tractors were used for land preparation with 64% of the large scale farmers using their own tractor while 89% of the small-scale farmers hired tractor services for land preparation. The cost of hiring for land preparation averaged Kshs 2,500 per acre.

As Table 4.6 shows, Kwale was the mostly used seed variety (30.2%) followed by Mwamba (24.8%) and Njoro BW2 (20.9%) seed varieties. The trend was similar for both large scale and small scale farmers. Other seed varieties used included Njoro 2, Fahari and Chiriku among others.

Table 4.6: Main Seed varieties planted

Variety	Large Scale (%)	Small Scale (%)	Overall (%)
Kwale	36	28.8	30.2
Mwamba	32	23.1	24.8
Njoro BW2	16	22.1	20.9
Chiriku	4	2.9	3.1
Njoro 2	8	1	2.3
Fahari	4	1	1.6

The study sought to establish the type of seeds the farmers planted. The results shows that 51% of the seeds used were purchased while 35% were recycled seeds for one year. It can be noted that about 10% of the seeds used were recycled for two or more years as shown in Table 4.7.

Table 4.7: Type of seed used

Type of seed	Large Scale (%)	Small Scale (%)	Overall (%)
Purchased	48	51.9	51.2
Recycled one year	36	34.6	34.9
Recycled 2 years	4	8.7	7.8
Recycled 3 or more years	12	1.9	3.9
Retained seed	0	2.9	2.3
Total	100	100	100

The main reason cited for using the recycled seeds was that the recycled seeds were cheaper than the purchased seeds. The farmers reported that the seed recycled was mainly selected after harvesting (63%), during growing season (13%) while some farmers bought already recycled seeds from other farmers. The main aspect used in the selection of seed for recycling was the plant aspect (80%) while some farmers looked at the plant aspect (13%).

4.2.2 Wheat Yields

The average wheat yield was 750Kgs per acre and 600kgs per acre for large scale and small scale farmers respectively. This translates to 1.9 and 1.5 tons per hectare respectively. The productivity was low compared to the national average (about 2.2 tons/ha) and this was confirmed by 77% of the farmers who reported that the harvest was poor while 21% of the farmers reported that the harvest was average. Only 2% of the farmers reported that the harvest was good. This trend was the same across the large scale and small scale farmers. The farmers complained of poor rains during the growing season. The seed application rate was 72kgs per acre and 64kgs per acre for large scale and small scale farmers respectively. The fertilizer rate applied was averaged 44 kg per acre for both farm types. The chemical application rate was 3 litres and 2 litres for large-scale and small scale farmers respectively.

4.2.3 Production Costs

The cost of production per acre averaged Ksh 21,432 for large scale and KSh 17,859 for small scale farmers as presented in Table 4.8 below. The cost of chemicals accounted for the largest cost which was 25% for large scale and 20% for the small scale farmers. Land preparation cost was second accounting for 24% and 18% for large scale and small scale respectively. The large-scale farmers hired more labour than small-scale farmers whereas the small-scale farmers used more family labour than the large-scale farmers

Table 4.8a: Mean Cost of Production (KSh/Acre)

Mean costs per acre	Large-Scale	% of total	Small-Scale	% of total	Overall	% of overall
Chemical cost per acre	5,257.4	25%	3,640.6	20%	3,953.9	21%
Land preparation cost per acre	5,101.8	24%	3,285.1	18%	3,690.0	20%
Cost of fertilizer per acre	3,141.5	15%	3,154.4	18%	3,151.9	17%
Cost seeds per acre	2,569.8	12%	2,579.6	14%	2,577.7	14%
Harvesting cost per acre	1,934.3	9%	1,887.0	11%	1,893.9	10%
Cost of hired labour per acre	1,762.6	8%	1,060.3	6%	1,196.4	6%
Planting cost per acre	1,191.1	6%	1,218.8	7%	1,215.8	7%
Cost of foliar per acre	355.8	2%	412.1	2%	401.2	2%
Imputed family labour per acre	118.0	1%	621.1	3%	523.6	3%
Total average cost	**21,432.4**	**100%**	**17859.0**	**100%**	**18,604.3**	**100%**

4.2.4 Gross Margins Analysis

The results on gross-margin analysis indicate that large scale farmers were harvesting on average 0.8 tons/acre compared to 0.6 tons/acre for the small scale farmers. The variables costs used were almost the same in value (chemicals, seeds, fertilizers) though large scale farmers spent more on chemicals. The cost of planting and harvesting are excluded since machinery was used in most of these operations.

Table 4.8b Gross Margin Analysis of Wheat production in Nakuru District 2008 season (Kshs/acre)

Value item	Large scale	Small scale
Harvest per acre in kgs	771.9	618.7
Price per Kg	26.8	26.8
Value of harvest (Kshs per acre)	**20,755.9**	**16,635.4**
Variable costs (Kshs/acre)		
Chemical cost per acre	5,257.4	3,640.6
Value of seeds per acre	2,569.8	2,579.6
Value of fertilizer per acre	3,141.5	3,154.4
Total costs per acre	**10,968.7**	**9,374.6**
Gross margin (Kshs/acre)	**9,787.2**	**7,260.8**

On average, the gross margins were Kshs 9,787 and Kshs 7,260 per acre for large scale and small scale farmers respectively. All other costs held constant, the gross margins looks attractive for

both categories of farmers. This indicates that wheat production can be a profitable enterprise among the large and small-scale farmers. With the supply of labour in the rural areas, the small scale farmers would manage to produce wheat in a cost-effective manner. This argument is supported by maize sector Kenya where majority of the farmers are small-scale farmers practicing labour-intensive farming techniques and they supply the bulk of maize produced in the country.

4.2.5 Wheat Marketing

The major buyers of wheat were large traders (75%), millers (15%) and NCPB (5%) among the large scale farmers while for the small-scale farmers main buyers were large traders (82%) and small traders (13.5%) as shown in Table 4.9.

Table 4.9: Buyer Type by Farm size

Buyer Type	Large Scale (%)	Small Scale (%)	Overall (%)
Large trader	75.0	82.0	80.7
Small trader	-	13.5	11.0
Miller	15.0	1.1	3.7
Consumer	-	3.4	2.8
NCPB	5.0	-	0.9
Kenya seed company	5.0	-	0.9
Total	100	100	100

The decision on wheat activities such which inputs to plant and where to sell were mainly taken by the head of the household across the farm sizes. This accounted for 90% and 84 % for small-scale and large-scale farmers respectively. In some cases, decisions were jointly taken by the head and the spouse and decisions by managers were reported by large-scale farmers only accounting for 4%.

4.3 Extension Advice

Agricultural training is important in enhancing agricultural production and increasing farmers' incomes. The results shows that majority of the farmers did not seek extension services. The farmers who sought extension advice were 48% and 25% among large-scale and small-scale farmers respectively. For those who sought extension services there were on average eight (8)

extension services for large-scale and three (3) extension contacts for small-scale farmers last year. The main sources of extension for large-scale farmers were private extension agents (22.7%), field days (18.2%) and traders/input dealers (13.6%) as shown in the Table 4.10 below. For the small-scale farmers, the main sources of extension services were traders/input dealers (22.2%) research organizations (19.4%) and through neighbours (13.9%). It is interesting to note that public extension was quite rare.

Table 4.10: Source of Extension Services

Service Provider	Large scale (%)	Small scale (%)	Overall (%)
Traders-input dealers	13.6	22.2	19.0
Research Organizations	9.1	19.4	15.5
Family-friend	13.6	13.9	13.8
Private extension agent	22.7	5.6	12.1
Field days-demonstrations	18.2	8.3	12.1
Neighbour-farmer	9.1	13.9	12.1
Public extension agent	4.5	8.3	6.9
Farmer Organizations-Coops	4.5	2.8	3.4
Newspapers/ Reports	4.5	0	1.7
ASK shows	0	2.8	1.7
Radio -television	0	2.8	1.7
Total	100	100	100

There were several reasons stating why most of the households did not seek extensions services. These are shown in Table 4.11 below. The main reasons were unavailability of extension services (51.9%), no need for extension services (18.5%) and 13.9% indicated long distances to extension services. The trend was similar across the different farm types except that the distance to small-scale famers was higher than large-scale farmers. About 11% of the farmers indicated that the exercise was time-consuming.

