Efficiency Analysis of Rice Production in Pakistan under Dry and Puddle Conditions.
(A Case Study of Punjab)

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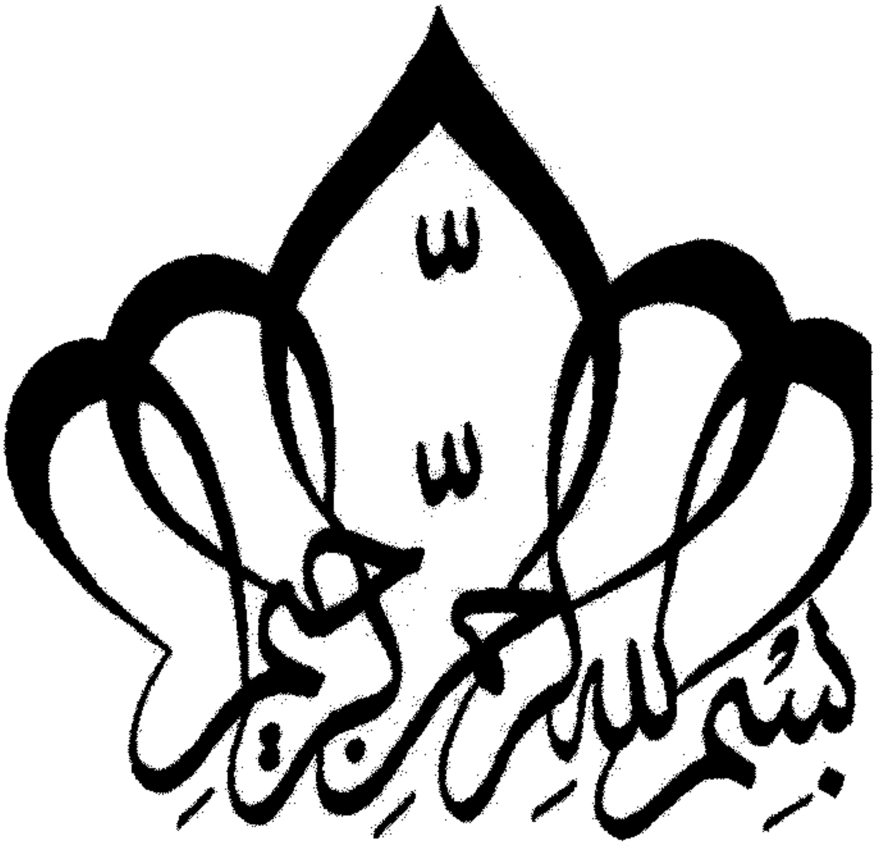

In the name of Allah Most Gracious and Most Merciful

I dedicate this work to my beloved
Parents whose constant encouragement
And help provided me incentive and
Opportunity to complete this study

DECLARATION

I hereby declare that this thesis, neither as a whole nor as a part thereof, has been copied out from any source. It is further declared that I have carried out this research by myself and have completed this thesis on the basis of my personal efforts under the guidance and help of my supervisor. If any part of this thesis is proven to be copied out or earlier submitted, I shall stand by the consequences. No portion of work presented in this thesis has been submitted in support of any application for any other degree or qualification in International Islamic University or any other university or institute of learning.

Sania Shaheen

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I express my heartfelt thanks to my beloved parents and my younger brother Adil Shahzad who encouraged me to fulfill my commitments towards studies. Their prayers and love boosted my spirit whenever I was depressed.

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Abstract:

The study examines the efficiency analysis of conventional and dry rice sowing systems. This research finds the factors which affect the rice output and cost of rice output as well as this study finds the sources of inefficiency. Furthermore, this study is estimate the technical, allocative and economic efficiency of conventional and dry rice sowing farmers. Data is collected from 300 farmers in the kharif cycle of 2013-14 from five main rice growing districts of Punjab namely: Hafizabad, Sheikhupura, Jhang, Vehari, and Gujranwala. Stochastic frontier analysis is used to find the results of study. Study results reveal that Direct seeded rice sowing method is more profitable for farmers in respect of yield and save labor cost and water saving as compare to conventional rice sowing method. On average technical, allocative and economic efficiency of sample rice farmers are 86 percent, 43 percent and 37 percent. The result of technical and allocative inefficiency reveals that education, experience, owner, tenant, selling agency, credit access, tractor and tube well ownership, extension services significantly contribute to improve farmer's technical and allocative efficiency. This study suggest that agriculture department and research institutes should design training programme to aware farmers about functioning of Direct seeded technology related to rice sowing and its consequences. In addition, government should focus on increasing the education level of farming communities by opening more schools in the rural areas. In addition, Government should plan policies to attract more educated people into farming sector by providing required incentives.

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LIST OF ACRONYMS

TE	Technical efficiency
AE	Allocative efficiency
GDP	Gross Domestic Product
EE	Economic efficiency
SFA	Stochastic Frontier Analysis
DEA	Data Envelopment Analysis
TI	Technical Inefficiency
AI	Allocative Inefficiency
LR	Likelihood ratio
OLS	Ordinary least square
MLE	Maximum Likelihood Estimates
RTS	Return to Scale
KG	Kilogram
FYM	Farm yard manure
HYV	High Yield Varieties
FAO	Food and Agriculture Organization
IFA	International Fertilizer Industry Association

Chapter 1:

INTRODUCTION

Pakistan is an agricultural country and its largest economic activity is agriculture. It has direct and indirect role in generating economic growth. This Sector provides employment to 48.4 percent of the total labor force of a country. Agriculture sector influences the growth of a country it provides raw material to industry as well as bring the 60 percent export earnings for a country. According to economic survey of Pakistan (2013-14), the agriculture growth stood at 2.1 percent as compared to 2.9 percent during last year.

There are two most important crop seasons prevailing in Pakistan that is "Kharif" and "Rabi" crop seasons. "Kharif" sowing season starts in April to June and harvested between the months of October to December. On the other hand "Rabi" sowing season starts in October to December and harvested in between April to May. Kharif crops are grown during the monsoon (rainy seasons) are called Kharif crops. Seed of the crops are sown in the beginning of the monsoon season. After maturation, these crops are harvested at the end of the monsoon season (Oct-Nov). Kharif crops are like: Paddy, Maize and Millet and Cotton crops.

Rabi crops are grown during the winter season (October-March) are called Rabi crops. Seeds of these crops are sown in the beginning of the winter season. After maturation of crops, they are harvested at the end of the winter season (April-May). Rabi crops are like: Wheat, Gram, and Mustard.

Rice is an important and economically feasible cereal crop of Pakistan which is the second major source of foreign exchange earnings after Cotton. According to economic survey of Pakistan (2013-14), rice accounts 3.1 percent of the value added in agriculture and 0.7 percent of GDP. In addition, rice production has increases 6,798 thousand tons in 2013-14 as compared to 5536 thousand tons in 201-13 reflecting, an increase of 22.8 percent.

Punjab and Sindh are the leading rice growing provinces out of which about 92 percent of the total area under rice. The main rice tract lies in the Punjab province covering more than one million hectares annually. Punjab due to suitable agro-climatic and soil condition received hundred percent of Basmati rice production in the country. In Pakistan important rice producing districts in Punjab are Gujranwala, Sialkot, Okara, Hafizabad, Sheikhupura and Mandi Bahuddin and Jhang. These areas contribute more than 70 percent of Basmati rice production in the county. Total rice areas in Punjab are 1.76 million hectare which is the 68 percent of total rice area in Pakistan.

There are two most important methods use for transplanting of rice like direct seeding system and wet seeding system. Wet seeding system

(Puddled condition) is basically a conventional technique for sowing rice and most of the farmers use conventional technique for sowing rice. Direct seeded method is a Dry method for sowing rice. It is a latest technique for sowing rice. It consists of sowing dry seeds on to dry soil while, wet seeding involves sowing pre-germinated seeds on to puddle soil.

Ahmad *et al.*, (2013)) said that per acre paddy yield in Pakistan far below than the major rice growing countries of the world because many yield-limiting factors like weed infestation, improper combination of fertilizers, smaller plant population per acre and shortage of labor for transplanting and harvesting are the major constraints. Pandey and Velasco, (2002) said that in response to rising labor costs, competitive demand for water and the need to increase crop production, many Asian farmers have shifted from conventional method of rice to direct seeding of rice.

Harris, (2006) said that high cost of farm labor invariably delay transplanting and often lead to use of aged seedling which cause low yield. Mann and Ashraf, (2001) write that in Pakistan, rice seedlings are transplanted by hired labour that resulted in labor shortage throughout the transplanting period. To minimize the shortage of labor rice research institutes developed the latest technology that is direct seeded. According to Awan et al., (1989) direct seeded technology of rice was found almost at same level in yield with the conventional planted crop.

Direct Seeded is a successful method of cultivation in some countries which save labor in more economical than transplanting and also provide good stand establishment [(Adair et al., (1992)]. The results of many years of experimentation of direct seeding technique concluded that this technology has great potential for adoption as a substitute for transplanting if the weeds are controlled properly with the accessibility of high yield probable varieties [Sharif et al., (2007)].

Unfortunately there is, at present, no proper and economically viable cropping system in practice to make the best use of rice land for determined productivity. Most of the farmers used conventional method for transplanting of rice. Conventional method required a lot of water for the transplanting of rice and this technique farmers face higher labor cost.

Direct seeded rice system is a newly developed technique. It is a water and labor cost saving technique. In this research our main focus is to find out which technique of rice sowing either conventional or direct seeded is beneficial for farmers and how much direct seeding technique save labor cost and save water. This research we also finds which technique conventional or dry sowing gives farmers higher yield.

In Pakistan high variation exist in rice yields. According to Wasim, (2002) rice yield per acre would be increased through HYV seeds, better fertilizer application, new farm technology, pest control, and better time of nursery sowing, better land preparation, better weed control and better method of harvesting. According to Abedullah et al., (2007) rice output per acre in Pakistan could be increased by increasing the accessibility of irrigation water in the area.

According to Jeffery and XU, (1998) different socio-economic and farm management factors responsible for instability in rice productivity or in other words inefficiency gap like lack of credit facility, deficiency of extension services etc. According to Hussain, (1995) age, education and extension services are the important variables that improve the managerial ability of farmers and contribute positive role to improve technical efficiency of rice farmers.

According to Idiong, (2007) education enhances the achievement and use of information on better technology by the farmers as well as their innovativeness.

Lot of studies has been conducted for examining the issues of yield gap and farmers efficiencies by using rice crop for different countries as well as identified different socio-economic and farm specific management factors which effect on farmers efficiency. These studies has been conducted by following authors in different countries [Zhang et al., (2002); Dhungana et al., (2004); Krasachat (2003); Javed et al.,(2010); Abu (2011); Ayambila, et al., (2013)].

Various studies has been conducted in Pakistan Abedullah, (2007) and Javed et al., (2010) concluded that a potential exist in a country to increase rice yield by increasing the rice cropping area and by adopting new technology.

1.1 Objectives:

- To carry out comparative efficiency analysis of Conventional rice and Direct seeded rice sowing systems.
- To find out the sources of inefficiency.
- To carry out the Gross margin analysis of Conventional and Direct seeded rice sowing systems.

1.2: Research question:

To compare the Conventional and dry rice sowing technique for rice and to find out which technique is more profitable for farmers in case of Productivity and less cost of Production.

1.3: Significance of the study:

Rice is one of the most important staple crop of Pakistan that requires more water as compared to other crops. Rice crop sowing date is the 15th June to 15th July that is scorching hot season in which farmers faces water shortages and due to it rice crop adversely affected. Recently direct seeded rice system is introduced in the rice growing areas. It is the modern cost saving technique that not only save water but also gives the farmers higher yield as well as it increases the efficiency of farmers. Direct seeded rice production system requires less irrigation than traditional transplanted rice.

This research work will helps to understand which technique gives the farmers more advantage both in terms of cost and yield. Moreover, this study will help to draw conclusions for promoting a right package of technology that help growers to get higher economic returns.

1.4: <u>Composition of study:</u>

This study consists of following parts: Section 1 comprises of introduction that briefly discuss the techniques of growing rice crop. Section-ii briefly discusses the literature review of previous studies. Section-III explains the procedure of data collection and Methodology. Descriptive and empirical results briefly explained in the section IV. Section V concludes the study with some policy recommendations.

Chapter 2

Literature Review

2.1 Theoretical Review:

The utilization of limited resources is an important issue in economics. The correlation that demonstrates the technology of a firm is called production function. This function explains the relationship between limited resources and output of a firm. Lot of production theories have prevailed prolong before Adam smith, but production theory were polished, in a mathematical sense, at the ending period of 19th century. When apprehensive with one output firm, the production function builds very easily. It informs us that the maximal quantity of output can be achieved by using different combination of inputs with given assured technical information [Gordon and Vaughan, (2011)].

The history earlier than Adam Smith is not absent in economic writing. Different Roman and Greek writers have tackled various problems in economics, comprising rapid attention to production and distribution. The authors also dedicated significant time to economics issues, involving planning and find out into production. Several scholars related with Mercantilist and Physiocratic in the time period of early 17th

century gives more careful attention to issues of production in the economy.

Robert, (1767) a member of the physiocrats, gives the concepts of diminishing returns in a one input production function. He describes that diminishing returns is just a different way that the marginal product of input ultimately reduces.

