UNIVERSITI PUTRA MALAYSIA

MEASURING TECHNICAL AND WATER USE EFFICIENCY AND THEIR DETERMINANTS FOR WHEAT PRODUCTION IN FAISALABAD, PAKISTAN

MOEED WAQAR GILL

FP 2015 9

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By

MOEED WAQAR GILL

Thesis submitted to the school of Graduate studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Master of Science.

February 2015

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DEDICATION

This thesis is especially dedicated to my parents. I would like to dedicate this thesis for my beloved family and all my supervisors and lecturers in the Department of Agribusiness and information systems and friends. Their guidance and relentless support have been a great inspiration to the realization of this project.

SUMMARY ABSTRACT

Pakistan is confronting one of the most striking challenges of water scarcity in the world. In Pakistan, per capita consumption of water is about 1038 m^3 and 90% of agricultural production comes from irrigated lands. The main objective of the study is to evaluate the technical and water use efficiency to increase wheat productivity in Faisalabad District, Pakistan. The study used DEA (Data Envelopment Analysis) approach to estimate the technical efficiency and Tobit regression model was used to discover factors responsible for technical inefficiency. A total of 180 farmers were selected and face to face interviewed was carried out in the District of Faisalabad. Three farm size categories, i.e. small farmers, medium farmers and large farmers chosen. The result shows that large farmers are more efficient than medium farmers and small farmers are least efficient. Small farms overall and water T.E in CRS are 0.75 and 0.67 and in VRS are 0.92 and 0.80 respectively. Medium farms overall and water T.E in CRS are 0.85 and 0.75 and in VRS are 0.93 and 0.85 respectively. Large farms overall and water T.E in CRS are 0.89 and 0.73 and in VRS are 0.95 and 0.87 respectively. Furthermore, small farmers are performing low due to unavailability of sufficient information about changing practices and the new improvement in the sector. Small and some medium farmers appeared to use their family labor in the agricultural practices. Small farmers do not have sources of income other than farming. This problem has not given the due significance by the agricultural extension workers, as they do not visit the farmers habitually.

Abstract of the thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Masters of Science

MEASURING TECHNICAL AND WATER USE EFFICIENCY AND THEIR DETERMINANTS FOR WHEAT PRODUCTION IN FAISALABAD, PAKISTAN

By

MOEED WAQAR GILL

February 2015

Chairman: **Amin Mahir Bin Abdullah PhD**

Faculty: **Agriculture**

Pakistan is confronting one of the most striking challenges of water scarcity in the world. In Pakistan, per capita consumption of water is about 1038 m^3 and 90% of agricultural production comes from irrigated lands. Total agriculture land of Faisalabad is 584,495.14 hectares and the total irrigated land is 465,604 hectares. The main objective of the study is to evaluate the technical and water use efficiency to increase wheat productivity in Faisalabad District, Pakistan. This study has also recognized a variety of socioeconomic and wheat farm related factors responsible for technical, allocative and economic inefficiency. The study used DEA (Data Envelopment Analysis) approach to estimate the technical efficiency and Tobit regression model was used to discover factors responsible for technical inefficiency. A total of 180 farmers were selected and face to face interviewed was carried out in the District of Faisalabad. A tabular study was undertaken to find out different farm particular characteristics of the three farm size categories, i.e. small farmers, medium farmers and large farmers. The average farm size of the small, medium and large farmers was found to be 3 acres, 9 acres and 28 acres, respectively. The average application of fertilizers by all categories was found to be two bags of urea and one bag of DAP (Diammonium Phosphate) and an average of 2 trolleys of FYM (Farmyard Manure) for one acre of field.