Table 4.11: Reasons for not seeking extension advice

Reason	Large scale (%)	Small scale (%)	Overall (%)
Extension agents not available	43.8	53.3	51.9
No need	31.3	16.3	18.5
Long distance	6.3	15.2	13.9
Time consuming	12.5	10.9	11.1
Expensive	6.3	4.3	4.6
Total	100	100	100

4.4 Credit

Credit is important in stimulating farm-level production. The results indicate that majority of the households did not seek cash credit. About 21% of the households sought credit and for those who sought credit 81.5% received as shown in Table 4.12 below. Across the farm types 75% and 82.6% of large-scale and small-scale farmers received credit. The main reasons for not getting the credit applied for among the small-scale farmers were; lack of collateral (60%), outstanding loan (20%) and 20% didn't know why they were denied credit. Among the large-scale farmers, the main reason was that the bank delayed the processing of the credit and therefore eventually the farmers did not get the credit they applied for.

Table 4.12: Proportion of Households that Sought and Received Cash Credit

Credit	Large scale	Small scale	Overall
Sought credit (%)	16.0	22.1	20.9
Received credit (%)	75	82.6	81.5
Amount received (Ksh)	607,500	57,978	153,547

The results further show that overall only 8.5% of the farmers sought in-kind credit. The proportion of large-scale farmers who sought in-kind credit was 20% while small-scale farmers accounted for 5.8%. For those large-scale farmers who sought in-kind credit all of the got it while for the small-scale farmers, 77% of those who sought in-kind credit received. The farmers who did not get the credit could not tell why they were denied the in-kind credit.

4.5 Social capital

About 28% and 34% of large-scale and small-scale farmers respectively belonged to a farmers' group. Those farmers who did not belong to a farmer's group cited lack of group nearby (60%), not helpful (16.5%) and 12% reported that the groups collapsed. Other reasons cited were; not interested (8.8%) and old age (2.2%).

The main services obtained from the group include training (47.8%), acquisition of inputs (14.9%) and financial services (16.4%) especially among the small-scale farmers as shown in Table 4.13.

Table 4.13: Services obtained from the Group

Service	Large scale (%)	Small scale (%)	Overall (%)
Training	50	47.3	47.8
Financial services	-	20	16.4
Input acquisition	25	12.7	14.9
Marketing	16.7	9.1	10.4
A I Services	-	10.9	9
Private	8.3	-	1.5
Total	100	100	100

4.6 Distance to Social Amenities

Access to amenities is crucial for fostering economic development. Improved access to amenity contributes to increased farm productivity and poverty reduction. Table 4.14 shows that most basic amenities were within easy access by the households; they were generally located within a radius of 1-15 km. However, some amenities such as distance to fertilizer and seeds sources are over 20 km. The households are near tarmac road implying that they are accessible to other services.

Table 4.14: Distance in Km.

Distance (km)	Large scale	Small scale	Overall
Distance to where you normally buy fertilizer	25.4	13.2	15.6
Distance to the nearest certified wheat seed seller	20.7	15.7	16.7
Distance to the nearest NCPB depot	19.4	15.5	16.2
Distance extension service	13.3	9.8	10.5
Distance to a tarmac road	1.7	2.9	2.7
Distance to a motorable road	0.2	0.2	0.2

Over 98% of the households reported to have access to a mobile phone implying that they are able to get information about inputs and marketing quite reliably.

4.7 Household Quality of Life Indicators

Aspects that affect the ability of households to create wealth (income) include the environmental conditions, which affect the health of the household, and hence the ability to work. Two aspects are considered in this analysis: housing conditions and toilet facilities. Table 4.15 shows that

90.7% of the households live in houses roofed with metal sheets. The proportion is equally high for both the large scale (76%) and small-scale (94%) households.

Table 4.15: Building materials of the main house

Material	Large scale	Small scale	Overall
	Roofing material in (%)		
Iron sheet	76.1	94.2	90.7
Tiles	16.0	1.9	4.7
Grass /makuti	8.2	3.8	4.7
	Wall material in (%)		
Bricks/Stones	60.2	44.2	47.3
Mud	20.4	36.5	33.3
Wood	16.3	10.6	11.6
Plastered	4.1	8.7	7.8
	Floor Material in (%)		
Cement	60.0	62.5	62.0
Earth	16.0	34.6	31.0
Tiles	24.0	1.9	6.2
Wood	-	1.0	0.8

About 60% and 44% of large-scale and small-scale households respectively have houses with brick/stones walls; while 20% of large scale and 36.5% of small-scale households have mud walled houses while over 62% of the households have houses with cement floor, with the proportion for the large-scale households at 60% and the small scale households at 62.5%. Some households (31%) have houses with earth floor.

Most households (91.5%) use pit latrines. Across the sub-samples, 72% of the large-scale and 96% of the small-scale households use pit latrines as shown in Table 4.16. Very few households (7%) use indoor (flush) toilets. About 1.6% of the households have no toilets.

Table 4.16: Type of toilet used

Type	Large scale (%)	Small scale (%)	Overall (%)
Pit latrine	72.0	96.2	91.5
Flush toilet	24.0	2.9	7.0
Bush	4.0	1.0	1.6
Total	100.0	100.0	100.0

4.8 Efficiency Estimates

4.8.1 Technical, Allocative and Economic efficiencies.

The maximum-likelihood (ML) estimates of the parameters of the stochastic production frontier were obtained using the program. FRONTIER 4.1 (Coelli, 1994). These results are presented in Table 4.17 which also presents the OLS results of the average production function for comparison.

The signs of the of the slope coefficients of both OLS and ML estimates are positive except for family labour that has a negative coefficient implying increasing the family labour affects wheat production negatively. ML estimated coefficients such as seeds, fertilizers and chemicals are significant while for OLS only chemicals coefficient is statistically significant. The estimate of the variance parameter gamma (γ) is also significantly different from zero, which implies that the inefficiency effects are significant in determining the levels of wheat output of the sampled farmers. The estimated production function is given as;

$$lnY_i = 4.5 + 0.48lnseed_i + 0.11 lnfert_i + 0.11lnchem_i + 0.09lnfoliar_i + 0.04lnhiredlab_i - 0.027Lnfamlabour_i$$

(Equation 4.1)

Where:

Y_i is the wheat output per acre in Kgs.

seed, is quantity of seeds per acre in kgs,

fert, is the quantity of fertilizer per acre in kgs,

foliar, is the quantity of foliar used per acre in kgs,

chem, is the quantity of chemicals used per acre in litres,

hiredlab, is the cost of hired labour per acre,

famlabour, is the imputed cost of family labour per acre.

Table 4.17: Ordinary least squares (OLS) estimates of the average production function and ML estimates of the stochastic production frontier for the sampled wheat producers

	OLS estimates			ML estimates		
Variable	Coefficient	Standard error	t-ratio	Coefficient	Standard error	t-ratio
Intercept	4.59	1.003	4.57	4.46	0.882	5.06
lnseed	0.28	0.228	1.24	0.48	0.205	2.35*
lnfertilizer	0.08	0.054	1.49	0.11	0.043	2.63*
lnfoliar	0.1	0.114	0.89	0.09	0.083	1.13
lnchemical	0.19	0.066	3.02*	0.11	0.042	2.64*
lnhiredlabour	0.04	0.029	1.52	0.04	0.025	1.76
lnfamilylabour	-0.04	0.034	-1.34	-0.027	0.031	-0.85
sigma squared	0.54			1.26	0.216	5.82
gamma(γ)	-			0.93	0.036	2.59*
Log likelihood	-140.54			-131.2		

*significant at the 5% level

The dual cost frontier derived from the stochastic production frontier shown in Table 4.17, is as follows;

$$Ln\ C_i = -0.151 + 0.266(lnpseed_i) + 0.009(lnpfert_i) + 0.0011(lnpfoliar_i) + 0.224\ (lnpchem_i) + 0.14\ (lnpwage_i) + 0.01(lnpfamlab_i) + 1.04\ (ln\ Y^*_i)$$

(Equation 4.2)

Where:

C_i is the cost of production per acre of i^{th} farm.

pseed, is the price of seed per kg.

pfert, is the price of fertilizer per kg.

pfoliar, is the price of foliar per kg.

pchem, is the price of chemical per litre,

pwage, is the wage rate per day,

pfamlab, is the imputed family labour per day

Y^*_i is the wheat output in kgs per acre adjusted for statistical noise.

4.8.2 Distributions of technical (TE), allocative (AE) and economic (EE) efficiency measures

The overall TE, AE and EE scores are presented in Table 4.18 below. The results indicate that overall the wheat farmers have high efficiency scores averaging 88% and 86% for TE and EE respectively. Small scale farmers had higher allocative efficiencies (96%) than large scale farmers (94%). However, the large scale farms have relatively higher technical and economic efficiencies compared to small-scale farmers.