After that Adam smith, (1776) gives more careful attention to economic problems related to productivity and income distribution in his influential book "The Wealth of Nation". Malthus and Edward, (1815) describes that if you were increase labor and capital together, then it would increases agriculture production of the land, but by a diminishing amount. They both, in effect of these theories again rediscovered the concept of diminishing return. Later On, David Ricardo accepted the results which arrive with his theory of income distribution when writing his classical economics book of political economy.

The Marginalist also takes experiment in the area of production. At the end of 18^{th} century, Walras *et al.*, (1800) integrated all thoughts of factors values into their books. These authors claim that all early post-smith economist theories common, in the sense that every one used production functions that were in predetermined proportions.

After that Thunen (1840) first time introduced variable proportions production function. He was the first author who permits to change the capital-labor ratio. He observes that if we were take one input fixed and increase all other inputs, then the level of output would increase by diminishing amount. In addition, he applied for the first time the concept of diminishing return to a two input in a variable proportion production function. An argument could certainly be raised in this era that he is the unique creator of marginal productivity theory. Although, in this era Thunen work never received much consideration as it is deserved though. Instead of Thunen, American economist Clark, (1894) received tribute as a creator of marginal productivity of theory. He received this title in the meeting of American Economic Association that was held in that year.

Later on, Wicksteed, (1894) explains that if production function was defined by a linearly homogenous function then every input were received its marginal product,(in other words, one that practice constant return to scale), the total quantity would then be engaged in factor of payments without any shortage or excess. Around the twist of the century, Knut Wicksell formed a production function that is very alike to the well-known Cobb-Douglas production function which is later prepared by Douglas and Cobb. Unluckily, this was never published in any intellectual Journal. So Cobb and Douglas never received credit in 1928.

Currently lot of development has been formulated under flexible forms of production function. The most famous production function has been developed known as transcendental logarithmic production function, which is commonly known as the translog production function. Diewart,

(1971) given the concept of generalized Leontief production function. Christensen *et al*., (1972) developed the concept of translog production function. The beauty of translog production function is it imposes fewer restrictions on such items elasticity of scale, homogeneity and elasticity of substitution. Translog production function is known as the flexible form of production function.

Now a day different theories has been done which estimate the efficiencies. Farrell was the first author who gives the concept of efficiency. Farrell, (1957) determines the article that escorts the development of several techniques for the measurement of efficiency of production. After that lot of authors has been done work in the area of efficiency of production. The empirical findings of these studies have been discussed in next section.

2.2 Empirical Review:

Measurement of farm efficiency for both in developed and developing agricultural countries are very important. Farrell, (1957) developing the concept of efficiency analysis at the farm level. The significance of increasing efficiency in agriculture production has been commonly famous and examined by the researcher both in Pakistan and all over the world such as: shehzad *et al.*, (1995); Ishfaq *et al.*, (1997); Krasachat (2003), Linh and Thiruchlvarn (2004); Brazdik (2006), Abedullah *et al.*, (2007); Akmal (2008) and Naila (2009); Gomez and Neyra (2010); Javed *et al.*, (2010); Orefi (2012).

II-I: Factor affecting the technical, Allocative and economic efficiencies of Rice Farmers:

In Efficiency analysis, two most popular techniques were mainly used, such as, stochastic frontier analysis (SFA) and Data envelopment analysis (DEA). Some authors used the Data Envelopment Analysis for measuring efficiency like: Zhang (2002), Dhungana *et al.*, (2004) and Krasachat (2003), Javed *et al.*, (2010), Orefi (2011), Daniel *et al.*, (2012) estimate the efficiency analysis of rice farmers by using data envelopment analysis. These studies identified that variety of natural resources influences on technical efficiency of rice farmers like seeds, labor, fertilizers, and mechanical power and technical inefficiency is much influenced by primary education and regional factors.

On the other hand, Esfandiari *et al.*, (2012) estimated water use efficiency of rice farmers in Kamfirouz Region, Fars Province, Iran. Data envelopment analysis is used to estimate the technical, allocative, economical and managerial efficiency of rice farmers. The results revealed that average technical, allocative, economical and managerial efficiency are 72, 40, 28, 79 and 91 percent respectively. The results show that for rice producers it is possible to reduce the level of water use about 65 percent, without dropping productions. The bad uses of inputs are linked to water, area and pesticide uses which are 40, 35 and 39.74 percent respectively.

Furthermore, Dung *et al.*, (2008) analyzed the scale efficiencies and technical efficiencies of rice producing families in the Mekong Delta by using stochastic frontier analysis and data envelopment analysis. Results shows that technical efficiency of rice farmers is 75% and the factors that affect the technical efficiency of rice farmers are farming area, investment expenses on fertilizers and agrochemical. The results of technical inefficiency show inefficiency depends on expertise and experience and ability to new techniques.

A lot of literature exist where authors using the stochastic frontier analysis to find the efficiency and identify the factors which affect the famers efficiency like: Ali and Flinn, (1989) and Jayasuriya, (1983) measuring the efficiency analysis on the basis of survey by using Stochastic frontier approach he concluded that higher output of rice could be achieved by increasing the availability of irrigation water (canal water, tube well etc.) in the area of rice because rice is a water demanding crop and required comparatively more water than other crops.

Rahman, (2003) estimate the technical efficiency and allocative efficiency of Bangladesh rice farmers by using the stochastic profit frontier and inefficiency effect model. The results revealed that mean level of profit efficiency is 77% and 23% profit is lost due to technical and allocative inefficiency in modern rice production. The efficiency differences are explained mainly by the variables of infrastructure, soil fertility, experience, extension services, tenancy and share of non-agricultural income.

Matthias *et al.*, (1999) and Ogundle, (2006) used the stochastic frontier methodology for measuring the technical efficiency of rice farmers. Stochastic frontier analysis approach are used for the estimation of production function applied to primary data concluded that sample irrigated area seed rate is used in rice production and seed variable would play a very important role for increasing rice output and for improving the efficiency for rice farms and household income.

Truong, (2006) estimates the technical efficiency of rice producing households in Vietnam. Data is collecting from 261 rice farming households in Mekong Delta. Data envelopment analysis and Stochastic frontier analysis is used for finding the results. The results reveal that the variables that affecting the technical efficiency of rice such as plot size, Seed and hired labor cost and farmers farming experience.

Hyuha *et al.*,(2007) measuring the profit efficiency of rice farmers in Eastern and Northern Uganda by using the methodology of stochastic frontier approach applied to primary data concluded that rice farmers were losing income due to technical and allocative inefficiency and for improving efficiency requires to expand the area under cultivation that create the positive impact on profits.

Sharif *et al.*, (2007) estimated the economic efficiency analysis and competitiveness in the production of rice crops in Pakistan. Policy metric analysis is used to find the results. Secondary data is collected from different sources finance division, agriculture prices commission etc. The results indicate that increased in the production of rice can increase the exports and the prevailing structure affect the farmers negatively.

Later on Idiong, (2007) estimate the farm level technical efficiency small scale swamp in rice production in cross river state of Nigeria. Primary data is collected from 56 farmer households in two local government areas in the cost river state. Cobb-Douglas Stochastic frontier analysis is used to find the result. This study finds that rice farmers were not technically efficient, farmer educational level, membership of cooperative association and access to credit significantly influenced the farmer efficiency positively.

Afterwards Hassan, (2008) estimates the farm-specific technical efficiency of rice growing irrigated and non-irrigated rice in Northern Ghana. Stochastic Frontier approach applied to cross sectional data and finds that there is no major difference between the technical efficiency of Non-irrigators and irrigators. The major determinants of technical efficiency are age, education, extension contact, and family size. On the other hand Linh, (2004) finds that technical efficiency is much influenced by regional factors.

Majumder *et al.*, (2009) compare the resource use efficiency of farming under different tenure condition in an area of Bhola district. Primary data is collected through questionnaire. Cobb-Douglas Stochastic frontier production function is used to find the results. The results reveal that cash tenant operators were originate more efficient than those of owner and crop share tenant operator and cash tenants were more efficient in production because they were intense to make more profit from their investment.

Later on Tijani, (2010) estimated the technical efficiency of rice farms in Osun, state Nigeria, and identified the socio-economic factors which influence on factor efficiency. Technical efficiency were estimated using the stochastic frontier approach applied to primary data results showed that efficiency are positively and significantly correlated with the application of traditional preparation method ,and with off farm income.

Narala and Zala, (2010) estimated the technical efficiency in central Gujarat by using the Stochastic Frontier analysis. The results concluded that the great potential exist for improving the productivity of rice by adopting the good management practices and proper allocation of existing resources and technology.

Baruwa *et al*., (2010) estimate the technical, allocative and economic efficiency of plantain farmers in Ondo State Nigeria. Cobb-Douglas Stochastic parametric technique is used to find these efficiencies. The result concludes that age is positively correlated to technical and economic efficiencies and extension services significantly contribute to technical efficiency.

Gomez and Neyra, (2010), Abedullah *et al*., (2007) measuring the efficiency analysis of rice farming system by using stochastic frontier analysis on the basis of survey identified that the parameter sowing area, number of ploughing hours, irrigation hour, labor hour and fertilizer nutrients play a very important role on rice production.

On the other hand Alam *et al*., (2011) examine the technical efficiency changes at the farm level for rice farms in Bangladesh using (1987 to 2004) Panel data. Results from Stochastic Frontier approach finds that technical efficiency of rice farmers has decreased from 83% to 60% due to Socio-economic factors. These factors like age, education, Tenure status, and involvement in off farm work were negatively persuade of technical efficiency but farm size positively influencing on technical efficiency.

Mingxian and Hongmei, (2011) investigate the factors that is influencing on collective water management and their influences on technical efficiency of rice production. Group and household level data is collected from 2006-2007 in china. The results of stochastic frontier analysis show that successful collective water management has a significant positive impact on technical efficiency of rice production because it delivers enough irrigation water at a serious stage of rice cultivation.

Backman *et al.*,(2012) estimates the technical efficiency of traditional variety and high yielding variety of rice in Bangladesh and identify the determinants of HYV rice adoption by using survey data from 360 farmers for the 2008/09 growing seasons. Stochastic frontier analysis indicates that HYV rice is connected with lower technical efficiency and had a greater variability in yield. The results shows that technical efficiency of HYV and tradition variety growing rice farmers were related to age, experience, off-farm income, extension visits, and access to microfinance.

Nyarko *et al.*, (2012) assesses the efficiency of resource use in rice production with the Kpong Irrigation Project (KIP) as a case study. Data is collected from seventy farmers by using the random sampling technique.

Cobb-Douglas stochastic frontier production function is used to estimate the coefficient and various variables. The results of efficiency calculation indicated that land, fertilizer, and seed were being underutilized and chemical were being highly over utilized in the study area.

Afroz and Islam, (2012) estimate the profitability of growing Aus rice and Jute rice to determine the resource use efficiency in three selected village of Raipura. Primary data is collected from sixty farmers through questionnaire. Cobb-Douglas production function is used to estimate the effects of individual inputs on production of Jute and Aus rice. The results of resource use efficiency shows that neither jute nor Aus rice farmers were efficient enough to use various inputs.

Galawat and Yabe, (2012) estimate the profit efficiency among rice farmers in Brunei by using a stochastic profit frontier and inefficiency affect model for analysing the three component technical, allocative and scale efficiency. The results shows that mean profit efficiency score is 80.7 % and 19.3% profit is lost due to combination of technical, allocative and scale inefficiencies. Factors that are related to profit-loss and profit inefficiency are non-membership of cooperative, no irrigation, lack of training and low yield variety.

Basorun and Fasakin, (2012) estimates the factors that influencing in rice production in Igbemo-Ekiti region of Nigeria. Data is collected from farmers through questionnaire. Cobb-Douglas stochastic function is used to find the results. The results revealed that status of the rice farmers, area of land cultivated, and availability of market for the rice products, the number of laborers involved in production and the use of agro-chemicals are critical factors that impacting the production.

Abdulai *et al.*, (2012), identify the technical efficiency of rice farmers at Tona irrigation project. Cross sectional data and stochastic production frontier model is used in this study. The results find that technical efficiency is 0.41 to 1 and mean value of 0.81.The factors that determined the technical efficiency is education and adoption of modern inputs like seeds and chemical fertilizers.

Enwerem and Ohajianya, (2013) analyzed the technical efficiency and the resources of inefficiency in large and small scale rice production in Imo state Nigeria. By using primary data and Cobb-Douglas stochastic frontier methodology results reveals that the factors that affected the output of rice is labour, Capital, land and planting materials.

Hidayah and Susanto, (2013) estimate the economies of scale, allocative and technical efficiency of rice farming in irrigated field at Kabupaten Seram Province of Maluku. Quantitative and qualitative data and Cobb-Douglas stochastic frontier analysis is used to find the results. The results revealed that three independent variables that has significant effect the production that is labor size, urea, fertilizer, and NPK fertilizer with following elasticity 0,55; 0,19 and 0,11 which means that technical efficiency of this farming has been achieved.

Some author used the translog stochastic frontier approach to estimate the technical efficiency of rice. Abedullah *et al*., (2010) estimate the environmental efficiency analysis of rice production by using the translog approach. Data is collected from five major Basmati rice growing districts in Punjab. The result concludes that the reduction in chemical weedicides will save 297 per acre and Rs 1307.3 million over the rice crop in Punjab. Empirical analysis concludes that reduction in environmental pollution composed with higher level of profitability is possible.