According to the study, the result shows that large farmers are more efficient than medium farmers and small farmers are least efficient. Small farms overall and water T.E in CRS are 0.75 and 0.67 and in VRS are 0.92 and 0.80 respectively. Medium farms overall and water T.E in CRS are 0.85 and 0.75 and in VRS are 0.93 and 0.85 respectively. Large farms overall and water T.E in CRS are 0.89 and 0.73 and in VRS are 0.95 and 0.87 respectively. Furthermore, the higher education level of large farmers was also crucial against the low yields of small and medium farmers. Especially small farmers are performing low due to unavailability of sufficient information about changing practices and the new improvement in the sector. Family size and Education are the significance variables. Many farmers are either uninformed of the credit ease of use or else; due to high interest rate they were not ready to take a loan. Small and some

medium farmers appeared to use their family labor in the agricultural practices. Small farmers do not have sources of income other than farming. But few medium sized farmers were identified with income from other sources. But mostly large farmers have their sources of income other than farming. This problem has not given the due significance by the agricultural extension workers, as they do not visit the farmers habitually.

Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

MENGUKUR KECEKAPAN TEKNIKAL DAN PENGGUNAAN AIR DAN PENENTU NYA UNTUK PENGELUARAN GANDUM DI FAISALABAD, PAKISTAN

Oleh

MOEED WAQAR GILL

Februari 2015

Pengerusi: **Amin Mahir Bin Abdullah, Ph.D.**

Fakulti : **Pertanian**

Pakistan adalah di antara Negara-negara di dunia yang menghadapi cabaran kekurangan air yang serius. Penggunaan per kapita air ialah 1038 m^3 dan 90% daripada pengeluaran pertanian dibekalan oleh kawasan berpengairan. Jumlah tanah pertanian di Faisalabad ialah 584,495.14 hektar manakala jumlah tanah berpengairan seluas 465.604 hektar. Tujuan utama kajian ini ialah untuk menilai kecekapan teknikal dan kecekapan penggunaan air bagi meningkatkan produktiviti gandum di Daerah Faisalabad District, Pakistan. Kajian ini telah mengenal pasti faktor sosio-ekonomi dan ciri ladang gandum yang mempengaruhi kecekapan teknikal, alokatif dan ekonomi. Kajian ini telah mengunakan Analisis Pengumpulan Data atau *Data Envelopment Analysis (DEA)* untuk mengganggar kecekapan teknikal ladang dan Regresi Tobit untuk mengenal pasti faktor yang mempengaruhi ketidakcekapan teknikal. Sejumlah 180 orang penanam telah ditemuduga secara bersemuka. Analisis penjadualan telah dijalankan untuk meninjau ciri-ciri ladang mengikut tiga kategori saiz ladang, iaitu kecil, sederhana dan besar. Purata saiz ladang kecil, sederhana dan besar ialah masing-masing 3 ekar, 9 ekar dan 28 ekar. Purata penggunaan baja oleh semua kategori ialah dua beg urea dan satu beg DAP (Diammonium Phosphate) dan dua troli FYM (Farmyard Manure) setiap ekar ladang.

Keputusan kajian menunjukkan ladang besar lebih cekap teknikal dari ladang sederhana, dan ladang kecil paling tidak cekap. Kecekapan teknikal ladang dan penggunaan air bagi ladang kecil dengan andaian pulangan skala malar ialah masing-masing 0.75 dan 0.67, manakala dengan andaian pulangan skala berubah ialah 0.92 dan 0.80. Bagi ladang sederhana, kecekapan teknikal dan penggunaan air dengan andaian pulang skala malar ialah masing-masing 0.85 dan 0.75, manakala dengan andaian pulangan skala berubah ialah 0.93 dan 0.85. Kecekapan teknikal dan penggunaan air bagi ladang besar dengan andaian pulangan skala malar ialah 0.89 dan 0.73, manakala andaian pulangan skala perubah ialah 0.95 dan 0.87, masing-masing. Kajian mendapati bahawa tahap pendidikan petani besar lebih tinngi daripada petani sederhana dan kecil. Petani kecil mengalami pretasi rendah di sebabkan kekurangan maklumat tentang perubahan amalan serta perkembangan baharu sektor pengeluaran gandum. Saiz famili