Table 4.18: Mean TE, AE and EE scores by farm size

Farmsize	TE	AE	EE
Small scale	0.85	0.96	0.84
Large scale	0.91	0.94	0.88
Overall	0.88	0.95	0.86

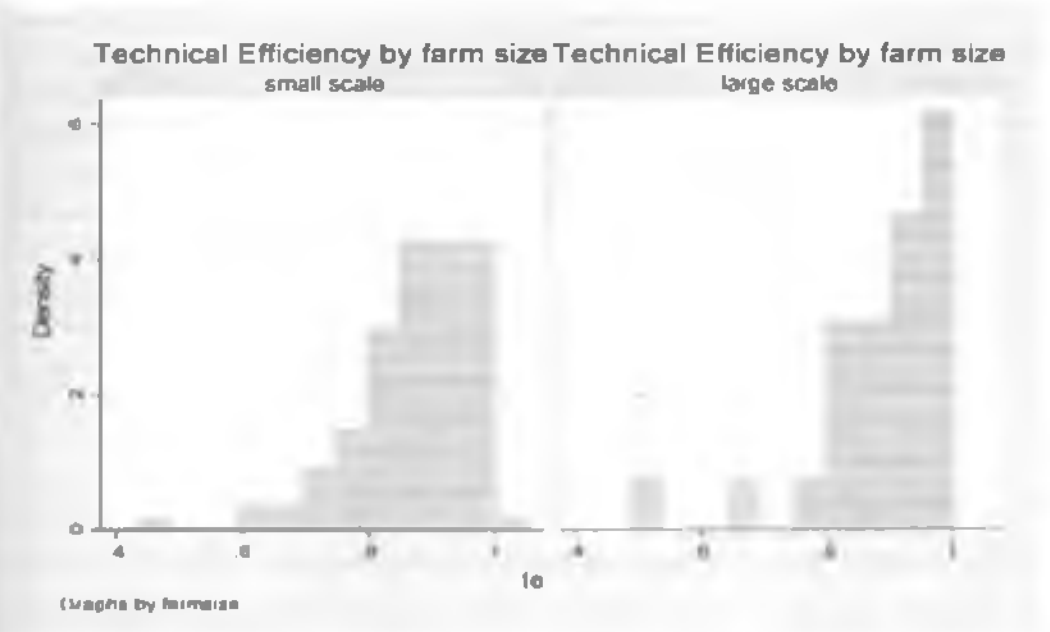

Figure 4.1: Frequency of Technical Efficiency by Farm Size

The figure 4.1 shows that there were more large-scale farmers with high technical efficiency scores than small-scale farmers.

4.8.3 Farm size and Efficiency

Statistical tests were carried out on the relationship between the size of the farm and technical efficiency. The farm size was categorized into two groups; small-scale farms (less than 20 acres) and large-scale farms (over 20 acres) as discussed in the sampling procedure.

The test results presented below shows that the mean differences in technical scores are significantly different from zero at 1% and 5% levels of significance as presented in Table 4.19. The null hypothesis that the mean difference equal zero is rejected. Thus, accepting the alternative that the mean difference for between small scale and large scale is less than zero.
These results indicate that large scale farms have a higher technical efficiency than small scale farms

Table 4.19: A two sample t-test on the association between technical efficiency and farm size

Group	Observations	Mean	Standard error	Standard deviation
Small scale farms	104	0.870409	0.108597	0.1035945
Large scale farms	25	0.9084932	0.0167085	0.1029982
Combined	129	0.8816276	0.009199	0.1044802
diff		-0.0380842	0.0199752	

Two-sample t -test with unequal variances

diff = mean(small scale) - mean(large scale) t = -1.9066
Ho: diff = 0 degrees of freedom = 127

Ha: diff < 0 Ha: diff != 0
Pr(T < t) = 0.0294 Pr(|T| > |t|) = 0.0588

Results on the statistical tests on the association between farm size and allocative efficiency are presented in Table 4.20. The result shows that the mean difference in allocative efficiency scores is statistically different from zero at 1% and 5% level of significance. The null hypothesis that there is no mean difference between small scale and large scale is rejected. This implies that there is statistical difference in allocative efficiencies between small-scale and large-scale wheat farms.

Table 4.20: A two sample t-test on the association between allocative efficiency and farm size

Group	Observations	Mean	Standard error	Standard deviation
Small scale farms	104	0.9631731	0.0044033	0.449053
Large scale farms	25	0.9374486	0.0122325	0.0611627
Combined	129	0.9581877	0.0043386	0.0492773
diff		0.0257245	0.0107804	

Two-sample t test with unequal variances

diff = mean(small scale) - mean(large scale) t = 2.3862
Ho: diff = 0 degrees of freedom = 127

Ha: diff != 0 Ha: diff > 0
Pr(T > t) = 0.0185 Pr(T > t) = 0.0092

A similar test was done on the association between farm size and economic efficiency. The results presented in Table 4.21 shows that there mean difference of economic efficiency scores between small-scale and large-scale farmers is statistically different from zero at 1% and 5% levels of significance. The null hypothesis is rejected and this implies that the large-scale farmers have higher economic efficiency than small-scale farmers.

Table 4.21: A two sample t-test on the association between economic efficiency and farm size

Group	Observations	Mean	Standard error	Standard deviation
Small scale farms	104	0.765494	0.0099778	0.095182
Large scale farms	25	0.8001347	0.0167307	0.1031347
Combined	129	0.7756982	0.0086697	0.0984684
diff		-0.0346407	0.0188443	

Two-sample t test with unequal variances

diff = mean(small scale) - mean(large scale) t = -1.8383
Ho: diff = 0 degrees of freedom = 127

Ha: diff < 0 Ha: diff != 0
Pr(T < t) = 0.0342 Pr(|T| > |t|) = 0.0684

4.8.4 Factors influencing efficiency

Several authors have investigated the relationship between efficiency and various socio-economic variables using two alternative approaches[1] One approach is to compute correlation coefficients to conduct other simple non-parametric analysis. The second way, usually referred to as a two-step procedure, is to first measure farm level efficiency and then to estimate a regression model where efficiency is expressed as a function of socio-economic attributes. Kalirajan (1991) observed that socio-economic attributes have roundabout effects on production and hence should be incorporated into the analysis directly while Ray (1988) argued that the two-step procedure is justifiable if one assumes that production function is multiplicatively separable in what he calls discretionary (included in production function) and non discretionary (used to explain variations in efficiency) inputs. This section discusses the results of the estimates obtained using the Tobit model.

For this purpose, the parameters technical efficiency (TE), allocative efficiency(AE) and economic efficiency (EE) indices were estimated censured Tobit procedure for the following socio-economic characteristics;-

1) Age, given by age of the household head

2) Level of education of head, equal to zero for no education, one for primary education and two for post-primary education

3) Distance to nearest extension services (km)

4) Land tenure, equals zero for owned land and one for rented land

5) Source of seed, equal to zero for recycled seed and one for purchased seed

The results presented in Table 4.22 presents the factors that influence technical, allocative and economic efficiencies of wheat production among the sampled households. The negative sign for the age of the head implies that efficiency of production declined with the age of the head though age was not statistically significant.

[1] For a review of several of these papers, see Bravo-Ureta *et al* , (1991)

The significant influence of education on farm efficiency is critical indicating that households headed by more educated heads were more efficient compared with households headed by less educated heads. The positive sign on the education implies that the education levels had positive influence on economic efficiency. The interpretation is that farmers who had a higher level of training were more technically and economically efficient than those with low level of training. These results are consistent with findings reported by authors who have carried out productivity studies. For instance Kibaara (2006) reported the presence of a strong association between technical efficiency and education attributes of small-holder maize farmers in Kenya.

Table 4.22: Tobit model estimates for different efficiency measures

	Technical efficiency		*Allocative efficiency*		*Economic efficiency*	
Variables	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
Age of head	-0.0003	-0.4	0.0003	1.01	-0.0002	-0.78
Education of head (0=no education, 1=has education)	0.0290	1.93*	-0.0086	-1.21	0.0109	2.61***
Distance to extension	-0.0016	1.45	-0.0010	-1.9*	-0.0008	-2.74*
Tenure (0=own land, 1=rented)	-0.0094	-0.53	-0.0018	-0.22	0.0013	0.25
Seed type (0=recycled, 1=purchased)	0.0104	-0.55	0.0013	0.15	0.0011	-0.23
Constant	0.8488	15.18	0.9634	36.52	0.8739	56.38
Sigma	0.1003		0.0474		0.0278	

Absolute value of t statistics in parentheses
* Significant at 10%; ** significant at 5%; *** significant at 1%

An interesting finding also is that the distance to extension services is statistically significant in both allocative and economic efficiency. There was a negative relationship between distance to extension services and farm efficiency. The farmers who could access the extension services with ease had higher levels of efficiency as opposed to the farmers who were quite distant from the extension providers.