Wadud and Rashid, (2011) estimated profit efficiency of rice farmers in selected areas of Bangladesh. Translog stochastic frontier is used for estimating the technical and allocative efficiency of rice farmers. The results revealed that Socio-economic variables like agriculture information and family dependency ratio creates positive effects on profit inefficiency.

Galawat and Yabe, (2012) estimate the efficiency of rice production by using Translog profit frontier. Primary data is collected from Brunei district in June 2010.Emperical results shows that mean profit efficiency score is 80.7% and 19.3% profit is lost due to the combination of Technical, Allocative and Scale inefficiencies. The factors that are associated to profit inefficiencies are no proper irrigation, Lack of training and low yield variety etc.

Afterwards yabe and Hoang, (2012) estimate the environmental factors that affect the profitability of rice farmers in red river delta. Primary data is collected from 349 farmers through personal interviews and translog profit function is used for finding the results. This study finds that Plant disease, soil fertility, irrigation, and water pollution were the four environmental factors that caused profit loss in rice production.

Furthermore Arayaphong, (2012) compare the cost and benefit of SRI and conventional rice system in Thailand. This study used the cost-benefit analysis to find out the mean and variation of profit and cost in economic term. The study finds that SRI saves the production input and increases yield gain significantly. Sensitivity analysis shows that SRI has better performance under best and bad situation for both types of soil (clay soil and sandy loam). In conclusion SRI is more beneficial and efficient than conventional system.

II-ii. Socio-economic and farm management factors influences on technical and allocative inefficiencies of rice farmers:

A wide variety of literature exist that identified Socio-economic and farm management factors which influence on technical inefficiency of farmers like : Battese and Coelli (1995), Parikh and Shah (1995), Kalirajan (1991), Wadud and white (2000), Rehman (2003), Shrama *et al.*, (1999), Hallam and Machado(1996), Dhungana (2004), Fleming and Villano(2004), Brazdik (2006), Tijani (2006), Amaza *et al.*,(2006), Abedullah *et al.*, (2007), Javed *et al.*,(2010), Narala and Zala (2010), Bjorndal and Adhikari (2012), identified the factors which influence on technical and allocative inefficiency among farmers concluded that age, education, experience, access to credit, tenure status, utilization of extension service, involvement in off farm work, farm size, ratio of adults in the farm household, Soil fertility were the major factors that influence on the technical and allocative inefficiency among farmers.

Furthermore Erhabor and Ahmadu, (2012) identify the socio economic factors that influence the technical inefficiency of rice farmers in Taraba state Nigeria. Primary data is collected from 133 respondents and stochastic frontier production function is used to find the results. The results revealed that inefficiency of the farmers increase with increase in age and inefficiency of farmers decreases with increase in the number of male farmers, family size, level of education and farming experience.

Basorun and Fasakin, (2012) identify the factors that influence the rice production in Igbemo-Ekiti Region of Nigeria. This study data is collected from 156 farmers in the state of Nigeria and multiple regression analysis is used to find the results. The results finds that the status of rice farmers, area of land cultivated, availability of market for rice products, number of laborers that involved in rice production and agro-chemical are the important factors that impact the rice production.

Rekwot *et al.*, (2011) determined the growth trend of demand and supply in Nigeria over the period of 1970 to 2011 and its inference of empowering youths and women. A growth model is used to analyze the time series data. The results shows that compound growth rate was (7.5% and 7.8%) of rice demand were higher than that of rice supply (6.5% and 6.7%) and this shows that the rate of demand-supply gap for rice in Nigeria has been an existing trend over the years and the trend would continue if accurate measure are not taken inspite the country huge potential exist to attain independence.

Pede *et al.*, (2007) estimate the effect of remittances on technical efficiency of rice farmers: A case study of rice farming household in Philippines. Primary data is collected through personal interviews for selected household. Stochastic frontier analysis is used to find the results. The results reveal that the higher percentage of remittances for farm inputs and the higher education of the male head of the household leads to decrease technical inefficiency.

II- iii. <u>Studies conducted in Pakistan:</u>

In Pakistan some researcher estimates the technical efficiency of rice farmers and finds the factors that effect on the technical efficiency of farmers.

Ahmad *et al.*, (1999) estimated the technical efficiency of rice farmers in Pakistan. Stochastic Cobb-Douglas stochastic frontier is applied to primary data and concludes that agriculture credit and extension offices play a major role in improving the farmer technical efficiency and revealed that educated and experienced framers also obtain higher productive efficiency and as a resulted achieved higher output.

Later on Abedullah (2007) estimate the technical efficiency of rice production in Punjab. Primary date is collected from Sheikhupura district and applied the Stochastic frontier methodology concluded that improper combination of the fertilizer nutrients create the soil degradation problem and also affect the quality of ground water as well as finds that old farmers are technically inefficient.

After that Javed *et al.*, (2010) estimated the technical efficiency of rice-wheat system in Punjab. Data Envelopment analysis was applied and conclude that year of schooling, number of contacts with extension agent and access to credit variables had negative impact on technical efficiency and farm size, age of farm's operator, and farm to market distance had positive impact on technical efficiency of rice farmers.

After that Akhtar *et al.*, (2012) analyses the impact of direct seeding rice on household welfare in Pakistan. Data was collected from three main rice-wheat area of Punjab Sheikhupura, Hafizabad and Gujranwala district through interviews. The empirical results indicate that adopters of direct sowing technology are receiving higher net return in the range of 8-9 mounds per acre and the profitability analysis shows that direct seeding rice sowing technology cost of production is lower than the conventional transplanting of rice.

Most of the studies have been done on conventional rice system but no study has done that compare the Conventional and Dry rice sowing and finds which sowing method is beneficial for rice farmers. To fill the gap this study compare the Conventional and Dry rice sowing method and aims to find that which sowing technique is profitable for farmers and which technique farmers faces less cost and achieved higher output. In this study we estimate the efficiency of conventional and dry rice sowing farmers and identified the factors which affect the efficiency of rice farmers.

Chapter 3:

Material and Methods

III- I. Data Collection Procedure:

The cross sectional data has been used in this study. Analysis is carried out by using primary data on input and output quantities and prices from 300 respondents belonging to five districts of Punjab namely: Sheikhupura, Hafizabad, Gujranwala, Jhang and vehari. From each district total 4 villages were selected randomly and form each village total 15 farmers were interviewed. Data was collected for the rice crop during Kharif season in year 2013. Well- structured and pre-tested questionnaire was used to collect the information from the respondents. The random sampling technique was used for the selection of sample farmers. We select randomly respondent's farmers for interview. The respondents of the study are those farmers who cultivated rice through conventional method or Direct seeded method.

The data was collected from 150 farmers who cultivate rice through conventional method and 150 from those who cultivate rice through direct seeded method. Difficulties were faced in collected data from large number of farmers and more particularly finding specific farmer who cultivate rice through conventional or direct seeding method. During interviews Urdu language were used for literate farmers and

Punjabi and Sarike languages from those farmers who are illiterate and not able to understand Urdu language.

III-ii: <u>Concept of Efficiency:</u>

Farrell's, (1957) determine the article that led to the development of several techniques for the measurement of efficiency of production. According to Dinc *et al.*,(1998) the term "efficiency" refers the success with which a farm best utilizes its accessible resources to produce maximum levels of possible outputs. Cooper *et al.*, (1995) said that farm is efficient if and only if it is not feasible to increase output (or decrease inputs) without more inputs or without decreasing output). The neoclassical theory of production defines the production function based on the idea of efficiency that gives the maximum possible output for a given sets of inputs.

Hollingsworth & Peacock, (2008) explain that efficiency creates the relationship between the inputs (usually land, capital, and labor) and the outputs of the production function, which define the possible combinations of inputs and the resulting outputs. According to Alam *et al.*, (2010), the measurement of the productive efficiency is a very important issue in farming sector especially for developing countries because it gives in series that is helpful for make managing decisions in resource allocation and for formulating agricultural and economic policies.

Analysis of efficiency dates reverse to Knight (1933), Debrew (1951) and Koopmans, (1955) provides the definition of technical efficiency and Farrell (1957) provide the definition of Frontier production function which gives the idea of maximality. Farrell, (1957) defines that efficiency is the actual productivity of a firm as comparative to its maximal productivity. Lassitsa *et al.*,(2005) said that maximal productivity is explained by the production frontier. In addition Coelli *et al.*, (2005) defines that all points on the production possibility frontier represent the maximum output possible from each input level.

III- iii. Types of efficiency:

Economists have developed three main measures of efficiency to fulfill the requirements of researchers, managers, and policy makers in financial mutual in this regard. Farrell, (1957) explains the concept of efficiency and its types. He defines that there are three types of efficiency. i) Technical efficiency. ii) Price or Allocative efficiency. iii) Economic efficiency.

Technical efficiency:

Technical efficiency explains the relationship between input and output. Farrell, (1957) defines the concept of technical efficiency which represents that ability of a farm to obtain maximum output from a given set of inputs, or the ability to minimize input use in the production of a given output vector. Farrell further explains that technical efficiency of a firm must always to some extent reflect the quality of inputs. The production frontier is the locus of maximum achievable output for each input combination. According to Worthington, (2009) technical efficiency refers to the use of productive resources in the most technically efficient way and another way technical efficiency implies the maximum possible output from a given set of inputs.

Allocative efficiency:

Farrell, (1957) defines that it refers the ability of a firm to choose the optimal combination of inputs given their input prices and technology. Allocative efficiency Farrell called it Price efficiency. On the other hand allocative efficiency related with choosing different technically efficient combinations of inputs that is used to produce the maximum possible outputs.

Rehman, (2012) said that allocative inefficiency arises if farms fail to allocating inputs which minimize the cost of production of a output, given relative input prices. Failure in allocating resources efficiently resulting in increased cost and decreased profit. In particular, a farm is said to be allocatively inefficient if the marginal rate of technical substitution between any two inputs is not equal to the corresponding ratio of input prices.

Economic efficiency:

Economic efficiency is the combination of technical and allocative efficiencies. Ellis, (1998) defines that economic efficiency reflects the ability of a farm to produce output at minimum cost. Thus, either one of the efficiencies may be necessary but not sufficient conditions to make sure economic efficiency for a farm. The simultaneous ability of both efficiencies gives the sufficient condition to ensure economic efficiency.

When taken collectively allocative efficiency and technical efficiency it establishes the degree of productive efficiency which is also known as total economic efficiency. Begum *et al.*, (2009) and Coelli *et al.*, (2005) explain that economic efficiency reveals the capability of a production unit to produce a maximum output at the lowest amount. According to Worthington, (2009) explains that if resources use completely allocatively and technically efficient then it can be said to have achieved total economic efficiency.

Technical inefficiency:

Ali and Byerlee, (1991) explain that a firm is considered to be efficient if it is operating on the production frontier while firm is considered to be technically inefficient when it fails to achieve maximum output from given inputs or fails to operate on the production frontier. On the other hand, technical inefficiency refers to a failure of the farm to produce the frontier level of output, given the quantities of inputs [(Kumbhakar, 1994)].

III-iv: <u>Efficiency measurement: Material and Methods:</u>

Mostly two methods are used to measure the efficiencies in farming sector that are Data Envelopment analysis (DEA) and Stochastic Frontier analysis (SFA) which leads to mathematical programming and econometric methods also.

Coelli *et al.*, (1998) considered that stochastic frontier approach more suitable approach than Data Envelopment Analyses (DEA) in agricultural sector, especially in developing countries, because farming sector mostly uncertainty occur so that data is highly affected by the random errors and the effects of climatic situation like floods, earth quake and diseases, so that (SFA) approach considered these random errors and statistical noise, whereas DEA approach not considered.

Kumbhakar and Lovell, (2000) and Cabrera, (2010) said that a stochastic frontier model is the most suitable approach especially in the rural sector because of its ability that deal with stochastic noise (such as random variable like Weather, Luck, and other events that is beyond the control of firm). It is capable for hypothesis testing, and allows for single step estimation of the ineffectiveness effects.

<u>Data Envelopment Analysis:</u>

DEA is an abbreviation for Data Envelopment Analysis, used to calculate efficiencies in production. It is a linear programming model to construct a non-parametric piecewise surface to calculate relative efficiencies. Data envelopment analysis (DEA) is a non-parametric approach that is used for the estimation of frontier and the calculation of efficiency measures [Tauer (1998), Jaforullah and whitemen (1999), Stokes *et al.*, (2007)].

Data Envelopment Analysis (DEA) was firstly developed by Charnes *et al.*, (1978). It is a non-parametric mathematical programming approach. DEA technique is basically helpful for the input-output based approach depending on either they use input distance function or output distance function.

The major weakness of DEA approach is that: It is a deterministic approach (Begum *et al.*, 2009). DEA does not make assumption about the distribution of efficiency. DEA analysis does not accommodate for statistical noise it explicitly account for Stochastic events like bad weathers, poor luck and measurement errors as it gives ambiguous results [Fare *et al.*, (2000), Karasachat (2003)]. All the deviation from frontier is attributed to inefficiency and not due to measurement error [Fare *et al.*, (2000), Karsachat, (2003)]. Its results are very sensitive to outliers, as observations from the sample are used to construct the frontier [Perelman (1999)]. It is not capable for hypothesis testing [Karasachat (2003)]. There is a lack of formal tests available to assess the strength of the functional form created by optimization of the DEA problem. DEA can only offer its finite sample, piecewise linear approximation (Warsaw 2011).