dan tahap pendidikan didapati signifikan dalam mempengaruhi kecekapan pengeluaran. Kebanyakan petani tidak membuat pinjaman kerana sama ada tidak dimaklum tentang kemudahan kredit, atau kadar feadah pinjaman terlalu tinggi. Ladang kecil dan sederhana menggunakan tenaga kerja keluarga dalam pengeluaran gandum. Kebanyakan petani kecil tidak mempunyai pendapatan sampingan selain bertani. Walaubagaimana pun sebilangan petani sederhana didapati mempunyai pendapatan sampingan dari sumber lain. Kebanyakan petani besar mempunyai pendapatan sampingan dari sumber lain. Masalah ini di sebabkan lawatan oleh pekerja pengembangan ke kawasan pengeluaran gandum tidak dilakukan secara tetap dan berjadual.

ACKNOWLEDGEMENT

All praises are for the **Almighty Allah;** the most gracious and merciful, the creator and the omnipresent, who bestowed on me perseverance, potential and ability to complete this study. All reverence and thanks to **Holy Prophet Muhammad (PBUH),** the greatest social reformer and savior of the human.

I am greatly indebted to **Associate Prof. Dr. Amin Mahir Abdullah** Faculty of Agriculture, University Putra Malaysia, under who's skillful, insightful and affable supervision the study was accomplished. I am grateful to **Prof. Dr. Mohd Mansor Ismail** and **Dr. Nitty Hirawaty Kamarulzaman** for marvelous guidance and cooperation during the course of present study.

I am also thankful to **Dr. Khuda Bakhsh**, Institute of Agriculture & Resource Economics, and University of Agriculture, Faisalabad for providing me necessary guidance, which helped and supported me a lot to complete my dissertation, and valuable guidance and assistance.

I am thankful to my all friends, especially Saad Javed Cheema, Zahid Rasool, Rahman Lateef, Waqar Tariq, Rana Anwer Nazir Sardar Azeem Zahid, Qamar Shabbir, Rashid Zafar, Asghar Raza, Abid Mustafa and Mustafa Malik for all kinds of help and cooperation and company. Above all I extended my heartfelt gratitude and sense of obligation to my uncle, father, mother, brother, and sister for their kind support and best wishes.

MOEED WAQAR GILL

I certify that a Thesis Examination Committee has met on 5 February 2015 to conduct the final examination of Moeed Waqar Gill on his thesis entitled "Measuring Technical And Water Use Efficiency and Their Determinants for Wheat Production in Faisalabad, Pakistan" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Zainal Abidin bin Mohamed, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Nolila binti Mohd Nawi, PhD
Senior Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Jamal ALi, PhD
Associate Professor
Universiti Utara Malaysia
(External Examiner)

ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 12 August 2015

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Amin Mahir Abdullah, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Mohd Mansor Ismail, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Nitty Hirawaty Kamarulzaman, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Khuda Bakhsh, PhD
Assistant Professor
Institute of Agricultural and Resource Economics
University of Agriculture, Faisalabad
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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Committee: Amin Mahir Abdullah

Signature: _____
Name of
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Supervisory
Committee: Mohd Mansor Ismail

Signature: _____
Name of
Member of
Supervisory
Committee: Nitty Hirawaty Kamarulzaman

Signature: _____
Name of
Member of
Supervisory
Committee: Khuda Bakhsh

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CHAPTER 1

INTRODUCTION

1.1 Background

In Pakistan, agriculture is the core driving force for the country's development. More than 66 percent of the county's population involved directly and indirectly in the agricultural sector. The agricultural sector is contributing around 21 percent to GDP where 45 percent employments of the overall labor force (GOP, 2013). It is also the source of substantial foreign exchange earnings. The entire rate of economic growth is highly depending on the performance of the agricultural sector. Relating to the different experiences, it shows that agriculture growth is generally rely on the time period of high/low agricultural growth and robust or poor performance of the national economy (Ali, 2000). Pakistan's economic structure has gone under substantial changes from previous forty years. The agricultural sector has declined to 21 percent in 2013 where in 1970 it was 39 percent, in the period of 52 years, a decline of 18 percent occurs, but however, it cannot deny that still the contribution of agriculture in GDP in very significant for the country (GOP, 2013).