Though the land tenure was not significant the negative sign shows that farmers who produced wheat in their farms likely to be more technically and allocatively efficient than those who produced on rented farms. The type of seed used was not statistically significant though has positive sign to efficiency. These results on the significant factors influencing efficiency; education levels and distance to extension services reject the null hypothesis that none of the identified social-economic factors influences efficiency.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

In Kenya wheat is the second most important crop after maize with regard to both production and consumption. Until the early 1970's Kenya was a net exporter of wheat but currently the country imports about 60% of wheat to meet the domestic demand. Wheat is grown in the cooler and medium-rainfall regions covering the Nakuru, Uasin Gishu, Trans-Nzoia and Narok districts and is mostly rain-fed. Wheat production is carried out by small, medium and large scale farmers. The small scale farmers are the majority of the producers but their production accounts for 25% of the total wheat produced. The domestic demand for wheat is growing at the rate of 7% per year even though production is increasing marginally. The increasing demand is driven by rapidly growing population, increased urbanization, ring incomes and a change in food preferences from traditional cereals towards wheat and wheat products.

Though the country has the potential of increasing the production of wheat, the sector is faced by several challenges. Some of the challenges include expensive inputs such as chemicals, seeds and fertilizers, insufficient farm machineries coupled with high fuel prices, unstable producer prices and sub-division of large scale farms into smaller farm units. These problems facing the wheat sector form the basis for this study. Due to the fact that majority of the wheat farmers in Kenya are small scale the study main objective was to establish their level of technical, allocative and economic efficiency in wheat production in comparison with the large scale farmers . The study sought to assess the effect of farm size and efficiency as well as identifying the social-economic factors influencing efficiency among the large and small scale wheat producers. Nakuru District being one of the leading wheat growing districts in the country was used as a case study.

This study uses the parametric stochastic efficiency technique that follows the Kopp and Diewert (1982) cost decomposition procedure to estimate technical, allocative and economic efficiencies. Its advantage lies in the application of a stochastic frontier model with a disturbance term specification that captures noise, measurement error and exogenous shocks beyond the farm. The

two-step regression model has been used to analyze the effects of the social-economic factors on economic efficiency using a censored tobit model.

The study was carried out in Rongai and Ngata divisions in the new Nakuru district where a representative sample of wheat farmers was randomly selected. According to the Ministry of Agriculture, these two divisions produces 75% and 25% of the total wheat produced in the district respectively. The sampling procedure used was stratified proportional sampling method since the population of the wheat farmers was not homogeneous. The sampling frame comprised all wheat farmers (in the 2008 season) in Ngata and Rongai divisions. Two separate list from the sampling frame were developed. One list consisted of all the farmers who grew wheat on more than twenty (>20) acres to form the first strata while the second list comprised of farmers growing wheat on twenty acres and less (20 and less) of land. The farmers were then randomly selected from each stratum using the proportionate random sampling to form the study sample.A total number of 138 farmers were sampled.

The household data was collected using a structured questionnaire by trained enumerators. The survey sought information on wheat acreages, quantity of inputs and their prices, quantity harvested, credit, extension, demographic characteristics of household members as well as the quality of life indicators.

The data collected was entered and cleaned using statistical softwares that included SPSS data entry builder, SPSS data editor. The Frontier 4.0 and STATA statistical packages were used in data analysis.

5.2 Production systems and farmers' profile

Majority of the farmers (both small scale and large scale) were growing wheat on rented land. The high cost of renting land had implications on the area that farmers were able to put under production.

Wheat production was highly mechanized with most of the farm activities being carried out by use of tractors. The large scale farmers reported high use of inputs such as certified seeds and fertilizers while most small scale farmers used recycled seeds during planting. The main reason

for the use of recycled seeds was that they were cheaper than the purchased hybrid seeds. As a result, the productivity among the small scale farmers was lower than the large scale farmers.

Wheat productivity in the district was below the normal yields mainly due to inadequate rainfall during the 2007 cropping season. The use of inputs such as certified seeds was quite low and farmers relied on recycled seeds. Fertilizer use was also low especially among the small scale farmers. The main cost components were cost of chemicals, land preparation costs and fertilizer and seed costs.

Majority of the farmers had achieved the primary level of education. The literacy level determines the rate and extent of technology adoption and with such level of education, the uptake of technology can be enhanced. Most farmers were self-employed in agriculture implying that they were available on their farms most of the times.

The results indicate that most farmers were not accessing extension services mainly due to unavailability of extension workers and farmers had to travel long distances to access extension advice. Similarly, few farmers accessed credit facilities mainly due to lack of collateral and very strict conditions of accessing credit.

On average, the gross margins were Kshs 9,787 and Kshs 7,260 per acre for large scale and small scale farmers respectively. All other costs held constant, the gross margins looks attractive for both categories of farmers. This indicates that wheat production can be a profitable enterprise among the small-scale farmers. With the supply of labour in the rural areas, the small scale farmers would manage to produce wheat in a cost-effective manner. This argument is supported by maize sector in Kenya where majority of the farmers are small-scale who supply the bulk of maize produced in the country.

5.3 Findings on efficiency estimates

The mean technical efficiency scores were quite high for both small and large scale farmers though were higher among large farms than for the small farms. However, the results show that there is still some considerable level of inefficiencies in the use of inputs for the corresponding output levels. For allocative efficiency, this was higher among small-scale farmers than for large-scale farmers. This implies that small-scale farmers were quite price-sensitive to the input prices

than the large scale farmers. The overall economic efficiency was quite high for both farm categories though was higher among large scale than small-scale farmers. The mean technical, allocative and economic efficiency estimates between large and small scale farmers was statistically significant.

The relatively high levels of technical efficiencies among the small scale farmers defies the notion that wheat production in the country can only be efficiently produced by the large scale farmers. This study shows that it is possible for small-scale farmers to produce wheat efficiently. In many parts of Africa including Kenya small farms remain at the center of agriculture and rural development. However, one of the main causes for the low agricultural productivity is the lack of appropriate machineries that cater to and suit the requirements of small-scale farms. For this reason, many small farms are deemed as unproductive and inefficient. The Asian agriculture is a classical example of rapidly increasing farm mechanization support to the small- scale wheat and rice farmers. Most developing countries in the region are now in transition from labor intensive to control intensive agriculture. Irrigation system machines, planting machines, powered sprayers, combine harvesters, dryers using biomass fuel, silo and storage handling, and advanced and high quality rice mill machines have been adopted by the Asian farmers. Taiwan's agriculture is 98 percent mechanized. Manufacturers of dryers in this country are able to produce competitive products. Products using biomass as fuel are also becoming popular. Mini-power tillers have the highest market share in both domestic and international market (FFTC, 2005).To raise the productivity of wheat among small scale farmers in the country basic farm mechanization requirements to cater to small-farm needs must be met, such as: suitability to small farms; simple design and technology; versatility for use in different farm operations; affordability in terms of cost to farmers; and most importantly, the provision of support services from the government and the private sectors/manufacturers.

The results shows that farm size has significant effect on technical and economic efficiency levels suggesting that cost inefficiency could be reduced by exploiting the economies of size. This finding rejects the null hypothesis that farm size has no effect on efficiency. These results suggest that gains from improving technical efficiency exist in all farm categories, although they appear to be much higher on large than on small farms. While small farms tend to use land more

intensively in an attempt to alleviate land constraints, the study suggests that the relatively higher level of technical efficiency observed on small farms is largely attributable to the adoption of traditional land saving techniques rather than the use of modern land saving technologies. Small-scale farms are found to be more allocatively efficient than the larger farms. Nevertheless, gains from improving allocative efficiency exist in more than 90% of the sample households. Accordingly, measures aimed at reducing labour congestion on the farms, relaxing liquidity constraints, and improving the functioning of land rental markets can significantly improve productive efficiency.

5.4 Findings on factors influencing efficiency

The Tobit results show that two factors were statistically significant in influencing the productive efficiency of the farms. Firstly, education of the head had a positive influence on the levels of farm efficiencies. Secondly, the distance to extension services was negatively related to efficiency levels. The shorter the distance to extension providers the higher the efficiency levels.

The positive relationship between the education level of household head and economic efficiency can be supported by similar results reported in studies which have focused on the association between formal education and technical efficiency (Uaiene and Arndt, 2009; Bozoglu and Ceyhan, 2007; Bravo-Ureta and Pinheiro, 1994). In general, more educated farmers are able to perceive, interpret and respond to new information and adopt improved technologies such as fertilizers, pesticides and planting materials much faster than their counterparts. This result is consistent with the findings by Abdulai and Eberlin (2001) which established that an increase in human capital will augment the productivity of farmers since they will be better able to allocate family-supplied and purchased inputs, select and utilize the appropriate quantities of purchased inputs while applying available and acceptable techniques to achieve the portfolio of household pursuits such as income.