Stochastic Frontier Analysis:

There are two approaches mostly used for measuring the efficiency, parametric approach and Non-parametric approach. Parametric approach used the econometric technique for the estimation of frontier functions. Parametric approach stipulates and estimates the stochastic production frontier and stochastic cost frontier. Stochastic Frontier analysis the output (or cost) is supposed to be a function of inputs, inefficiency and random error.

The main advantage of the stochastic frontier function approach (SFA) is: it considered the stochastic error and then allows hypothetical testing [(Coelli (1995) and Battese, (2005)]. It has a benefit over DEA when statistical noise is a problem (Coelli1995).It does not assume that all firms are fully efficient [(Battese *et al.*, (2005)]. It requires both price and quantity information [Battese *et al.*, (2005)]. SFA separate errors component from inefficiency components [Bauer (1990), Greene (1993), Skinner (1994) and Radam *et al.*, (2010)].

Agriculture sector SFA approach is most appropriate then DEA, because in agriculture sector ambiguity prevail because of Climatic conditions and some other random error involved [Ezeh (2004), Coellie (1996)]. Farmer will always operate under uncertainty and therefore present research is related to agriculture sector so this research here using the stochastic frontier production function approach.

III-v: Theoretical Framework of Stochastic Frontier Approach:

Stochastic production frontier model were simultaneously introduced by (Aigner and Chu (1968), Seitz (1971), Timmer (1971), and Richmond (1974) Lovell, and Schmidt (1977) and Meeusen and Van den Broeck (1977), it was the effort of these authors that led directly to the development of SFA. The main feature of the stochastic production frontier is that the trouble term, which had two components, one describes for random effects and another explain for technical inefficiency. "V" captures the random effects that occur due to the measurement error, statistical noise and other non-fair influences that cannot manage the firm and "U_i" captures the technical inefficiency that can control the firm.

The functional form of the model can be defined as:

$$y_i = X_i \beta + \left(V_i - U_i \right) \quad i = 1,2,\ldots\ldots N \quad \ldots\ldots\ldots\ldots(1)$$

Y_i = It represents the production (or the logarithm of the production) of the ith firm.

X = It's a K ×1 vector of the input quantities used by the producer of firm.

ß = It Shows the vector unknown parameters to be estimated.

V_i = It is a random variable which is assumed to be identically independent distribution (iid) N (0, δ^2_v).

U_i = It is a non-negative random variables which are assumed to account for technical inefficiency in production function and are assumed to be iid N (0, $\delta^2 u$).

$$\varepsilon = V_i - U_i \qquad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

ε = It is the error that shows the difference of technical inefficiency and random error term.

V_i = it is a is a symmetrical two sided normally distributed random variable that captures the stochastic effects outside the farmers control like Weather, Disaster, and Luck etc.

U_i = It is a one sided ($U_i \geq 0$) efficiency component and Non-negative that captures the technical inefficiency of the farmer. Both U_i and V_i are independent of each other's.

Battese and Corra, (1977) extended the model and change the $\delta^2 v$ and $\delta^2 u$ with:

$$\delta^2 = \delta^2 u + \delta^2 v \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

δ^2 explains that total variation in dependent variables is due to technical inefficiency and random shocks together and γ shows that the systematic influence that are not explained the production function it is the ratio of variance of u to the total variance.

$$\gamma = \delta^2 u / \delta^2 u + \delta^2 v \qquad \text{.......... ....} (4)$$

This can be calculated by the Maximum likelihood estimates. This parameter must be lies between zero and one. On the basis of the size of γ, whether the differences between the best and actual practices were real or accidental. The smaller the ratio, the higher is the probability that the differences are accidental. [Kalirajan and Shand, (1985)].

Technical efficiency is obtained by the ratio of observed output (Y_i)to the maximum achievable level of output(y^*).

$$TE = Y_i / y^* = \exp(-u_i) \qquad \text{..} (5)$$

or

$$TE = \exp(X_i\beta + v_i - u_i) / \exp(X_i\beta + v_i) \qquad = \exp(-u_i)$$

In order to estimate these efficiency some author suggested a two-stage method, in which the first stage consists of technical efficiency estimation using a SFA approach, and the second stage involves the condition of a regression model that relaxes technical efficiency with some explanatory variables [(Pitt and Lee (1981); Kalirajan,(1982); Parikh and Shah, (1994)].

One-stage SFA models in which the inefficiency effects (u_i) are explained as a function of a vector of observable explanatory variables were proposed by [Kumbhakar *et al.*, (1991); chneider and Stevenson (1991); Huang and Liu (1994)].

In different time period authors imposed the restriction with regard to this model specification like: Battese *et al.*, (1989) impose the restriction that by assuming η is to be zero provides the time-invariant model. The additional restriction of μ equal to zero reduces the model (Pitt and Lee (1981). Aigner *et al.*, (1977) imposed the limit of T=1 then the model becomes the single cross-sectional, half-normal term.

III-vi. <u>Theoretical Frame work of Stochastic Frontier Cost Function:</u>

Aigner *et al.*, (1977) and Hughes (1988) and Battese and Coelli (1988) defines the stochastic frontier cost function. The model specification of the cost stochastic frontier simply change the ($V_i - U_i$) in to ($V_i + U_i$), functional form can be defined as:

$$Y_i = X_i\beta + V_i + U_i \qquad i = 1,2. \quad ..N$$

..........(1)

In the cost function U_i defines how far away the firm operates above the cost function. If it assumed the allocative efficiency then U_i is closely related to the cost of technical inefficiency.

Cost efficiency lies between zero and infinity. Cost efficiency relation to the cost frontier without log dependent variable can be defined as

$$EEF = \exp\left(X_i\beta + v_i + U_i\right) \Big/ \exp\left(X_i\beta + v_i\right) \quad \text{.......... ...(2)}$$

Cost efficiency measures with log dependent variable can be defined as:

$$EEF = \exp\left(u_i\right) \quad \text{......... ....(3)}$$

In stochastic frontier production approach mostly Cobb-Douglas and translog stochastic frontier is generally used to calculate the efficiency, basically it is based on Cobb-Douglas and translog stochastic frontier approach that could be specific also as production or cost function (Udoh and Akintola, 2001). On the assumption that V_i and U_i are independent and normally distributed, the parameters β, σ^2_u, σ^2_v ,σ^2 , γ and λ can be estimated by the method of Maximum Likelihood Estimates (MLE), using the computer Frontier Version 4.1 (Coelli, 1996) which is also estimates the technical and allocative efficiency.

III-V: <u>Cobb-Douglas Cost Stochastic frontier model:</u>

A stochastic function of the C-D type is proposed by Battese and Collie (1995) for wheat crop of Pakistan.

The general expression of Cobb-Douglas function is:

$$Y = AL^a k^b$$

Y represents the set of output; L shows the measure of labor input and K capital. A term demonstrates the constant term. It is also considered the joint impact of inputs that are measured to be fixed on the production function. The main property of C-D type function is the "a" and " b" are the elasticity of production with respect to labor and capital and second property is that the function is homogenous of degree, "a+b" [(Coudere and Marijse,1991)].

Cobb-Douglas cost stochastic frontier model is used the [Schmidt and Sickles (1984) ,Rahman (2002), Kahi and Yabe (2011)]

$$\ln(y_i) = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + \beta_{10} \ln X_{10} + \beta_{11} \ln X_{11} + v_i + u_i$$

Where $V_i + U_i$ is a composed error term, ln (Y) represents log of Cost of output and ln (X_i) log of independent variables. (i=1, 2, ... 11)

Y_i = cost of rice output / acre of the ith farm

X_1 = Pesticide cost / acre

X_2 = Seed cost /acre

X_3= Fertilizer cost / acre

X_4 = Per acre cost for land preparation

X_5 = Cost of irrigation / acre

X_6 = Farm yard manure cost / acre

X_7= Weedicide cost / acre

X_8 = Insecticide cost

X_9 = Harvesting cost

X_{10}= labor cost

X_{11} = Rice Output.

III-VI Cobb Douglas Stochastic frontier Production Approach:

If we take the log of output and the input quantities, then the Cobb-Douglas production function is obtained. The logarithmic functional form of Cobb-Douglas stochastic frontier production function single output used the model [Battese and Coelli (1993), Abedullah *et al.*, (2007), Raman and Chowdhury (2012)].

The functional form of Cobb-Douglas Stochastic frontier production function is:

$$\ln(Y_i) = B_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + \beta_{10} \ln X_{10} + \beta_{11} \ln X_{11} + V_i - U_i$$

Where $V_i - U_i$ is a composed error term, ln (Y) represent log of output and ln (X_i) log of independent variables and i= ith farm.

Y_i = Rice Output/ acre of the ith farm.

X_1= Dummy variable 0 for Conventional Puddling and 1 for Dry rice.

$X_2 =$ Area under Rice crops

$X_3 =$ NPK Nutrients/ acre (N=Nitrogen, P= Potash, K= Phosphorus it is the fertilizers that is used the farmers for sowing rice)

$X_4 =$ Seed per acre/ (kg)

(How much seed bags used the farmers per acre)

$X_5 =$ Irrigation hours / acre

$X_6 =$ Weedicide (liters) / acre

$X_7 =$ Labor hour/ acre (Labor hours for weeding, fertilization and Spraying Pesticide).

$X_8 =$ Total tractor hour for land preparation (Ploughing, Planking, Hewing, Spraying Land leveling).

$X_9 =$ Farm yard Manure

$X_{10} =$ Insecticide

$X_{11} =$ Pesticide

The stochastic frontier model is estimated by the computer frontier program 4.1

The main advantage of Cobb-Douglas Stochastic production function is:

Cobb-Douglass functional form is considered more suitable in testing the return to scale hypothesis. Cobb-Douglass functional form considered more ease when we have a comparatively large number of inputs in the production frontier function. It creates a sufficient representation of the data. Its directly indicate the elasticity of variables.

The disadvantage of Cobb-Douglas production function is that it has fixed input elasticity's and returns to scale. The elasticity of Cobb-Douglas type of production function is fixed irrespective of the amounts of every input that are used.

III-vii. Functional form of Technical inefficiency:

Battese and Coelli (1995) extended this model specification it considered that U_i is the non-negative random variables which are supposed to explain for technical inefficiency in production. The function determined the technical inefficiency effects are defined in its general form as a linear function of socio economic and management factors.

The functional form of technical inefficiency is used the [Battese and Coellie (1993), Abedullah *et al.*, (2007), Rahman and Chaudhary (2012)].

$$U_i = \delta_0 + \delta_1 \text{education} + \delta_2 \text{experience} + \delta_3 \text{owner} + \delta_4 \text{Tenant} + \delta 5 Ownercumtenant + \delta_5 \text{Market Distance} + \delta_6 \text{ Selling Agency} + \delta_7 \text{Credit Access} + \delta_8 \text{Tractor} + \delta_9 \text{TubeWell} + \delta_{10} \text{extension services} + \delta_{11} \text{Household size} + V_i$$

U_i represents the technical inefficiency and Z_i represent the socio economic and farm management factors and δo, δ_i (i...1, 2....11) is the parameter to be estimated and v_i is the unobserved random variables which are identically independently distributed.

Education = Farmers Education.

Experience = Farmers Experience

Owner = used as a Dummy Variables if farmer is an owner = 1 otherwise Zero.

Tenant = Dummy Variable showing value if farmer is a tenant=1 other wise, zero.

Owner-Cum-Tenant= Dummy variable as a third category of farmers is Omitted.

Distance from main market (Km)

Crop sale = Dummy variable showing value =0 if the crop sale in a village and = 1 if the crop Sale in a market.

Credit availability = Farmers borrow money from bank or own cash or borrow to relatives.

Tractor = Dummy variable showing value equal=1, if farmer is a tractor owner, otherwise zero.

Tube Well: Dummy variable showing value equal=1, if farmer is a Tube well owner, otherwise zero.

Number of household size

Technical inefficiency can be estimated by subtracting one from technical efficiency.

$$U_i = 1 - TE \qquad 0 \leq TE \leq 1$$

$$EEF = \left(X\beta + V_i - U_i\right) / \left(XB + V_i\right)$$

$$EEF = \exp\left(-U_i\right)$$

III-viii. <u>Translog Stochastic Production frontier Approach:</u>

The translog production function is an elegant flexible function. This function has both linear and quadratic term with its capacity of using more than two factor inputs. This function can be judge by second order Taylor series (Christensen, *et al.*, Jorgenson & Lau 1973). The following advantage of translog stochastic production frontier approach is defined the Coelli (1998) and Battese (2005).