A total geographical area of Pakistan is 79.6 million hectares and 29.39 million hectares are used for the production of different crops. Almost 19 million hectares are irrigated while the rest of the area is under dry farming (GOP, 2013). The country has 6.6 million farms and 86 percent of farms are small, consisting of less than 5 hectare area and comprised 44 percent of the whole farm area. Just 5 percent farmers have area above 10 hectares which occupy 37 percent of the total farm area of the Pakistan (GOP, 2013).

Pakistan is the only country which has the largest contiguous gravity flow irrigation system in the world; it has 3 storage reservoirs, 68 small dams, 19 diversion barrages and 45 canal commands with 12 link canals. In 1859, the first controlled all-year irrigation began with the completion of the Upper Bari Doab Canal emanating from the Madhopur Headwork on the Ravi River. The Sakhar Barrage is considered as the first modern hydraulic structure on the Indus River, which completed in 1932 (FAO, 2004).

Table 1.1 shows the decrease and increase at the Agricultural growth rate of the area under agriculture, major crops, minor crops, livestock, fishery and Forestry in percentage change in growth last 9 years.

Table 1.1: Agriculture Sector Growth Rate from 2005-06 – 2012-13

Year	Area Agriculture Sector %	Major Crops %	Minor Crops %	Livestock %	Fishery %	Forestry %
2005-06	6.5	17.7	1.5	2.3	0.6	-32.4
2006-07	6.3	-3.9	0.4	15.8	20.8	-1.1
2007-08	4.1	7.7	1	2.8	15.4	-5.1
2008-09	1	-6.4	10.9	4.2	9.2	-13
2009-10	4	7.8	-1.2	3.1	2.3	-3
2010-11	0.6	-2.4	-7.8	4.3	1.4	2.2
2011-12	2.4	-0.2	2.7	4	1.9	-0.4
2012-13	3.1	3.2	-1.3	4	1.8	1

Source: Federal Bureau of Statistics Pakistan (2013)

In Pakistan agricultural output is dominated by crop and livestock production. In agriculture the share of crop and livestock in total value added are 48 and 51 percent respectively. In the country like Pakistan mainly there are two principal crop seasons Kharif and Rabi. Kharif starts in April, ends in October-December while Rabi season starts in October-December, and ends in April-May. Rice, sugarcane, cotton, maize, mong and mash are Kharif crops while wheat, gram, tobacco, rapeseed, barley and mustard are Rabi crops (GOP, 2013). Among all the crop wheat the major crops grown in Pakistan. The share of the major crops in total value added in agriculture is 31.9 percent (GOP, 2013).

Table 1.2 shows the increase and decrease in percentage change in wheat area, production and yield in some previous years. Area measured in hectares, production measured in tons and yield measured in kg/hec.

Table 1.2: Area, Production, and Yield of Wheat from 2005-06 – 2012-13

Year	Area		Production		Yield	
	(000 hectares)	Percent Change	(000 tons)	Percent Change	(Kgs. /Hec.)	Percent Change
2005-06	8330	1.4	21109	8.2	2534	6.7
2006-07	8448	1.7	21277	-1.6	2519	-1.9
2007-08	8578	1.1	23295	9.5	2716	7.8
2008-09	8550	-0.3	20959	-10	2451	-9.8
2009-10	9046	5.8	24033	14.7	2657	8.4
2010-11	9132	1	23311	-3	2553	-3.9
2011-12	8901	-2.5	25214	8.2	2833	11
2012-13	8666	-2.6	23517	-6.7	2714	-4.2

Source: Federal Bureau of Statistics Pakistan (2013)

Wheat is the main essential food crop of the individuals of Pakistan. It is the largest grain crop grown in the country. It contributes 12.5 percent to the value added in agriculture and 2.6 percent to real GDP. In 2013 the total area of wheat production is 8666 thousand hectares and it shows a decline about 2.6 percent from previous year 2011-2012. Total wheat production was estimated about 23.5 million tons in 2013 which also decrease by 6.7 percent from the previous year.