The result that shorter distances to extension providers influenced farm efficiency is also consistent with findings by Seyoum et al. (1998) who found a 14% difference in technical efficiency between farmers who had access to extension services and those who did not in a study on farmers within and outside the Sasakawa- Global 2000 project. Extension workers play a central role in informing, motivating and educating farmers about available technology.

5.5 Policy Recommendations

While self-sufficiency in wheat remains a stated goal of the government, it has remained elusive over the years. With current yields, self-sufficiency will be accomplished only if area under wheat is increased substantially or through intensification leading to higher yields.

The implications of the findings from this study on how Kenya can close the gap between domestic production and wheat demand requires a combination of efforts both from the public and private sector that includes the following:

1. Extension services are crucial in enhancing increased productivity. Currently there is poor provision of extension services especially to the small-scale farmers. Though extension services have been privatized, there is need for public-private partnerships in the provision of extension services. Increasing the efficiency of input use by improving the farmer knowledge and skills provides a potential for productivity growth in the medium to long term.
2. Seed is an important farm input in wheat production. In addition to accounting for a significant proportion of cost, it determines yields or productivity. Currently farmers are either using uncertified farmer-saved seed or buy uncertified seeds from other farmers. Improvement in the quality of seeds is crucial and therefore the regulatory roles in this input sector need be streamlined Kenya must therefore endeavor to produce high quality certified wheat seed.
3. Land preparation (largely mechanized) has been identified as a high cost center in wheat production. This is influenced by among others cost of diesel fuel along with repairs and maintenance on farm machinery. To reduce this cost and therefore improve competitiveness of domestically produced wheat, it would be important to reduce the cost on diesel and spare parts for farm machinery through reduction of taxes and tariffs. In the medium/ long term there is need to invest in simple technology machineries to be used especially by the small scale farmers.
4. Opening up more areas in the potential wheat areas in the country. This mostly in the marginal areas through irrigation. This could assist in increasing output substantially faster than if input use increases. For the existing small scale wheat farmers, they should be supported in lowering their costs of production to ensure that they remain in production since their output is quite significant in addressing the production gap.

5.5 Further Research

The issue of low wheat productivity in Kenya is much more complex, with economic efficiency notwithstanding. There are production-level issues to do with productivity, extension, access to seeds, fertilizers, credit and other inputs that have been addressed in this work.

However, there also issues that would inform more on wheat productivity and competitiveness that can be considered for further research. These includes on-farm wheat seeds productivity (recycled vis a vis purchased seeds) , potential to open up new lands for production under irrigation; and last but not least, policies that favor increased investment in agriculture that would allow farmers, including the small ones, to acquire modern production skills.

REFERENCES:

Abdulai A, Eberlin R 2001. Technical Efficiency during Economic Reform in Nicaragua: Evidence from Farm Household Survey Data. *Economic Systems* Vol. 25, No. 2, pp. 113-125.

Aigner D, Lovell CK, Schmidt P (1977). Formulation and estimation of stochastic frontier Production function models. *Journal of Econometrics, 6, 21-37.*

Ali M, Byerlee, D (1991). Economic efficiency of Small farmers in a changing world: A survey of recent evidence. *Journal of International Development*, 3(1), 1-27

Azhar R (1991). Education and technical efficiency during the Green Revolution in Pakistan, *Economic Development and Cultural Change*, 56, 651-665.

Battese GE, Coelli TJ (1995). A model for Technical Inefficiency Effects in Stochastic Frontier Function for Panel Data. *Empirical economics* 20 (325-332).

Battese GE, Sohail J, Manzoor AG (1996). An Investigation of Technical Inefficiencies of Production of Wheat Farmers in Four Districts of Pakistan. *Journal of Agricultural Economics*, 47 (1): 37-49.

Bagi FS (1982). Relationship between Farm Size and Technical Efficiency in West Tennessee Agriculture. *Southern Journal of Agricultural Economics*, 14:139-144

Bauer PW (1990). Recent Developments in the Econometric Estimation of Frontiers, *Journal of Econometrics*, Vol. 46, pp. 36-56.

Bedassa T, Krishnamoorthy, S (1997). Technical Efficiency in paddy farms of Tamil Nadu: An analysis Based on Farm Size and Ecological Zone. *Agricultural Economics* 16: 185-192

Berry RA, Cline WR (1979). *Agrarian Structure and Productivity in Developing Countries* The Johns Hopkins University Press, Baltimore.

Bozoglu M, Ceyhan V (2007). Measuring the Technical Efficiency andExploring the Inefficiency Determinants of Vegetable Farms in Samsung Province, Turkey. Agric. Syst. 94:649-656.

Butt MS (1984). Education and farm productivity in Pakistan, *Pakistan Journal of Applied Economics*, 3: 65-82.

Bravo-Ureta B E, Evenson R E (1994). Efficiency in agricultural production: the case of peasant farmers in eastern Paraguay. Agric.Econom. 10, 27-37.

Bravo-Ureta B E, Rieger L (1991). Dairy farm efficiency measurement using stochastic frontiers and neoclassical duality. *American J. Agric Econom* 73, 421-428.

Byerlee D (1987). Maintaining the Momentum in Post Green Revolution Agriculture: A micro-level perspective from Asia, International Development Paper no.10, East Lansing, Michigan: Michigan State University.

Coelli TJ (1994). A guide to FRONTIER version 4.1: a computer program for stochastic frontier production and cost function estimation Department of econometrics, University of New England, Armidale, Australia

Coelli TJ, Battese GE (1996). Identification of Factors which Influence the Technical Inefficiency of Indian Farmers. *Australian Journal ofAgricultural Economics*, 40:103-128.

Drysdale P, Kalirajan KP, Zahao S (1995). The Impact of Economic Reform on Production Growth in Chinese Agriculture. *American Journal of Agricultural Economics* 73:2, 266-275.

Economic Review of Agriculture(2010). Central Planning and Monitoring Unit. Ministry of Agriculture.

Farrell MJ (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society*. Series A, 120, 253-290.

FAOSTAT. Agriculture Outlook (2010)

FAOSTAT. Agriculture Outlook (2008)

Food and Fertilizer Technology Centre (2005). Small farms mechanization systems development adoption and utilization. Annual Report

Republic of Kenya (2007). Economic Survey.

Guven C, Ibrahim S (2009). Egypt Grain and Feed Annual Report.

Hassan RM, Mwangi W, Karanja D (1993). Wheat Supply in Kenya: Production technologies, sources of inefficiency and potential for productivity growth. *CIMMYT Economics Working Paper* No. 93-02. Mexico D.F CIMMYT.

Ha'unga P (2002) Productive Efficiency of the Squash Export Industry in Tonga. PhD Thesis. University of Hawaii.

http:www.intracen.org/tradestat/sitc3-3d/epo46.htm

http://www.agron.iastate.edu/courses/agron212/Readings/Oat_wheat_history.htm January 2002.

Hussain SS (1989). Analysis of economic efficiency in Nothern Pakistan: estimation, causes and policy implications. unpublished PhD dissertation, Urbana-Champaign: University of Illinois.

Igbekele AA, Daramola AG, Falusi OA (2005). Technical Efficiency of Small Scale Farmers: An Application of the Stochastic Frontier Production Function to Rural and Urban Farmers in Ondo State, Nigeria.

Ikiara GK (1988). Rising to the Challenge The private Sector Response in Kenya In Liberalized and Neglected? Food marketing Policies in Eastern Africa (Ed Seppala) World Development Studies, 12 UNU/WIDER.

Kalirajan K (1991). The importance of efficient use in the adoption of technology: a micro panel data analysis. *Journal Prod. Anal 2, 113-126.*

Kalirajan KP, Shand R T (1992). Casuality between technical and allocative efficiencies: an empirical testing. *Journal of Economic Studies*, 19, 3-17.

Khem RS, Pingsun L, Halina MZ (1999). Technical, allocative and economic efficiencies in swine production in Hawaii: a comparison of parametric and nonparametric approaches. *Journal of agricultural economics*.vol 20. pp 23-35.

Kibaara B (2005). Technical Efficiency in Kenya's Maize Production: An Application of the Stochastic Frontier Approach. Msc Thesis. Colorado State University.

Kopp RJ, Diewert WE (1982). The decomposition of frontier cost function deviations into measures of technical and allocative efficiency. *Journal of Economics*. 19, 319-331.

Krejcie RV, Morgan DW (1970) Determining Sample Size for Research Activities. Education and Psychological Measurement. 1970, vol 30, pp 607-610.