It provides the opportunity to describe the data in a more flexible way. The translog form imposes no limitations upon returns of scale or substitution possibilities. Cobb-Douglas form is an enough representation of the data, given the condition of the translog model. The logarithmic functional form of translog stochastic frontier production function single output used the model [Madau (2011), Strauss *et al.*, (1986), Hassan (2012)].

$$
\begin{aligned}
Ln(Y_i) = {} & \beta_o + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4 + \beta_5 \ln x_5 + \beta_6 \ln x_6 + \beta_7 \ln x_7 \\
& + \beta_8 \ln x_8 + \beta_9 \ln x_9 + \beta_{10} \ln x_{10} + \beta_{11} \ln x_{11} \\
& + 1/2 \begin{bmatrix} \beta_{11}(\ln x_1)^2 + \beta_{22}(\ln x_2)^2 + \beta_{33}(\ln x_3)^2 + \beta_{44}(\ln x_4)^2 + \\ \beta_{55}(\ln x_5)^2 + \beta_{66}(\ln x_6)^2 + \beta_{77}(\ln x_7)^2 + \beta_{88}(\ln x_8)^2 + \\ \beta_{99}(\ln x_9)^2 + \beta_{1010}(\ln x_{10})^2 + \beta_{1111}(\ln x_{11})^2 \end{bmatrix} \\
& + \beta_{12}(\ln x_1 * \ln x_2) + \beta_{13}(\ln x_1 * \ln x_3) + \beta_{14}(\ln x_1 * \ln x_4) + \beta_{15}(\ln x_1 * \ln x_5) + \\
& \beta_{16}(\ln x_1 * \ln x_6) + \beta_{17}(\ln x_1 * \ln x_7) + \beta_{18}(\ln x_1 * \ln x_8) + \beta_{19}(\ln x_1 * \ln x_9) + \\
& \beta_{110}(\ln x_1 * \ln x_{10}) + \beta_{111}(\ln x_1 * \ln x_{11}) + \beta_{23}(\ln x_2 * \ln x_3) + \beta_{24}(\ln x_2 * \ln x_4) + \\
& \beta_{25}(\ln x_2 * \ln x_5) + \beta_{26}(\ln x_2 * \ln x_6) + \beta_{27}(\ln x_2 * \ln x_7) + \beta_{28}(\ln x_2 * \ln x_8) + \\
& \beta_{29}(\ln x_2 * \ln x_9) + \beta_{210}(\ln x_2 * \ln x_{10}) + \beta_{211}(\ln x_2 * \ln x_{11}) + \beta_{34}(\ln x_3 * \ln x_4) + \\
& \beta_{35}(\ln x_3 * \ln x_5) + \beta_{36}(\ln x_3 * \ln x_6) + \beta_{37}(\ln x_3 * \ln x_7) + \beta_{38}(\ln x_3 * \ln x_8) + \\
& \beta_{39}(\ln x_3 * \ln x_9) + \beta_{310}(\ln x_3 * \ln x_{10}) + \beta_{311}(\ln x_3 * \ln x_{11}) + \beta_{45}(\ln x_4 * \ln x_5) \\
& + \beta_{46}(\ln x_4 * \ln x_6) + \beta_{47}(\ln x_4 * \ln x_7) + \beta_{48}(\ln x_4 * \ln x_8) + \beta_{49}(\ln x_4 * \ln x_9) + \\
& \beta_{410}(\ln x_4 * \ln x_{10}) + \beta_{411}(\ln x_4 * \ln x_{11}) + \beta_{56}(\ln x_5 * \ln x_6) + \beta_{57}(\ln x_5 * \ln x_7) + \\
& \beta_{58}(\ln x_5 * \ln x_8) + \beta_{59}(\ln x_5 * \ln x_9) + \beta_{510}(\ln x_5 * \ln x_{10}) + \beta_{511}(\ln x_5 * \ln x_{11}) + \\
& \beta_{67}(\ln x_6 * \ln x_7) + \beta_{68}(\ln x_6 * \ln x_8) + \beta_{69}(\ln x_6 * \ln x_9) + \beta_{610}(\ln x_6 * \ln x_{10}) + \\
& \beta_{611}(\ln x_6 * \ln x_{11}) + \beta_{78}(\ln x_7 * \ln x_8) + \beta_{79}(\ln x_7 * \ln x_9) + \beta_{710}(\ln x_7 * \ln x_{10}) + \\
& \beta_{711}(\ln x_7 * \ln x_{11}) + \beta_{89}(\ln x_8 * \ln x_9) + \beta_{810}(\ln x_8 * \ln x_{10}) + \beta_{811}(\ln x_8 * \ln x_{11}) + \\
& \beta_{910}(\ln x_9 * \ln x_{10}) + \beta_{911}(\ln x_9 * \ln x_{11}) + \beta_{1011}(\ln x_{10} * \ln x_{11}) + V_i - U_i .
\end{aligned}
$$

Where $(V_i - U_i)$ is the composed error term. Ln (Y_i) is the log of rice output and ln (X_i) is the log of independent variables. i represents the ith farm.

Y_i = Rice Output/ acre of the ith farm.

X_1 = Dummy variable 0 for Conventional Puddling and 1 for Dry rice.

X_2 = Area under Rice crops

X_3 = NPK Nutrients/ acre (N=Nitrogen, P= Potash= Phosphorus it is the Fertilizer that is used the farmers for sowing rice).

X_4 = Seed per acre/ (kg) (how many seed bags use the farmers per Acre)

X_5 = Irrigation hours / acre

X_6 = Weedicide (liters) / acre

X_7 = Labor hour/ acre (Labor hours for weeding, fertilization and Spraying Pesticide)

X_8 = Total tractor hour for land preparation (Ploughing, Planking, Hewing, Spraying and land leveling).

X_9 = Farm yard Manure/Acre

X_{10} = Insecticide/Acre

X_{11} = Pesticide/Acre

III- ix. Translog cost stochastic frontier approach:

The logarithmic functional form of translog stochastic frontier cost function single cost of output used the model [Strauss *et al.*, (1986)].

$$
\begin{aligned}
Ln(Y_i) = {} & \beta_O + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4 + \beta_5 \ln x_5 + \beta_6 \ln x_6 \\
& + \beta_7 \ln x_7 + \beta_8 \ln x_8 + \beta_9 \ln x_9 + \beta_{10} \ln x_{10} + \beta_{11} \ln x_{11} \\
& + 1/2 \begin{bmatrix} \beta_{11}(\ln x_1)^2 + \beta_{22}(\ln x_2)^2 + \beta_{33}(\ln x_3)^2 + \beta_{44}(\ln x_4)^2 \\ + \beta_{55}(\ln x_5)^2 + \beta_{66}(\ln x_6)^2 + \beta_{77}(\ln x_7)^2 + \beta_{88}(\ln x_8)^2 \\ + \beta_{99}(\ln x_9)^2 + \beta_{1010}(\ln x_{10})^2 + \beta_{1111}(\ln x_{11})^2 \end{bmatrix} \\
& + \beta_{12}(\ln x_1 * \ln x_2) + \beta_{13}(\ln x_1 * \ln x_3) + \beta_{14}(\ln_1 * \ln x_4) + \beta_{15}(\ln x_1 * \ln x_5) + \\
& \beta_{16}(\ln x_1 * \ln x_6) + \beta_{17}(\ln x_1 * \ln x_7) + \beta_{18}(\ln x_1 * \ln x_8) + \beta_{19}(\ln x_1 * \ln x_9) + \\
& \beta_{110}(\ln x1 * \ln x_{10}) + \beta_{111}(\ln x_1 * \ln x_{11}) + \beta_{23}(\ln x_2 * \ln x_3) + \beta_{24}(\ln x_2 * \ln x_4) + \\
& \beta_{25}(\ln x_2 * \ln x_5) + \beta_{26}(\ln x_2 * \ln x_6) + \beta_{27}(\ln x_2 * \ln x_7) + \beta_{28}(\ln x_2 * \ln x_8) + \\
& \beta_{29}(\ln x_2 * \ln x9) + \beta_{210}(\ln x_2 * \ln x_{10}) + \beta_{211}(\ln x_2 * \ln x_{11}) + + \beta_{34}(\ln x_3 * \ln x_4) + \\
& \beta_{35}(\ln x_3 * \ln x_5) + \beta_{36}(\ln x_3 * \ln x_6) + \beta_{37}(\ln x_3 * \ln x_7) + \beta_{38}(\ln x_3 * \ln x_8) + \\
& \beta_{39}(\ln x_3 * \ln x_9) + \beta_{310}(\ln x_3 * \ln x_{10}) + \beta_{311}(\ln x_3 * \ln x_{11}) + \beta_{45}(\ln x_4 * \ln x_5) + \\
& \beta_{46}(\ln x_4 * \ln x_6) + \beta_{47}(\ln x_4 * \ln x_7) + \beta_{48}(\ln x_4 * \ln x_8) + \beta_{49}(\ln x_4 * \ln x_9) + \\
& \beta_{410}(\ln x_4 * \ln x_{10}) + \beta_{411}(\ln x_4 * \ln x_{11}) + \beta_{56}(\ln x_5 * \ln x_6) + \beta_{57}(\ln x_5 * \ln x_7) + \\
& \beta_{58}(\ln x_5 * \ln x_8) + \beta_{59}(\ln x_5 * \ln x9) + \beta_{510}(\ln x_5 * \ln x_{10}) + \beta_{511}(\ln x_5 * \ln x_{11}) + \\
& \beta_{67}(\ln x_6 * \ln x_7) + \beta_{68}(\ln x_6 * \ln x_8) + \beta_{69}(\ln x_6 * \ln x9) + \beta_{610}(\ln x_6 * \ln x_{10}) + \\
& \beta_{611}(\ln x_6 * \ln x_{11}) + \beta_{78}(\ln x_7 * \ln x_8) + \beta_{79}(\ln x_7 * \ln x_9) + \beta_{710}(\ln x_7 * \ln x_{10}) + \\
& \beta_{711}(\ln x_7 * \ln x_{11}) + \beta_{89}(\ln x_8 * \ln x_9) + \beta_{810}(\ln x_8 * \ln x_{10}) + \beta_{811}(\ln x_8 * \ln x_{11}) + \\
& \beta_{910}(\ln x_9 * \ln x_{10}) + \beta_{911}(\ln x_9 * \ln x_{11}) + \beta_{1011}(\ln x_{10} * \ln x_{11}) + V_i + U_i
\end{aligned}
$$

Where $(V_i + U_i)$ are a composed error term, ln (Y_i) represents log of Cost of output and ln (X_i) log of independent variables. βs are the coefficient of linear, cross and square products terms. i represent the ith farm.

Y_i = cost of rice output / acre of the ith farm

X_1 = Pesticide cost / acre

X_2= Seed cost /acre

X_3= Fertilizer cost / acre

X_4= Per acre cost for land preparation

X_5 = Cost of irrigation / acre

X_6 = Farm yard manure cost / acre

X_7 = Weedicide cost / acre

X_8 = Insecticide cost/acre

X_9 = Harvesting cost/acre

X_{10}= labor cost/acre

X_{11} = Rice output

The translog stochastic cost frontier model is estimated by the computer frontier program 4.1.

III-x. Test of the Model Specification:

The hypotheses have been tested with regard to model specification. These tests are performed using generalized likelihood - ratio statistics, (LR). The maximum-likelihood technique is useful for the estimation of the parameter and forecast the technical efficiencies of the firms over time. The generalized likelihood ratio is measured for testing the null hypothesis, which the inefficiency effects not stochastic or they do not depend on the firm-specific variables (Battese and Collie 1992 and 1995).

Which are defines as:

$$LR = -2\ln[L(H_0) - L(H_1)]$$

L (H_0) and L (H_1) are the values of the log likelihood function under the condition of the null and alternative hypothesis, respectively.

III-xi **<u>Testing of Hypothesis:</u>**

$$H_0 = \gamma = \delta_0 = \delta_1 = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \delta 11 = 0$$

$$H_0 = \gamma = \delta_0 = \delta_1 = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \delta 11 = 0$$

$$H_0 = \delta_1, \delta 2, = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \delta 11 = 0$$

$$H_0 = \delta_1, \delta 2, = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \delta 11 = 0$$

$$H_O = \sum \beta ij = 1$$

$$H_O = \sum \beta jk = 1$$

The first null hypothesis tested $H_0 = \gamma = \delta_0 = \delta_{1=}$, ... δ_{11} which state that the farm level technical inefficiency not exist in the production frontier model.

The second null hypothesis we test $H_0 = \gamma = \delta_0 = \delta_{1=}$, ... δ_{11} which states farm level allocative inefficiency not exist in the cost stochastic frontier model.

The third null hypothesis we test $H_0 = \delta_1 = \delta_2 =$, ...$\delta_{11}$ which states that farm level technical inefficiency are not affected the independent variable which is included in the production frontier model.

The fourth null hypothesis states that farm level technical inefficiencies are not affected by the independent variable that is included in the cost stochastic frontier model.

The fifth null hypothesis states that whether the sum of Elasticities in Cobb Douglas production function has always constant return to scale.

The sixth null hypothesis states that whether the sum of Elasticities in Cobb-Douglas cost function has always constant return to scale.

After testing hypothesis we decided to use translog stochastic frontier model in this study. Details are mentioned in chapter 4-2, Empirical chapter.

Chapter IV:

Descriptive Analysis Discussion of Results

Introduction:

Pakistan in the world considered as largest producer of Rice. Every year, it produces an average of 6 million tones. According to Federal Bureau of statistics, Government of Pakistan report (2012-13) rice sowing area is estimated at 2.31 million hectares in Pakistan, 10.1% less than last year's area of 2.57 million hectares. Moreover, Rice production decreased from 6.95 million tons in 2008-09 to 5.54 million tons in 2012-13, Hence, it shows declining of 20%. The production decreases due to decrease in area and effects of monsoon rain and late receding of water period in rice field delay the sowing. All these factors affected the productivity and technical, allocative and economic efficiency of Rice Crop. This chapter is committed to presentation and discussion of descriptive analysis. Section IV-I is about descriptive analysis; Section IV-2 include empirical analysis.

IV-I: Descriptive statistics of sample farms:

After collection of data, the next most important step was to enter the data and its descriptive analysis. For the purpose of descriptive analysis used statistical package for social science (SPSS 20) in this study. Descriptive statistics gives us all information about variables which is mentioned in questionnaire. Descriptive analysis provides us help to identify the percentages, mean, and standard deviation of different variables. Every variable is explained one by one in this chapter.