In the real GDP, the contribution of livestock sector is around 11.6 percent, which is more than the contribution of both major and minor crops altogether. It has increased GDP by 4 percent than the last year. About 30 to 35 million population of rural of the country is working in livestock rearing for their livelihood directly indirectly. On average household holdings of buffalo/cattle is 2-3, sheep/goats 3-4 and poultry is 10-12 per household which is contributing around 35 to 40 percent of their income. Milk is only the largest and most important product among the livestock products. In the world ranking Pakistan is the fifth largest milk producing country. Main source of milk in Pakistan is Buffaloes and cows. Gross milk production is 47.951 billion liters annually in the country. The share of total milk production in livestock from buffaloes, cows and goats is 64.7, 34.5 and 0.8 percent, respectively (GOP, 2013).

1.2 Agriculture of Punjab

Punjab is the second largest province of Pakistan. Nearly 60 percent of the population of Pakistan is located in the province of Punjab. The word Punjab is literally translated from the language of Persian words “Punj” which means five and “Aab” means water. Thus Punjab can be called as “five water” or “land of five rivers”. The location of Punjab is at the northwestern edge of the geological Indian plate in South Asia. Areas nearby province, Punjab are Sindh, which is in the direction of South, Baluchistan and KPK towards West, Kashmir to the North and Indian Punjab and Rajasthan towards the East.

The province of Punjab uses 70 percent agriculture land of Pakistan. Total geographical area of Punjab is 20.63 million hectare, and area of cultivation in Punjab is 12.57 million hectares represents about 57 percent of the total area of the country. Average farm size is 12 acres in Punjab province and Punjab contributes its large share in terms of production as shown in the Figure 1.1. Punjab province is currently producing 53.2 per cent of rice, 81.9 percent of cotton, 75.6 percent of wheat and 73.5 percent of the sugarcane of Pakistan (GOP, 2013).

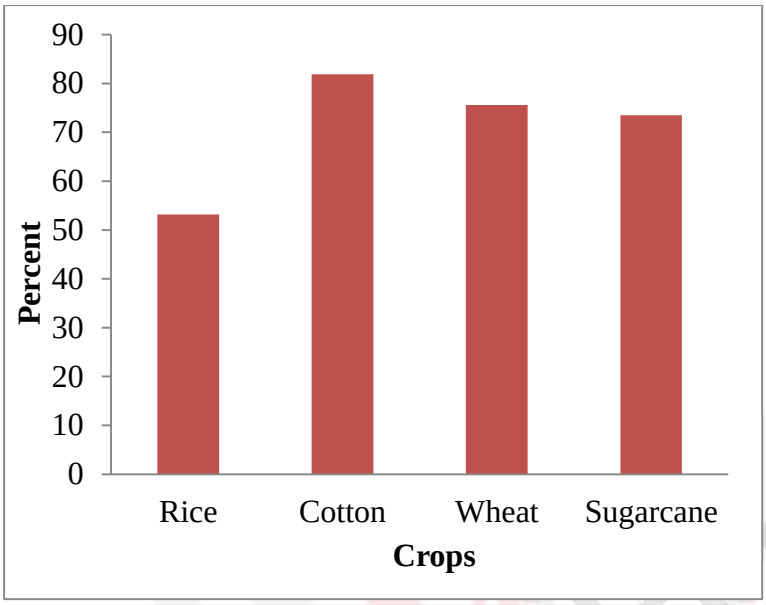

Figure 1.1: Share of major crops production of Punjab, Pakistan in 2012

Total area of irrigated in the province, Punjab is 14.48 million hectares, out of which canal irrigated area consists of 3.65 million hectares, tube-well irrigated cover the area of 2.72 million hectares, canal-tube well irrigated are 7.71 million hectares where tanks irrigated has 0.2 million hectare area (GOP, 2013). Punjab is situated in the temperate zone within the monsoon belt. Annual rainfall in the Punjab province swings from 150 millimetres in the south regions, 620 millimetres in the central region and 1150 millimetres in the northern region (Mustafa & Khan, 2005).