Kumbhakar SC, Ghosh S, Mcguckin JT (1991). A Generalised Production Frontier Approach for Estimating Determinants of Inefficiency in US Dairy Farms. *Journal of Business and Economic Statistics*, 9(3), pp 279-286.

Kumar S R, Russell R (2002). Technological Change, Technological Catch-up, and Capital Deepening: Relative Contributions to Growth and Convergence. *American Economic Review* 92(Jun. 2002):527-548.

Lau LJ, Yotopoulos PA (1971). A Test for Relative Economic Efficiency: Application to Indian Agriculture. *American Economic Review*, 61:94-109.

Leibenstein H (1966). Allocative efficiency vs x-efficiency. *American Economic Review*, vol 56, pp 392-415.

Makanda DW, James FO (1993). Promise and Problem in the Development of Kenya's Wheat Agriculture.

Ministry of Agriculture (2008). Ministry of Agriculture Brief Nakuru District. July Edition

Ministry of Agriculture (2008).Ministry of Agriculture. Workshop Proceedings of the National Workshop on Wheat Industry in Kenya. Kenya Agricultural Research Centre, Nairobi, Kenya. 27th May 2008

Mulwa R, Emrouznejad A, Muhammad L (2009) Economic Efficiency of Smallholder maize Producers in Western Kenya: a DEA meta-frontier analysis. *International Journal of Operation Research* Vol. 4, No.3, pp 250-267.

Muyanga M, Jayne T, Kodhek G, Joshua A (2005). Staple Food Consumption Patterns in Urban Kenya Trends and Policy Implications. Tegemeo Working Paper No 19.

Nyagito H, Ikiara M M, Ronge EE (2002). Performance of Kenya's Wheat Industry and Prospects for Regional Trade in Wheat Products. *KIPPRA Discussion Paper* No 17.

Nyoro J, Muyanga M, Komo I (2005). Wheat and wheat products trade in Kenya. Report prepared for cereals growers association and cereal millers association

Obare GA, Nyagaka DO, Nguyo W, Mwakubo SM (2010). Are Kenyan smallholders allocatively efficient? Evidence from Irish potato producers in Nyandarua North district. *Journal of Development and Agricultural Economics Vol. 2(3), pp. 078-085, March 2010.*

Parikh A, Ali F, Shah MK (1995). Measurement of economic efficiency in Pakistani Agriculture, *American Journal of Agricultural Economics*, 77 (3): 675- 685.

Ray S (1988). Data envelopment analysis, nondiscretionary inputs and efficiency: an alternative interpretation. Socio-Econom. Plann. Sci. 22, 167-176.

Reifschneider D, Stevenson R (1991). Systematic Departures from the Frontier: A framework for the Analysis of Firm Inefficiency. *International Economic Review, vol 32, pp 715-23*

Rejesus A, Smale M, Heisey P (2005). Sources of Productivity Growth in Wheat. A Review of Recent Performance and Future Prospects.

Rosegrant MW, Agcaoili-Sombilla M (2010). Food, agriculture and the environment discussion paper 5. Global food projections to 2020, Implications for investment.IFPRI, Washington DC, USA.

Seyoum MJ, Battese GE, Fleming EM (1998). Technical Efficiency and Productivity of Maize Producers in Eastern Ethiopia: A Study ofFarmers within and Outside the Sasakawa-Global 2000 Project. Agri.Econ. 19: 341-348.

Siam G, Croppenstedt A (2007). An Assessment of the impact of Wheat Liberalization in Egypt: A Multi-Market Model Approach. ESA Working Paper No.07-15. Agricultural Development Economic Division, Food and Agriculture Organization, United Nations

USDA (2008). Foreign Agricultural Service GAIN Report

USDA (2009).Foreign Agricultural Service GAIN Report.

USDA (2010). Foreign Agricultural Service GAIN Report.

Wang J, Crammer GC, Wailes EJ (1996). Production Efficiency of Chinese Agriculture: Evidence from rural household survey data. *Agricultural Economics Journal* 15 (1): 17-28

Wilson P, Hadley D, Ashby C (2001). The Influence of Management Characteristics on the Technical Efficiency of Wheat farmers in Eastern England. *Agricultural Economics* 24: 329-338

Willis J L, Wroblewski J (2007). What Happened to the Gains From Strong Productivity

World Bank (1983). *'Kenya Growth and Structural Change'. Basic EconomicReport*. World Bank Washington, DC.

Growth? (2007). Federal Reserve Bank of Kansas City, Economic Review, First Quarter 2007.

Uaiene RW, Arndt C (2009). Farm Household Technical Efficiency inMozambique. Contributed Paper Prepared for Presentation at theInternational Association of Agricultural Economists Conference.Beijing. China 16-22 August. 2009.

Xu X, Jeffrey S.R (1997). Efficiency and Technical Progress in Traditional and Modern Agriculture: Evidence from Rice Production in China. *Agricultural Economics* 18(2): 157-165.

ANNEXES

Annex 1: Variable Correlation Results

	wlkg_acre	seedkg_acre	fertkg_acre	foliarlt_acre	chemkg_acre	hiredlab_acre	famlab
wlkg_acre	1						
seedkg_acre	0.1397	1					
fertkg_acre	0.2774	0.0604	1				
foliarlt_acre	0.1489	0.0393	-0.2213	1			
chemkg_acre	0.1951	-0.1251	0.0226	-0.0978	1		
hiredlab_acre	0.1584	0.0425	0.0932	-0.0205	-0.0617	1	
famlab_acre	0.1234	0.0495	0.1003	0.1279	-0.0578	0.0128	1

Source: Authors's computation

Annex 2: Nakuru District - Main enterprises, current production levels, potential production (2007-2009)

Crop	2007 achievements		2008 achievements			Targets for 2009		
	HA	PROD	HA	Yield/ha	TOTAL PROD.	HA	Yield/ha	PROD.
Maize	7915	234292	7350	10	73500	10000	32	320000 Bags
Wheat	2865	114275	4815	40	192600	7350	40	294000 Bags
Sorghum	42.3	571.5	17	5	85	236	5	1180 Bags
Finger Millet	51	438	29	5	145	121	5	605 Bags
Beans	5191	63227	3865	1	3865	7715	15	115725 Bags
Cow Peas	15.8	78.6	17.3	3	51.9	32	3	
Pigeon peas	4.45	27.4	0.2	3	0.6	17	7	119 Bags
[illegible] potatoes	27.8	220	14	7	98	1065	8	856 T
Irish potatoes	503	3336.8	75	6	450	81	8	648 T
Horticulture						865		
Sisal	7500	3750	7000	0.5	3500	7000 (25)	0.5	3512.5 T

Source: Ministry of Agriculture,2007, Nakuru District Annual Report

Annex 3: District Profile- Nakuru District

District Area (Total)	1484.1Km^2
Arable Land	796.23 Km^2
Water mass	40-45 km^2
Forests	7 km^2
National parks	188 km^2

Number of Divisions.....8 No. of constituencies...2 Local Authorities 2

Names of constituencies... .Rongai, Nakuru Town

Number of Locations.....21 Number of Sub locations.....46 (including Wesseges & Maji Tamu locations)

Altitude range	1800-2400 m.a.s.l.
Mean Maximum Temperature	29.3 °C
Mean Minimum Temperature	24.0°C
Rainfall Range	760-1270mm (sub-humid equatorial climate)
Rainy seasons	2 : LR March- July, SR September-December

Population (1999).....396560 2009 Projections.....471514

Population Density .....391 pp sq km	Growth rate.....3.4%
Average Family Size	5
Farm Holdings	109835
Farm families	126037
Average Farm size (Small scale)	2.5 Acres
Average Farm size (large scale)	200 Acres
Staff: Farmer ratio.....1:1580	
Agricultural parastatals	6 NCPB, AFC, Kenya seed PBK, KEPHIS, New KCC
Research Centres	KARI Njoro, KARI Lanet, KARI Naivasha mandate

AEZs Lower Highland (LH3-LH4) Wheat/maize/barley zone

Lower Midland (LM3)

Upper Mid land (UM2-5) Upper Sisal zone

Source: Ministry of Agriculture, 2007. Nakuru District Annual Report

Wheat Household Survey, 2009:

This survey is being carried out with the objective of finding out production and marketing aspects of wheat production in Nakuru District. We intend to interview about 130 farmers. We appreciate information that you will provide to us and we pledge to treat the information CONFIDENTIALLY. We promise to use your responses for the study purpose only.

Household No. **HHID** _____

Date: (ddmmyy) **SURDATE** _____

HH Name _____

Respondent(s) _____ **MEM** _____

(**Enumerator Instruction** Record the member number of the Respondent from the **Demography table** after the survey is completed.)