Table 1: Farm Size of sample farms:

Characteristics	Less than 5 acre	5-15 acre	15-25 acre	>25 acre
Conventional Average farm size (acre)	3.13	8.81	19.88	47.11
Percent farms (%)	10	65	18	8
Direct seeded average farm size (acre)	3.14	9	19.96	39.6
Percent farms (%)	9.3	65.40	18.70	6.90
Total Average farm size	3.92	8.90	19.93	43.35
Total farm size (%)	9.6	64.90	18.30	7.10

The farm size instrument is included in this study. Farm size variable is an important factor in farming system. According to Abedullah *et al*., (2007) the impact of farm size is uncertain on inefficiency. The large planting area is likely to have positive effects on farmers efficiency because larger the planting area, the greater likely is the opportunity to apply modern technologies such as tractors and irrigation. Therefore, farmers with large planting area could be more efficient or less inefficient. In addition, Kamruzzaman *et al*., (2007) said that farm size positively influences on technical efficiency and further explains that larger farms are more efficient than smaller farms. It is not doubtful that large farms can quickly utilize existing resources and might have a greater ability to access modern inputs on time.

Table 1 shows variation in farm size of conventional and direct seeded rice farmers. Table represents that 10% conventional farmer's use area less than 5 acre and 65 percent conventional farmers use area between 5-15 percent and 18 conventional farmers use area between 15-25 percent and 8 percent farmers use area above 25 acres respectively. On the other hand 9.3% direct seeded farmers use area less than 5 acre and 65% farmers use area between 5-15 acres, 18.70 percent farmers use area between 15-25 acres and 6.90 percent farmers use area above 25 acre respectively.

Overall total 9.6% farmers use area less than 5 acres. 64.90 percent farmers use area between 5-15 acres and 18.30 percent farmers use area between 15-25 acres and 7.10 percent farmers use area above 25 acres respectively. The results show that large number of sample farmers use area between 5-15 acres respectively in the study area.

Table2. Tenancy status of farmer's categories:

Farmers Status of owner ship			
	Conventional farmers (%)	**Direct seeded farmers (%)**	**Over all**
Owner(#)	138	137	275
(%)	92	91.3	91.7
Tenant(#)	12	13	25
(%)	8	8.67	8.33

Table 2 represents that tenancy status of farmers like farmer is owner or tenant. The table results reveal that out of 150 conventional farmers the most frequent form of land tenure is owner 92% and 8 % conventional farmers are tenant. Moreover, out of 150 direct seeded farmers 91.3% farmer's status is owner, 8.67% farmer's status is tenant. Overall the sample results explain that out of 300 farmers the most common type of land tenure is owner that is 91.7% while 8.33% farmers are tenant. Hence, the greater number of farmers is owner in the study area.

Tenancy status also affected the technical efficiency of rice farmers. Collie *et al*., (2002) and Rehman *et al*., (2007) concluded that farmers who hold a large proportion of rented-in land are less efficient than those farmers who cultivated own land.

Table 3: Characteristics of Farmers:

Characteristics	**Conventional farmers**	**Direct seeded farmers**	**Over All**
Age (years)	50	45	48
Education(Years)	10	10	10
Experience (years)	20	25	23
Distance from farm to main market (KM)	4	5	5
Family Size(No)	8	6	7

This study has taken following important factors Age, Education, Experience, Distance from main market and family size which have a significant impact on farm efficiency and decision making. Chaudhary *et al*., (2002) concluded that age is an important factor in decision making, and also have a significant positive impact on farm inefficiency. When age increases farmers inefficiency will also increases. In this study we have taken information about Age, education level and experience of the farmers in years. The table shows that overall average age of sample farmer is 48 years in this study.

This study descriptive statistics results indicates that average education of sample farmers is ten years of education and average experience of sample farmers is twenty three (23) years and average household size of sample farmers is seven. Ahmadu and Erhabor, (2012) said that higher level of education of the farmers lead to lower technical inefficiency. This is because education brings clarification and defines the farmers to access essential information which could improve their ability to make rational production decisions and to innovate. It means, strengthening of effort to provide both adult and extension education to rice farmers which reduce the challenge of inefficiency in the use of resources by the farmers and enhance rice production in the country.

Furthermore, Ajibefun *et al.*,(2002), Onyenweaku and Nwaru (2005) concluded that farming experience associated negatively with the inefficiency of the farmers by saying that 'practice makes perfect.

This study average distance from farm to main market is 5 kilometers. According to FAO and IFA (1999), the use of purchased inputs would have been higher in developing countries if the supply outlet were made available to the farming communities at a walking distance.

In addition, study finds that average family size of farmer is seven. According to Ahmadu and Erhabor (2012) increased family size decreased the inefficiency of farmers in production operations. Okoruwa and Ogundele (2004) and Tiamiyu *et al.*, (2008) agrees with the statement of Adewuyi and Okunmadewa, (2001) that large household size decreases inefficiency through labor involvement in production operations.

Table 4: Ownership sample:

Ownership Sample	**Conventional farmers**		**Direct seeded farmers**		**Overall**	
	Owner	Hired	Owner	Hired	Owner	Hired
Tractor ownership	141	9	137	13	278	22
Tube Well Ownership	136	14	142	8	278	22

Table 4 represents the ownership sample of farmers (conventional and direct seeded farmers). Table results explain that out of 150 conventional farmer's 141 farmers have a tractor ownership and 9 farmer's uses hire tractors. Furthermore, out of 150 Direct seeded farmers 137 farmers possess a tractor and 13 farmers uses hire tractor. The next part of table shows the ownership pattern of farmers regarding tube well. The sample results reveal that 136 conventional farmers possess a tube well and 14 farmer's uses hire tube well. In addition, 142 direct seeded farmers owned tube well and 8 farmer uses hire tube well.

Overall the sample results shows that 278 farmers own both tractor and tube well and 22 farmers uses hire tractor and tube well in the study area. Therefore, the larger number of farmers own both tractor and tube well in this study area. Hence, it shows that there is no variation exists in both types of farmer's ownership status. According to Agarwal, (1983) finds that tractor owning farms have significantly higher cropping intensity than tractor hiring farms. He further, concluded that Ownership of a tractor give the user any special benefit over one who just hire the machine.

Table 5: Sources of irrigation:

Groups of operational holding	Conventional farmers	Direct seeded farmers	Over all
Canal (#)	1	42	43
(%)	0.67	28	14.33
Tube well (#)	37	20	57
(%)	24.67	13.33	19
Canal +Tube Well (#)	112	88	200
(%)	74.67	58.67	66.67

Table 5 represents the sources of irrigation of sample farmers during kharif cycle. The table results explain that out of 150 conventional farmers only 0.67% farmers relined on canal irrigation and 24.67% conventional farmers relined on tube well irrigation and 74.67% conventional farmers relined on both canal and tube well irrigation only. Moreover, out of 150 direct seeded farmers only 28% direct seeded farmers relined on canal irrigation and 13.33 % depends on tube well irrigation only. In addition, 58.67% direct seeded farmers depends on Canal+ tube well sources of irrigation.

Over all the table results exhibits that tube well and Canal are essential in supplying water to study area. On the whole 14.33% farmers depends on canal irrigation only and 19% farmers depends on Tube well irrigation and 66.67% farmers relined on canal + Tube well sources of irrigation. Hence, greater number of sample farmers depends on Canal + Tube well sources of irrigation in the study area. However, according to Agarwal, (1983) concluded that Tubewell irrigated farms have higher cropping intensity than canal irrigated farms. On the other hand Chaudhary *et al.*,(2002) concluded that canal is a less flexible source, as tube well and tube well plus canal are relatively more trustworthy sources and provides timely supply of water throughout the cropping season and thus results in higher farm productivity.

Table 6: Rice area used in different farm size category:

Rice area in acres	Less than 5 acres	5-15 acre	15-25 acre	Greater than 25 acre
Conventional rice field	18	117	7	8
(%)	12	78	4.7	5.4
Direct seeded field	45	100	4	1
(%)	30	66.7	2.67	0.7
Over all	63	217	11	9
(%)	21	72.3	3.7	3

Table 6 results explain that how much acre farmers cultivate rice in kharif season. The survey results explain that 12% conventional farmers cultivate rice in less than 5 acres, 78% famers cultivate rice in 5-15 acres respectively and 4.7% and 5.4% famers cultivate rice in 15-25 acres and above 25 acres respectively. Moreover, 30% direct seeded farmers cultivate rice in less than 5 acres. 66.7% farmers cultivate rice in 5-15 acres, 2.67% farmers cultivated direct seeded rice in between 15-25 acres and 0.7% direct seeded farmers cultivated rice in above 25 acres respectively.

Overall 21% farmers cultivate rice in less than 5 acres area. 72.3% farmers cultivate rice in 5-15 acres. 3.7% farmers cultivate rice in 15-25 acres and 3 percent farmers cultivate rice above 25 acres respectively. On the whole large number of farmers cultivated rice in 5-15 acres, respectively in this study area. According to Tijani, (2006), Dhutta and Akond, (2013) and Abedullah *et al.*, (2010) area planted to rice would play an important role in rice production and increases in rice planted area would significantly lead to increase rice yield.

Table: 7 Rice varieties used in different sowing method:

Rice Varieties	Conventional Method	Direct seeded Method	Over all
Super Basmati(#)	125	56	181
(%)	83.4	37.4	60.4
Super Basmati+ Basmati 385+Basmati 386 (#)	2	0	2
(%)	1.30	0.00	0.70
Super India+ Super Basmati+ Basmati 386	1	2	3
(%)	0.70	1.30	1.00
Super Basmati+ Super India(#)	2	2	4
(%)	1.40	1.40	1.40
Basmati 386(#)	3	43	46
(%)	2	28.70	15.30
Super India(#)	1	1	2
(%)	0.70	0.70	0.70
Basmati 515(#)	3	17	20
(%)	2	11.30	6.70
Basmati 385(#)	2	6	8
(%)	1.30	4.00	2.70
Kernal	0	1	1
(%)	0	0.70	0.30
Super Basmati+ Basmati 386(#)	5	10	15
(%)	3.30	6.70	5
Super Basmati+515(#)	4	12	16
(%)	2.70	8	5.30
Basmati 386+Super India(#)	2	0	2
(%)	1.30	0	0.70

Total(#)	150	150	300
Total (%)	100	100	100

Table 7 results explain that conventional and direct seeded farmers cultivate different verities of rice in the field. The survey results explain that 83.4% conventional farmers cultivate super Basmati rice only in the field. On the other hand, 37.4% direct seeded farmers cultivate super Basmati rice only. Only 1.30% conventional farmers cultivate different varieties of rice super Basmati+ Basmati 385+ Basmati 386 in the field. 0.70% conventional farmers and 1.30% direct seeded farmers cultivate Super India+ Super Basmati+ Basmati 386 combination of rice varieties in the field.

1.40% conventional and direct seeded farmers cultivate combination of rice Super Basmati + Super India in the field. 2% conventional farmers and 28.70% direct seeded farmers cultivate only Basmati 386 rice variety. 0.70% conventional and direct seeded farmers cultivate Super India Rice variety only. 2% and 11.30% conventional and direct seeded farmers cultivate Basmati 515 rice variety only. Moreover, 1.30% and 4% conventional and direct seeded farmers cultivate Basmati 385 Rice variety only in the field. Only 0.70% direct seeded farmers cultivate Kernel rice variety only. 3.30% and 6.70% conventional and direct seeded farmers cultivate Basmati 386+ Super Basmati rice varieties. 2.70% and 8% conventional and direct seeded farmers cultivate Super

Basmati+ Basmati 515 rice varieties. Only 1.30% conventional farmers cultivate Basmati 386+ Super India rice varieties.

On the whole Survey results explain that 60.4% farmers cultivate only Super Basmati Rice variety. 0.70% farmers cultivate Super Basmati+Basmati386+ Basmati385 Rice Varieties in the field. 1% farmers cultivate Super India+ Super Basmati+ Basmati 386 combination of rice varieties. 1.40% farmers cultivate super Basmati +Super India rice varieties and 15.30% farmers cultivate Basmati 386 rice variety only.0.70% farmers cultivate super India and 6.70% famers cultivate Basmati 386 only in the field. 0.30 farmers cultivate only Kernel rice variety and 5% farmers cultivate Super Basmati+ Basmati 386 rice varieties. 5.30% farmers cultivate Super Basmati+ Basmati 515 rice varieties. 0.70% farmers cultivate only Basmati 386+super India in the field. Hence, the result shows that greater number of sample farmers cultivate only Super Basmati rice variety only in the field.

Table: 8 Seed rate and sowing method on sample farms:

Particulars	**Conventional Rice Field**	**Direct seeded Rice Field**
Seed Rate (Kg/acre) Mean and Std	12 (5.21)	30 (15.27)
Sowing Method (%)		
Drill	20	8
Broadcast	80	92

Table 8 shows that application of average seed rate is 12 kg/acre in conventional rice field and 30 kg/acre in direct seeded field. Hence, direct seeded farms required 18 kg/acre more seeds than conventional rice farms. Khan *et al.*, (2003), Anthony and Achike, (2010) and Dhutta and Avond, (2013) finds that seed is an important factor and playing a major role in rice yield and further explains that seed have a strong and positive impact on rice yield.