1.3 Water Issues

Water is a resource which is very crucial to the social and economic activities and it is getting scarce. This is the only resource without which one cannot think of any ecosystem that can prevail. Currently, managing water resource at government as well as at the social level is one of the core challenges. There is a dire need to manage water resources by special mechanism and highly efficient infrastructure to be built to ensure efficient use and sustainable development of the resource. One greater consideration is required that it is a global resource not only a local, national or regional resource while any decision is being made should be on the usage of the resource.

Water is being mostly used in three of the sectors, specifically agricultural, industrial, and domestic sectors, while agricultural sector is just the highest water-using sector in the world in contrast to the other sectors. In Pakistan, the consumption per capita of water is about 1200 m3 per year, the majority of the share of the agricultural sector and the other two sectors, the share is almost negligible, showing that the water efficient use one has to make industry more efficient so that breaking source can be sustained agriculture.

However, irrigation is a key feature of agriculture where more than 90 percent of agriculture production originates from irrigated lands of the Punjab, which are the key use of water resources of the country (Qureshi et al., 2003). Another important point is that major sources of water for irrigation come from nearby countries and its lack of water resource pressurizes most farmers and their upcoming future. These indications make it even more difficult for farmers to produce according by utilizing proper system of water use and to the demand for food also other commodities and we live in a country that has a rapidly growing population of which the food demand must have to be met in the future. This demand is hard being met by the way we are operating right now (GOP, 2013).

Table 1.3 shows the actual availability of water in the two seasons in Pakistan, namely Kharif and Rabi seasons. This table is actually showing the information on water availability situation from 2004 to 2013.

Table 1.3: Actual Surface Water Availability (Million Acre Feet, 1AF = 1233.48 m^3) from 2004-05 – 2013-13

Period	Kharif	Rabi	Total	% increase/decrease over the average
Average system Usage	67.1	36.4	103.5	0
2004-05	65.9	31.5	97.4	-5.9
2005-06	59.1	23.1	82.2	-20.6
2006-07	70.8	30.1	100.9	-2.5
2007-08	63.1	31.2	94.3	-8.9
2008-09	70.8	27.9	98.7	-4.6
2009-10	66.9	24.9	91.8	-11.3
2010-11	67.3	25	92.3	-10.8
2011-12	53.4	34.6	88	-15
2012-13	60.4	29.4	89.8	-13.4

Source: Indus System River Authority (2013)

In the table 1.4 shows a transparent situation of water resource flow at different headwork of the canal system of Pakistan. This table shows the water supply evaluation to the provinces in Kharif and Rabi in the year 2011 with Kharif and Rabi in 2012. The whole situation of water flow in the canals has been better in Kharif in 2012 by an increase in 13% than the previous year's discharge. The discharge in Kharif in 2011 was 53.41 MAF, which increased by 13% in Kharif in 2012 and was 60.40 MAF. While the situation was not that satisfactory in Rabi in 2012 as compared to Rabi in 2011 as it decreased by 15% (GOP, 2013).