Identifying Variables:

Supervisor _____ **SUPER** _____

Enumerator: _____ **ENUM** _____

District _____ **DIST** _____

Division: _____ **DIV** _____

Location: _____ **LOC** _____

Sub-Location: _____ **SUBLOC** _____

Village: _____ **VIL** _____

LAND USE

Q1a. How much land (in acres) do you currently own (**in total**)? **LOWED** _____

Q1b. **In total** how many acres did you **cultivate** during the 2008 **main** season **LCULTV** _____

Q1c. **In total** how many acres did you **put under wheat** during the 2008 **main** season? **LWHEAT** _____

Q1d During the **2008 main season** did you **rent in** any land to **grow wheat**? (1=yes; 2=no) **RENT** _____

(If NO, Go to Question 3) (IF YES, Continue)

Q2a **IF YES,** How many acres did you rent to grow wheat (**in total**) **ACRERENT** _____

Q2b How much did you **pay** for the land Kshs/acre per season ? **CASHRENT** _____

Q3.WHEAT MAIN CROP Season 2008 (Refers to July/October 2008 harvest) ***filename crop09.sav Key variables hhid crop***

crop code		Acres	Is this field 1=owned w/ deed 2=owned w/o deed 3=rented 4=owned by parent/ relative 5=government/communal/co-operative	First Land preparation technology 1=hired tractor 2=own tractor 3=hired oxen 4=own oxen 5=hand hoe	Second Land preparation technology 1=hired tractor 2=own tractor 3=hired oxen 4=own oxen 5=hand hoe	Total Land preparation Cost	Seed variety	Seed source 1=purchased 2=retained seed 3=recycled one year 4=recycled two years 5=recycled three or more years	Quantity of seed used & cost, if purchased this season			1st Fertilizer used			2nd Fertilizer used			Harvest		Sales		For the largest Sale				
									Qty	Unit	Cost per unit	Type	Qty	Unit	Type	Qty	Unit	Qty	Unit	Qty	Unit	Price received per unit	Buyer type	Transport cost per unit	Distance in Km to the point of sale	Was the harvest of the crop 1=Good 2=Average 3= Bad
crop	**field**	**acres**	**tenure**	**Landtech1**	**Landtech2**	**lpcost**	**seedvar**	**sdsor**	**sqt**	**sunit**	**scost**	**ft1**	**fq1**	**fu1**	**ft2**	**fq2**	**fu2**	**hvt**	**hunit**	**sold**	**shunit**	**price**	**buyer**	**transcos**	**distkm**	**hvcrop**
wheat																										
wheat																										
wheat																										

Unit codes: 1=90 kg bag 11=50 kg bag 2=kgs 3=litre	7=25kg bag 8=10kg Bag 9=gorogoro 10=tonnes 12=debe 13=grams	14=wheelbarrow 15=cart 16=canter 17=pickup 18=2kg packet(seed)	**Fertilizer codes:** 0=None 1=DAP 2=MAP 3=TSP 4=SSP	5=NPK (20:20:0) 6=NPK (17:17:0) 7=NPK (25:5:+5S) 8=CAN (26:0:0) 9=ASN (26:0:0) 10=UREA (46:0:0)	11=SA (21:0:0) 12=Other (specify)___ 13=manure 14=foliar feeds 15=NPK (23:23:23) 16=NPK (20:10:10) 17=DAP + CAN	18=compost 19=magnas lime 20=DSP 21=NPK(23:23:0) 22=NPK(17:17:17) 23=NPK(18:14:12) 24=NPK(15:15:15)	25=mavuno-basal 26=kevo green 27=rock-phosphate 28=NPK 14:14:20 29=mjingu 1100 30=UREA+CAN 31=Mavuno-top dress	**Buyer type codes:** 1=small trader 2=large trader 3=NCPB 4=miller	5=NGO 6=consumer 10=other(specify)___

Seed Variety Code:

1=Mbuni 2=Fahari 3=Pasa 4=Nyangumi 5=Kwale 6=Tembo 7=Duma

8= Mbega **9**=*Ngamia* **10**=*Nungu* **11**=*Njoro 1* **12**=*Njoro BW2* **13**=*Chozi* **14**=Mwamba **15**=Indigenous/Local type.

16=Don't know **17**=Other (specify)_____

If seed source is not purchased then ask the following questions

Q4a. When does the farmer select **wheat seed** to plant for recycling? **SEEDRCYL**_____
1=during growing season, 2= at harvest, 3= before harvest, 4=Other (specify)_____

Q4b What is the reason for recycling 1=Cheap 2= No difference 3=Other (specify)_____ **REARYMZ**_____

Q4c. What criteria does the farmer consider in the selection of **Wheat seed** **SEEDCRET**_____
1= plant aspect, 2= year aspect 3= Other (specify)_____

Q5a. Did you plant other crops (**except wheat)** during the 2008 long rain season? 1=Yes 2=No **PLANTCRP**_____

Q5b .Among the crops you **last harvested and sold**, (***including wheat***) which gave you the highest **CASH INCOME**? **CASHINC** _____

Q5d. Which year did this household start growing **wheat?** **YRWHEAT**_____

CREDIT

A. CASH CREDIT (For wheat purpose only)

Q6a. Did any household member **try to get any cash credit during** the 2008/09 crop year **for wheat farming**? (1=Yes) (2=No skip to Q7a)**CASHCRD** _____

Q6b. (If Yes) Did you receive the **cash credit** that **you tried to obtain**? (1= Yes) (2=No) **CASHRD** _____

Q6c. (If yes) How **much cash credit** did you receive (ksh) **CASH** _____

Q6d. For the **two** main sources of cash credit, what was the **source** and the **amount** that you received from each? **CSRC1** ____ **CAMT1** _____

CSRC2 ____ **CAMT2** _____

(1= neighbor 2=farmer group 3=SACCO 4=Commercial bank (specify)_____ 5=relative/friend
6=NGO/MFI, specify_____ 7=AFC 8= group (ROSCA) 9=Village bank 10=Shopkeeper 11=other specify)_____

Q6e. *If you tried to obtain* **cash credit but did not get** what was the reason for not getting? **NCASH** _____
(1=no collateral 2=Had outstanding loan 3= Don't Know 4=Loaning institution had no money 5= Other, specify_____

B. IN KIND CREDIT (For wheat Purpose only)

Q7a. Did any household member **try to get any credit in kind** during the 2008/09 crop year **for wheat farming**? (1=Yes) (2=No skip to Q8a) **INKDCRD** _____

Q7b. (If Yes) Did you receive the **credit** in kind **that you tried to obtain**? (1= Yes) (2=No) **CRED** _____

Q7c. If you tried to obtain credit in kind **but did not receive** what was the reason for not getting **NCRED** _____
(1=Had outstanding loan 2= Don't Know 3= Other, specify_____)

CROP INPUTS

Q8a. What **WHEAT CROP INPUTS** did you purchase/hire on **CREDIT OR IN CASH in 2008/09 cropping year**? **(Excluding seeds)**

Input09.sav *Key Variables: hhid inptype*

Fertilizer codes: 1=DAP 2=MAP 3=TSP 4=SSP 5=NPK (20 20 0) 6=NPK (17 17 0) 7=NPK (25 5 +5S) 8=CAN (26 0 0) 9=ASN (26 0 0) 10=UREA (46 0 0) 11=SA (21 0 0) 12=Other (specify)___ 13=manure 14=foliar feeds 15=NPK (23 23 23) 16=NPK (20 10 10) 17=DAP + CAN 18=compost 19=magnum lime 20=DSP 21=NPK(23 23 0)	22=pesticide 23=insecticide 24=herbicide 25= fungicide 26=sprayer 27= AT equip 28=land preparation(on credit only) 29=technical support 30= plough 31=water 32=planter cost 33=harvester cost 34=transport 35=fuel 36=gunny bags 37=ridger cost 38=Land 40=other specify_____	**Input type** **For chemicals remember to write the Name of the chemical**	Quantity bought/hired	**Unit** 1=90 kg bag 2=1kg 3=Litre 15=grams 20=50 kg bag [illegible] 99=gorogoro 10=acre	**Mode of Purchase** 1=own cash 2=borrowed cash 3=on hand credit 4=own and borrowed cash	**Source of fertilizer and other inputs** (Source type / codes) 1=small trader 2=Hawker 3=large company 4=CBO 5=ICIA 6=Farmer group 7=Other coop 8=Relative or friend 9=Relative on travel 10=Other specify_____	**Price per unit specified**	**Kilometers from point of purchase to farm**	**Transport Cost per Unit of the fertilizer (KSh) (Instruction: fill for only fertilizers)**	**How is/was the credit repaid?** 1=crop revenue 2=livestock revenue 3=off farm income 4=both livestock and crop revenue 5=other specify_____
inptype			**nhumbt**	**Unit**		**mdpurch**	**inpsrce**		**punit**	**hmn**	**trnscost**	**mpaid**