Seed sowing method is also an important factor and playing a major role in rice yield. Broadcasting of seeds is the usual method of Rice planting in the study area. Around 80% conventional farmers and 92% direct seeded farmers used the method of broadcasting for sowing seeds in the field. On the other hand, only 20 % conventional farmers and 8% direct seeded famers adopt drill method when seed planted in conventional and direct seeded fields.

Table 9: Rice management Differential on Conventional and Direct seeded field:

Particulars	Conventional Rice Field		Direct Seeded field		Overall	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Use of Nitrogen(kg per acre)	51	18.51	55.32	16.73	53	17.57
Use of Phosphorus(kg per acre)	39	15.49	26.61	11.59	32.81	18.18
Use of Potash (Kg per acre)	22.73	10.93	13.00	6.59	17.63	13.24
Use of NPK (Per acre)	4.6644	0.37889	4.47	0.4149	4.5686	0.4081

FYM applied (per acre)	4.22	0.4318	3.83	1.297 5	4.02	0.9844
Weedicide cost (Per acre)	648.63	284.32	1581.43	528.6 3	1115.03	630.07
Insecticide cost (per acre)	2133.3 3	354.58	2045.33	515.4 7	2089.33	443.85
Pesticide cost (per acre)	884.00	338.39	1700	245.7 7	1292	504.16
Total number of Ploughing (per Acre)	4.90	1.8729	3.63	1.97	4.27	2.02
Total number of irrigation (per acre)	33	22.02	17.37	5.77	19.69	6.05

Table 9 shows the rice management discrepancies when rice planted in conventional and direct seeded fields. NPK ratio, FYM, Weedicide cost, Insecticide cost, Pesticide cost, number of ploughing and number of irrigation all these factors would play a positive and significant role on rice yield.[Alam *et al.*, (2011),Abedullah *et al.*,(2007), Chaudhary *et al.*, (2002), Dhungana *et al.*, (2004), Krasachat (2003)].

Table 9 results reveal that on average the quantity of nitrogen applied on conventional rice field is 51 kg per acre and on average approximately 55 kg/per acre applied in direct seeded rice field. In case of Phosphorus on average 39 kg/per acre applied on conventional rice field and approximately on average 26 kg/per acre applied on direct seeded rice field. In case of Potash on average approximately 22 kg/per acre applied in conventional rice field and on average 13 kg per acre applied in direct seeded field respectively.

Usage of NPK ratio on conventional and direct seeded rice field is 4.66 and 4.47 respectively. Though, there is small variation in Nitrogen, Phosphorus, and Potash and NPK magnitude when rice planted in conventional and direct seeded rice field. Application of Farm yard Manure (FYM) on average in conventional rice field are 4.22 kg per acre and on average 3.83 in direct seeded rice field.

Weeds are the major problem of study area. Use of weedicide spray is the common method exercise by the farmers to control weeds. According to survey results weeds problem are major facing by direct seeded rice farmers as compare to conventional rice farmers. The results shows that approximately 648 Rs/per acre weedicide cost facing conventional rice farmers and 1581 Rs/per acre weedicide cost facing direct seeded rice farmers in the study area. Almost 933 Rs/per acre additional cost facing by the direct seeded farmers as compared to conventional rice farmers. Furthermore, pesticide is also the major problem of study area. Conventional farmers on average facing pesticides cost 884 Rs per acre and direct seeded farmers bearing 1700 Rs/per acre respectively. Approximately Rs 816 per acre additional cost facing by direct seeded rice farmers as compared to conventional rice farmers.

In case of insecticide approximately 2133 Rs/per acre insecticide cost facing the conventional rice farmers and 2045 Rs/per acre cost facing the direct seeded rice farmers. Consequently, there is small variation in insecticide cost on both conventional and direct seeded field. In case of conventional rice field on average total number of ploughings is 4.90. In comparison, an average of 3.63 ploughings is done in Direct seeded rice field. Hence, total number of ploughings in conventional and direct seeded field is slightly varied.

Total number of irrigation given to rice in the study area are varied largely; in case of conventional rice field average number of irrigation is approximately 33 and 17 number of irrigation on direct seeded field. Consequently, conventional rice field required 16 more numbers of irrigation as compare to direct seeded rice field. The reason behind that under conventional technique more water required for rice crop as compare to direct seeded rice field.

Table: 10 Labor cost per acre on Conventional and direct seeded rice field:

Particulars	Conventional Rice field	Direct seeded Rice field
Labor hour per acre (Average)	38.44	19.21
Standard Deviation	7.61	3.93
Labor cost per acre (Average)	7414.33	1941.33
Standard Deviation	596.58	431.04

Table 10 represents the labor cost per acre which is facing the farmers of conventional and direct seeded rice field. The survey results shows that on average labor hour required in conventional rice field is

38.44 and on average 19.21 in direct seeded field. So, in conventional rice field required 19 more labor hours as compare to direct seeded rice field. As a result conventional rice farmers face more labor cost as compare to direct seeded rice farmers. Conventional rice farmer's face labor cost on average approximately 7414 Rs/ per acre and 1941 Rs/per acre direct seeded farmers. This is due to transplantation of rice under conventional rice field. As a result, on conventional rice field required more labor hour for transplantation of rice plants. So, conventional farmers face additional labor cost as compared to direct seeded field because direct seeded field there is no need for transplantation of rice plants. According to Alam *et al.*, (2011) labor is the major determinant of rice production. On the other hand, Abdulai *et al.*, (2013) said that rice is a labor intensive crop and labor hour have a significant positive impact on rice yield.

Table: 11: Wheat sowing dates stretch on sample farms:

Wheat planting dates	Conventional Rice field	Direct seeded field	Over all
Before 15^{th} November	5	7	12
(%)	3.33	4.67	4
15 to 30^{th} November	23	143	166
(%)	15.33	95.33	55.33
Above 30^{th} November	122	0	122
(%)	81.33	0	40.67

Table 11 represents that in this study area 3.33% farmers planted wheat on conventional rice field before 15^{th} November and 4.67% farmers on direct seeded field. 15.33% conventional farmers and 95.33% direct seeded farmers planted wheat between 15 to 30^{th} November respectively. Only 81.33% conventional farmers planted wheat in December.

Studied conducted Chaudhary *et al.*, (2002) shows that November planting produce higher wheat yield. Mushtaq and Saleem (2010) concluded that the best time of plantation of wheat is early November when wheat sowing after November 25 result in lower yield reduction 15 kg per acre. Consequently, 100% direct seeded farmers planted wheat in November. Although, our results conclude that only 18.66 % conventional farmers planted wheat in November and around 81.33 percent conventional farmers sowing wheat in December.

Table 12: Impact on wheat crop:

Particulars (Per Acre)	**Conventional Rice field**	**Direct seeded field**
Planking # (Average)	5	3
Manure # (Average)	6	4
Ploughing # (Average)	3	2

Table 12 shows the impact of wheat crop on conventional and direct seeded field. The survey results explain that conventional farmers on average total 5 number of planking per acre use for the preparation of land for wheat planting in conventional field. On the other hand, direct seeded farmers use total 3 number of planking in direct seeded field for the preparation of land for wheat planting.

Moreover, table results reveal that conventional farmers use total 6 Farm yard manure trolleys per acre in conventional rice field for wheat plantation whereas, total 4 FYM trolleys per acre use direct seeded farmers in direct seeded field.

On the other hand, Conventional farmers' uses total 3 numbers of ploughings in conventional rice field for wheat planting and total 2 ploughings per acre uses in direct seeded field for wheat planting. On the whole survey results explains that wheat planting in conventional rice field require more number of planking, FYM and ploughing as compare to direct seeded rice field.

Table 13: Rice-wheat Yield:

Rice –wheat yield per acre on conventional and direct seeded field:

Particulars	**Conventional rice field**		**Direct seeded rice field**		**Over all**	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**
Rice Yield per acre(Maunds)	42.76	8.73	45.56	11.93	43.64	10.48
Wheat yield Per acre (Maunds)	39.42	7.67	42.86	6.238	41.14	7.194

Table 13 demonstrates that Rice-Wheat yield per acre on Conventional rice and direct seeded rice field. First part of the table represents the conventional and direct seeded rice yield per acre in kharif season. Conventional rice field per acre is an approximately 43 Maunds. On the other hand direct seeded field rice yield per acre is an approximately 46 Maunds. On the whole, direct seeded farmers achieve 3 Maunds greater rice yield as compare to conventional farmers.

The next part of table explains that wheat yield per acre on conventional and direct seeded field in Rabi cycle. The table results explains that on average wheat yield for the conventional rice field is just about 40 Manuds per acre and approximately 43 Manuds on direct seeded field. The results clearly show that 3 Maunds wheat yield differential per acre in between Conventional and direct seeded rice field.

There are following factors responsible for distinction between wheat yield in Conventional and Direct seeded field like as: This study reveals that approximately all Direct seeded farmers after cultivation of rice planted wheat in November. On the other hand, large part of Conventional farmers after cultivation of rice planted wheat in December. As a result, due to late plantation of wheat Conventional farmers received lower yield. The several studies Bashir and khan, (2005) suggest that best time for the plantation of wheat is November. While, wheat planted after November wheat yield reduces 15 kg per acre. This late planting factor is also affecting the soil fertility and land preparation.

The table results reveal that Direct seeded farmers receive rice yield 4 mounds more as compared to conventional farmers. Conventional farmers uses traditional method for the cultivation of rice so it may receive lower yield with higher cost of rice output as compare to direct seeded famers. In addition, large number of conventional farmers in this study area achieve lower rice yield as compare to direct seeded farmers. After taking the results it is expected that conventional farmers next kharif cycle may be used new technology direct seeded method for the cultivation of rice.

IV-1: II. Gross Margin analysis of Conventional and Direct Seeded Rice:

Table 14: Gross Margin analysis of conventional Rice:

Inputs	Unit	Quantity	Price	Value
Leaser leveler	Rs	1	2100	2100
Motivator	Rs	1	2000	2000
Ploughing	Rs	4 to 5	656	3280
Planking	Rs	1 to 2	597	1194
Tractor	Rs	1	2000	2000
Seed	Cost	5 to 6 kg	96	576
Urea	Price per 50kg/ bag	1 to2	1800	3200
DAP	Price per 50kg/ bag	1 to 2	3800	7600
FYM	Rs/per ton	4 to 5	1200	6000
Weedicide	Cost	2 to 3 liter	648	1944
Insecticide	Cost	2 to 3 liter	2100	6300
Pesticide	Cost	2 to 3 liter	884	1768
Irrigation	#	22	1400	30800
Total variable cost				**70762**
Price of Rice straw	Rs			8820
Price of rice output	Rs			81389.943
Gross Margin Effect				**20001.00**

Table 15: Gross Margin analysis of Direct seeded rice:

Inputs	Unit	Quantity	Price	Value
Leaser leveler	Rs	1	2100	2100
Rotavator	Rs	1	2000	2000
Ploughing	Rs	3 to 4	660	2640
Planking	Rs	1 to 2	564	1128
Tractor	Rs	1	1750	1750
Seed	Cost	15 to 16 kg	90	1440
Urea	Price per 50kg/ bag	2	1800	3600
DAP	Price per 50kg/ bag	1 to 2	3800	7600
FYM	Rs/per trolley	4 to 5	1200	6000
Weedicide	Cost	5 to 6 liter	1600	9600
Insecticide	Cost	2 liter	2045	4090
Pesticide	Cost	3 to 4 liter	1700	6800
Irrigation	#	15	1200	18000
Total variable cost				**66748**
Price of Rice straw	Rs			9112
Price of rice output	Rs			88043.09
Gross Margin Effect				**30407.09**

The gross Margin analysis of Rice production on Conventional and Direct seeded field are represented in table 14 and 15 respectively. On average Gross Margin of rice on Conventional rice field is Rs.20001.00 and on Direct seeded field is Rs.30407.09. This represents a broad variation among gross margin of Rice on conventional and direct seeded fields. The reasons behind that in direct seeded rice field required less number of irrigation hour and more kg seeds as compare to conventional rice field. Direct seeded rice fields received higher yield by using better land preparation and by properly managing weedicide and insecticides problems as compared to Conventional rice fields. It shows a potential yield in rice productivity, on direct seeded fields is higher for farmers of study area as compared to conventional rice fields.

Chapter IV-II

Results and Discussion

IV. Empirical Analysis:

In frontier 4.1 by (Collie 1996) the Translog production frontier function and the inefficiency model are together estimated by the maximum likelihood (MLE) method.

IV- II. i. Hypothesis Testing:

In order to choose the type of production function that best fit our data set test the null Hypothesis $H0: \sum\beta ij = 1$, whether, the sum of elasticities in Cobb Douglas production function have constant return to scale. Hence, for the selection of production function that best reliable to our data set author estimated both cobb-Douglas and translog production functions. The value of log likelihood function for Cobb Douglas and translog production functions are 16.47 and 51.33. By employing the log Likelihood ratio test $[\chi^2 = -2*(16.47-51.33)] = 69.72$. This χ^2 calculated value is compare with the tabulated value $\chi^2_{(22,\ 0.05)} = 33.924$. The null hypothesis is rejected as the calculated value is greater than tabulated value. Therefore, the test results show that in present model there is no constant return to scale so the flexible functional form based on translog is used in present study.