Table 1.4: Canal Head Withdraw (Million Acre Feet, 1AF = 1233.48 m^3)

Provinces	Kharif (Apr-Sep) 2011	Kharif (Apr-Sep) 2012	% change in Kharif 2012 over 2011	Rabi (Oct-Mar) 2011-12	Rabi (Oct-Mar) 2012-13	% change in Rabi 2012-13 over 2011-12
Punjab	29	34.29	18	18.73	17.61	-6
Sindh	22.61	23.29	3	14.51	10.13	-30
Baluchistan	1.21	1.86	54	0.88	1.12	27
KPK	0.6	0.96	60	0.48	0.56	17
Total	53.41	60.4	13	34.59	29.42	-15

Source: Indus System River Authority (2013)

After independence Pakistan used to be a water plentiful country, at that time per capita water consumption was 5260 m^3, which turned into a water scarce or strained country with water availability of 1038 m^3 per capita in 2010 and by the year 2012, there is a threat that nearby Pakistan will reach at the stage of 'acute water shortage' (WAPDA, 2012). The surface water sources of Pakistan are not infinite and the potential for increasing supplies is not only restricted but rather there is likelihood of reduction in surface water provisions in future because of many different factors in the country. The gap between demand and supply of surface irrigation water is covered by the utilization of groundwater. Therefore, the groundwater has progressively acquired a critical role in rural and agricultural improvement of Pakistan (Qureshi et al., 2003). In the face of inconsistent canal water supplies, most of the farmers have shifted their dependence on private tube wells which again places excessive stress on groundwater provisions (Qureshi et al., 2003). Adverse environmental effects related to irrigation are accelerating because of over utilization of groundwater and miserable water management is causing the sinking of water tables in different areas and has increased water logging and salinity in the rest of the areas (Pingali & Shah, 2001).

1.4 Problem Statement

Due to inefficient use of resources in Pakistan and being, the developing country the food per capita availability is very low. Most of the people are living below the poverty line which is 35 percent of the total population and have little access to the food resources. These problems have worsened in the rural areas of Pakistan at the rate climbs over 40 percent in the areas (GOP, 2013).

In the year of 2013, government has to import food such as, wheat to fulfill the domestic food requirement (GOP, 2013). The food import bills are increasing over time and this worrying the government. Thus improving the domestic production could reduce the food import bills.

In Pakistan, the major concern of agricultural production is how to use the input resources efficiently, for example water and land. Due to unsustainable agricultural

systems, water scarcity and soil degradation, the cost of these funds in the past few years had rapidly strengthened and these problems are expected to continue to rise more in the near future. To tackle these problems, there is a great need to work on an efficient use of the inputs, in particular water, as water is becoming increasingly scarce, and we are still working on the basis of this source by maintaining an opt-out the conversion of the traditional low-efficiency irrigation practices for high-efficiency irrigation techniques.

India is continuously building dams on the main sources of water supply to Pakistan, which constitutes a threat to the Pakistani agriculture as the reduced supply of water may occur during the sowing seasons radically. This particular problem and many others ask us to work on the efficiency of water use and curtail inefficiencies in the irrigation pattern.

Despite the growing problems in the water scarcity, unsustainable water use patterns are evident in Pakistan. In Pakistan and different parts of the dry Middle East has increased salinity due to poor irrigation practices that a heavy hand upon the researchers to propose to analyze the problems of water use and to point out the sources of their thoughts together of the inefficiencies in particular for agriculture.

1.5 Objectives

General objective is to estimate technical and water use efficiency of wheat farms to increase wheat productivity.
Following are the specific objectives;

1. To estimate technical efficiency of wheat farms.
2. To measure the extent of irrigation water use efficiency in wheat farms.
3. To determine the factors which effect technical and water use efficiency.

1.6 Significance of the Study

The study shows that the technical efficiency would be measured from the sampled farmers in the District Faisalabad which is the one of the most wheat production area of Pakistan and this city contributing 20% of wheat in Pakistan. Moreover, the factors affecting technical inefficiency in socioeconomic aspects and demographic aspects would be investigated.

New better knowledge and understanding of the farms and water use efficiency for the wheat areas. Problems and issues faced by the farmers can be minimized by use inputs efficiently and the study identifies socioeconomic and farm related factors dependable for technical, allocative and economic efficiencies. Output of study can be used by the strategy makers, especially Department of Agriculture and Bureau of Rural Development of Pakistan.

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