Q9a *Did you hire* **permanent labourers** in this household during the **main crop** season in 2008/2009? 1= Yes, 2=No (If no go to the table Q10a) **PERMLAB**_____

Q9b If Q9a= **YES**, how many months did you hire the permanent labourer (s) during the 2008 **main season**? **MONLAB**_____

Q9c How much did you pay for the permanent labourer(s) per month? (Evaluate in-kind payments, e.g., food, shelter, etc.) **PAYMON**_____

Q9d What **proportion** of his or her or their time **(in %)** was devoted to: **wheat-related** work? **PRWHEAT**_____

LABOUR INPUTS: ***Record amount paid for hired tractor/oxen and all the labour used (both hired and family labour) for the largest wheat field***

Q10a Record the **Field Number** (from crop table) **FIELDNUM**_____ **MHARV**_____ **MUNIT**_____

TRACTOR/DRAFT AND LABOUR INPUTS- LARGEST WHEAT FIELD -2008 main season *file name wheatlabr09.sav Key variables Hhid activity*

	Tractor/Oxen				Hired Labor				Family Labor (adults)				Family Labor (children)	
	Tractor 0=None 1=Own 2=Hired	If X1 is hired How much did you pay on this field	Oxen 0=None 1=Own 2=Hired	If X3 is hired How much did you pay on this field	# hired	# of days	Ksh per person per day	Contract labour Total Cost	# of males	# of days	# of females	# of days	# of children	# of days
ACTIVITY	**X1**	**X2**	**X3**	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**	**X11**	**X12**	**X13**	**X14**
1=1st Plough														
2=2nd plough														
3=Harrow														
4=Planting														
5= Top dressing														
6=1st Spraying														
7= 2nd Spraying														
8= 3rd Spraying														
9=Weeding														
10=Watchman														
11=Harvesting														
12= Head to storage														
13=Diving														
14= Threshing														
15=others (spfy) _____														

Harvest units codes

1= 90-kg bag, 2= kg, 9=Gorogoro, 11=50 kg bag 12=Debe, 10=Tonnes 15=other (specify)_____

DECISION MAKING, EXTENSION and GROUP PARTICIPATION

Q11a Who **makes decisions** on wheat activities (e.g what to plant, which inputs to use, where to sell etc)? **DECISION** _____

(1= head 2=spouse 3=Son/daughter 4=both head and spouse 5=other (specify)_____

Q11b. Did you **actively seek advice** on **wheat crop** in the **last 12 months**? 1=yes 2=no (go to Q11 e) **SEEKADV** _____

Q11c. If Yes, from who did the household receive the service? **EXT1** _____ **EXT2** _____

(1=public extension agent 2=private extension agent 3=neighbour/farmer 4= ASK Shows 5=traders/input dealers 6=radio/television 7=family/friend 8=newspaper/magazines 9=farmer organizations/cooperatives 10=field days/demonstrations 11= NGO agent 12=research organizations 13= other (specify)_____

Q11d. Total number of **extension contacts on wheat** in the last cropping year (2008) **TCONTACT**_____

Q11e. If no, why didn't you seek advice? ***(give up to 2 reasons)*** **SEEKNOT1**_____

SEEKNOT2_____

1=long distance 2=Expensive 3=time consuming 4=extension agents not available 5=Other (specify)_____

Q11f. Do you (hh) belong to a farmers group? 1=Yes 2=No **go to Q11h)** **GRPMEM** _____

Q11g If Q11g=1 (Yes), what benefits/services do you get from the group? (Specify up to 2) **SERV1** _____

(0=none 1=Training 2=Marketing 3=Input acquisition 4= Financial services 5=A I services 6= Other (specify)_____ **SERV2** _____

Q11h. If (Q11g=2 (No)), why are you are not a member of the group? **GNOTMEM1** _____

(1=Not helpful 2=Group collapsed 3=No group nearby 4=Other (specify)_____ **GNOTMEM2**_____

Reference Period: March 2008 to Feb 2009

ID	Name	In which year was the person born?	What is the sex of ...? 1=male 2=female	Relationship to current head *See codes below*	Marital Status *See codes below*	Is ... Currently enrolled in formal schooling? 1 = Yes 2 = No	What is the highest level of education completed? *See codes below*	Has the person been trained on wheat production in the last 2 years? 1=Yes 2=No	How many months in the period since 2008 & Feb 2009 has the person been living at home?	What is your main occupation in march 2008 to Feb 2009?
MEM	**NAME**	**YBORN**	**SEX**	**RHEAD**	**METAT**	**SCHOO**	**HEDU**	**WHETRAIN**	**MONTH**	**OCCUP**
1	Head									
2	Spouse									
3										

Instruction: record the details of the respondent even if he/she is not the head or spouse

Relation to head
1= head
2= spouse
3= own child
4= step child
5= parent
6= brother /sister
7= nephew /niece
8= son/daughter-in-law
9= grandchild
10=other relative
11=unrelated
12=brother /sister-in-law
13=parent-in-law
14=worker
15=Other specify

Marital Status
1 = single
2 = monogamously
3 = polygamously married
4 = divorced
5 = widowed
6 = separated
7 = other, specify _____

Education levels
-99=don't know
0=none
1=pre- primary
2=some primary
3=completed primary
4= village polytechnic
5=some secondary
6=completed secondary
7=attended college
8=attended university
9=other (specify)

Occupation
1=self-employed in agriculture
2=self-employed on non-farm enterprise
3=Salaried worker
4=Domestic work
5=Unemployed, looking for a job
6=student
7=retired
8=Not able to work (handicapped)
9=Other (specify)_____

(**Enumerator Instruction:** Distance should be recorded in kilometres (Km))

a) What is the **distance** from your homestead to where you **normally buy** fertilizer **FERTBUY** _____

b) What is the distance from your homestead to the nearest **certified wheat seed seller? CERTSD**____

c) What is the distance from your homestead to the nearest **NCPB** depot? **NCPBKM** _____

d) What is the distance from your homestead to **extension advice**? **DEXTN** _____

e) What is the distance from your homestead to the nearest **market place** for **wheat**? **MKTKM** _____

f) What is the name of the market **MARKET**_____

f) What is the distance from your homestead to a **motorable road**? **(Usable during wet seasons)** **DMTROAD** _____

g) What is the distance from your homestead to a **tarmac road**? **DTMROAD** _____

h) Do you (hh) **have access** to a mobile phone (1=Yes) (2=No) **MOBACC** _____

i) If No member of the HH has a mobile phone. what is the distance to the phone access point? **PHONE** _____

WAGE RATES AND LAND RATES

Q14a. What is the **daily wage rate** for **general farm labour** in this area? (Ksh per day): **WAGERATE** _____

Q14b. For this wage, what is the **typical number** of hours **worked per day**? (Hours): **HOURS** _____

Q14c. What is the **land rental rate for one acre of good quality land for one year** in this area? (Ksh per acre) **LRRY** _____

Q14d. What is the **land rental rate for one acre of good quality land for one season** in this area? (Ksh per acre) **LRRS** _____

OBSERVE AND ASK ABOUT THE FOLLOWING:

Q15a. What is the **roofing** material of the **main house**? **ROOF** _____
(1=grass /makuti 2=iron sheet 3=tiles 4=other (specify)_____

Q15b. What is the **wall** material of the **main house**? **WALL** _____
(1=mud 2=bricks/stones 3=iron sheet 4=wood 5=plastered 6=other (specify)_____

Q15c. What is the **floor** material of the **main house**? **FLOOR** _____
(1= earth 2=cement 3=wood 4=tiles 5=other (specify)_____

Q15d. What type of **toilet** is used by the household? **TOILET** _____
(1= pit latrine 2= bush 3= flush toilet 4= other (specify)_____

Q16a. How was the **2008** cropping season 1= excellent, 2=Good, 3=Poor **HOWSEAS** _____

Q16b What is your **wheat yield/acre** when season is;

Excellent	**EXCYLD** _____	**UNITEXC**_____
Good	**GOODYLD** _____	**UNITGOOD**_____
Poor	**POORYLD** _____	**UNITPOOR**_____

Harvest units codes
1= 90-kg bag. 2= kg. 9=Gorogoro. 11=50 kg bag 12=Debe. 10=Tonnes

ENUMERATOR COMMENTS REGARDING INTERVIEW (e.g. quality of responses etc)

Q17. What is your assessment of the quality of data collected: **QUALDATA** _____
1= reliable
2= not reliable
3= Other (specify)_____

Thank You!