Similarly, to select the type of cost function that adequately represents our data set we test the null hypothesis: $H0: \sum \beta jk = 1$, i.e The sum of elasticities in Cobb Douglas cost function has constant return to scale. For this purpose author estimated both cobb-Douglas and Translog cost function. The value of log likelihood function for both Cobb Douglas and Translog cost functions are find - 20.54 and 41.48 respectively. By using the log likelihood ratio test [χ^2 = -2(-(20.54)-(41.48)] = 41.88. This χ^2 calculated value is compare with the tabulated value $\chi^2_{(23,\ 0.05)}$ = 35.172. The test result reveals that χ^2 calculated value is greater than its tabulated value. Hence, the null hypothesis coefficient of Cobb Douglas cost function has constant return to scale is rejected. Therefore, the test results show that in present model there is no constant return to scale so the flexible functional form based on translog is used in present study.

Table 16: <u>Hypothesis Testing:</u>

Testing of Hypothesis				
Hypothesis	**Log Likelihood Function**	**Test Statistics χ^2**	**Critical Value $\chi^2_{(0.05)}$**	**Decision**
$H_0=\gamma=\delta_0$ - - - - - - - - $\delta_{11}=0$	51.33	27.36	21.02	Rejected
$H_0= \delta_1= \delta_2$............ $\delta_{11}= 0$	48.79	64.72	19.68	Rejected
$H_0=\gamma=\delta_0$- - - - - - - - - $\delta_{11}=0$	41.48	64.01	21.02	Rejected
$H_0= \delta_{1,}=\delta_2$............ $\delta_{11}= 0$	34.98	45.20	19.68	Rejected

The first null Hypothesis that is tested states that technical inefficiency effects are not present in the production frontier model. It means that stochastic production frontier is not different than the traditional average production function. It should be renowned that OLS fit and log likelihood function for the full stochastic production frontier model is calculated to be 37.65 and 51.33 respectively. This implies that the generalized likelihood-ratio statistic (χ^2) for testing the absence of technical inefficiency effect from the frontier is calculated to be χ^2 = 27.36. This value is estimated by the Frontier 4.1. The degree of freedom is equal to the number of restrictions in null hypothesis. The value of "χ^2" test is significant because it exceeds from the tabulated value. The log likelihood ratio test represents that inefficiency exists in the data set. Therefore, null hypothesis of no technical inefficiency in rice production is rejected. It means that technical inefficiency effect exists in the data set.

The second null hypothesis of this study tested $H_0 = \delta_1 = \delta_2 = - - - - - - \delta_{11}$ implying that the farm level technical inefficiencies are not affected by the independent variables which is included in the production model. The results provide a likelihood ratio test statistics of 64.72, which is greater than the critical value. Thus, this hypothesis is also rejected.

The third null hypothesis states that allocative inefficiency effects are not present in the cost frontier model. The OLS fit and Maximum likelihood function for the full stochastic cost frontier model are calculated to be χ^2 = 64.01.This value is estimated by the Frontier 4.1. The degree of freedom is equal to the number of restrictions in null hypothesis. The test static value of "χ^2" is greater than tabulated value. Hence, the test represents that inefficiency exists in the data set. Therefore, null hypothesis of no allocative inefficiency in rice cost function is rejected.

The fourth null hypothesis state that farm level allocative inefficiencies are not affected the explanatory variable that is included in the model. This provides a likelihood ratio test statistics (χ^2) is 45.20, which is larger than the critical value. Thus, this hypothesis is also rejected.

Production Frontier and technical efficiency estimates:

Table 17 shows the result of both OLS and MLE estimates. In total 90 parameters are estimated in stochastic production frontier model including 77 in stochastic frontier model and 11 in the inefficiency model. The other two variables sigma square and gamma relate to variances of the random variables and technical inefficiency, V_i and U_i. In this study, observed that the estimated value of γ is 91.09 and it is statistically significant at one percent level. However, it reveals that 91 percent variation in output is due to technical inefficiency. This means that stochastic frontier model is significantly different from deterministic frontier, which does not include random error. This result is consistent with those reported by Coelli and Battese, (1996) Wadud and White,

(2000) Sharma *et al.*, (1999), Abedullah *et al.*, (2007). The value of sigma-square is observed that 24.15 and significant at 1 percent level indicating the accuracy of the specified assumptions of the distribution of the composite error. Here, all 90 variables are statistically significant in this study.

IV- II. ii. Production Frontier and Technical Efficiency Estimates:

Table 17: OLS and Maximum Likelihood Estimation of the Translog Stochastic Production Frontier:

		OLS		Frontier Function	
Variables	**Parameter**	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Stochastic Production Frontier					
Constant	β_0	77.61***	31.04	48.31***	5.77
Ln(Conventional Rice/Direct seeded Rice)	β_1	21.49***	15.68	24.13***	27.20
Ln(Area under rice crop)	β2	24.73***	18.64	43.22***	5.07
Ln(NPK Ratio per Acre)	β3	-12.67***	-10.74	-13.71***	-14.87
Ln(Seed use per acre/kg)	β4	22.33***	10.13	21.54***	25.65
Ln(Irrigation hour per acre)	β5	84.26***	5.34	31.82***	24.21
Ln (Weedicide liters per acre)	β6	21.58***	3.29	15.64***	15.04
Ln(Labor hour per acre)	β7	31.03***	10.51	98.31***	10.71
Ln(Total tractor hour for land preparation)	β8	-10.07***	-3.60	-10.94*	-1.85
Ln (Farm Yard Manure)	β9	-28.48***	-15.96	-11.21***	-10.41
Ln(Insecticide)	β10	12.79***	13.51	10.36***	21.20
Ln(Pesticide)	β11	-78.85***	-17.25	-69.83***	-8.60
0.5*Ln(Conventional/Direct seeded rice)^2	β12	19.68***	15.13	17.96***	8.35
0.5*ln(Area under rice crop)^2	β13	14.01***	5.40	23.67***	3.23
0.5*ln(NPK Ratio)^2	β14	-29.96*	-1.84	-24.59**	-2.11
0.5*ln(Seed)^2	β15	45.97***	23.53	30.97***	6.71
0.5*ln(Irrigation)^2	β16	16.21***	25.27	23.88***	14.03
0.5*ln(weedicide)^2	β17	30.66*	1.91	11.90***	7.37
0.5*ln(Labor hour)^2	β18	13.96**	2.08	19.11***	9.16
0.5*ln(Tractor Hour for land preparation)^2	β19	-10.60***	-3.41	-10.65***	-10.44
0.5*ln(Farm Yard Manure)^2	β20	-95.13***	-7.27	-39.46***	-5.10
0.5*ln(Insecticide)^2	β21	-49.10***	-10.98	-15.23***	-13.96
0.5*ln(Pesticide)^2	β22	-16.56***	-8.50	-16.57***	-11.26

Ln(Dummy Conventional rice/Direct seeded rice*Area Under Rice Crop)	β23	22.25***	6.80	35.14***	15.72
Ln(Dummy Conventional rice/Direct seeded rice*NPK Ratio)	β24	31.04***	11.98	20.17***	10.80
Ln(Dummy Conventional rice/Direct seeded rice*Seed)	β25	66.33***	12.32	62.15***	15.43
Ln(Dummy Conventional rice/Direct seeded rice*Irrigation hour)	β26	27.68***	10.23	13.31***	6.65
Ln(Dummy Conventional rice/Direct seeded rice*weedicide)	β27	62.56***	12.34	46.57***	14.10
Ln(Dummy Conventional rice/Direct seeded rice*Labor Hour)	β28	34.96***	11.87	50.07***	12.17
Ln(Dummy Conventional rice/Direct seeded rice*Tractor Hour)	β29	58.51***	12.76	57.18***	15.93
Ln(Dummy Conventional rice/Direct seeded rice*FYM)	β30	32.19***	30.73	32.20***	20.53
Ln(Dummy Conventional rice/Direct seeded rice*Insecticide)	β31	-28.80***	-3.49	-25.47***	-11.37
Ln(Dummy Conventional rice/Direct seeded rice*Pesticide)	β32	79.79***	25.17	77.85***	31.37
Ln(Area under rice crop*NPK Ratio)	β33	24.04***	10.12	37.20***	23.21
Ln(Area under rice crop*seed)	β34	61.07***	7.23	84.06***	12.63
Ln(Area under rice crop*Irrigation)	β35	20.01***	16.94	18.41***	18.69
Ln(Area under rice crop*weedicide)	β36	52.76***	8.14	41.63***	-11.03
Ln(Area under rice crop*labor hour)	β37	78.34**	2.12	38.88***	-27.46
Ln(Area under rice crop*tractor hour)	β38	24.58***	4.91	38.05***	-19.23
Ln(Area under rice crop*FYM)	B39	46.43***	5.43	30.00***	13.24
Ln(Area under rice crop*insecticide)	β40	-14.80***	-2.68	-15.79***	-17.04
Ln(Area under rice crop*Pesticide)	β41	77.78***	8.19	10.36***	11.54
Ln(NPK Ratio*Seed)	β42	17.05**	2.10	13.87***	10.43

Ln(NPK Ratio*Irrigation hour)	β43	26.50***	5.45	35.76***	5.90
Ln(NPK Ratio*Weedicide)	β44	58.24***	8.19	16.01***	15.93
Ln(NPK Ratio*Labor hour)	β45	17.05***	3.17	29.14***	19.43
Ln(NPK Ratio*Tractor hour)	β46	64.16***	10.12	94.44***	21.82
Ln(NPK Ratio*FYM)	β47	24.97***	5.66	45.93***	12.88
Ln(NPK Ratio*Insecticide)	β48	-97.14***	-0.77	-10.43***	-20.76
Ln(NPK Ratio*Pesticide)	β49	14.20***	9.11	28.04***	26.00
Ln(Seed*Irrigation Hour)	β50	17.37***	6.04	68.61***	24.30
Ln(Seed*Weedicide)	β51	82.79***	4.16	51.65***	8.21
Ln(Seed*Labor Hour)	β52	36.21***	3.57	20.33***	10.53
Ln(Seed*Tractor Hour)	β53	34.91***	10.67	22.38***	9.37
Ln(Seed*FYM)	β54	28.16***	3.90	56.53***	13.41
Ln(Seed*Insecticide)	β55	-25.45***	-11.46	-32.01***	-18.45
Ln(Seed*Pesticide)	β56	71.68***	8.76	45.49***	8.86
Ln(Irrigation hour*Weedicide)	β57	19.95***	13.02	62.35***	2.60
Ln(Irrigation*Labor Hour)	β58	22.63***	9.66	27.29***	13.78
Ln(Irrigation*Total Tractor Hour)	β59	19.86***	26.61	47.80***	10.57
Ln(Irrigation*FYM)	β60	10.62***	18.51	11.65***	9.17
Ln(Irrigation*insecticide)	β61	-29.26***	-12.74	-13.39***	-2.60
Ln(Irrigation*Pesticide)	β62	55.71***	16.98	53.40***	1.96
Ln (weedicide*Labor Hour)	β63	16.65***	2.02	58.06***	35.60
Ln(Weedicide*Tractor Hour)	β64	14.17***	11.37	55.39***	6.64
Ln(Weedicide*FYM)	β65	77.73***	19.02	17.83***	6.79
Ln(Weedicide*Insecticide)	β66	11.88***	6.59	83.16***	7.24
Ln(Weedicide*Pesticide)	β67	61.68***	46.60	29.01**	2.15
Ln(Labor Hour*tractor hour)	β68	14.80***	4.60	19.95***	11.03
Ln(Labor Hour*FYM)	β69	18.98***	19.52	47.07***	10.16
Ln(Labor hour*Insecticide)	β70	13.10***	34.20	31.34***	11.51
Ln(Labor hour*Pesticide)	β71	17.93***	7.34	23.26***	12.02
Ln(Tractor hour*FYM)	β72	17.69***	3.10	43.28***	13.87
Ln(Tractor Hour*Insecticide)	β73	19.34***	13.90	12.20***	12.21
Ln(Tractor hour*Pesticide)	β74	47.67***	15.70	47.73***	20.23
Ln(FYM*Insecticde)	β75	15.83***	2.51	15.41***	26.56
Ln(FYM*Pesticide)	β76	89.70***	17.01	50.51***	13.37
Ln(Insecticide*Pesticide)	β77	10.66***	2.58	14.04***	8.96
Variance Parameters					
Sigma Square	δ^2			24.15***	29.63
Gamma	γ			91.09***	25.06
Log Likelihood Function		**37.65**		**51.33**	

***:1% significance, **: 5% significance,*: 10% significance

To observe the effects of sowing methods on rice productivity whether, rice is planted under conventional method or direct seeded method. This study use dummy variable in the rice production, explain that one if famer use direct seeded technique for rice sowing and zero is used if farmer use conventional technique for rice sowing. The estimated parameter of rice under conventional or direct seeded method is positively and statistically significant at 1 percent level. The result shows that rice production per acre increases significantly when rice planted through direct seeded method. The major cause for this result is Direct seeded rice farmers received higher yield per acre by using better land preparation and by properly managing weedicide problems as compared to Conventional rice farmers.

Area under rice crop is another important factor of rice production. The result reveals that Coefficient of Area under rice is positive and statistically significant at 1 percent level. This result shows that, an increase in the area under rice crop would significantly lead to increase rice yield. Similar results are acquired by (Abedullah and Mushtaq, 2010); (Nimoh *et al.*, 2012); (Bakash *et al.*, 2004) along with Pakistani rice and wheat farmers and Sri Lanka tea small holders respectively.

The parameter NPK ratio is an important factor for rice productivity. The results reveal that coefficient of NPK ratio is negative and statistically significant at 1 percent level. It is clearly demonstrate that farmers use improper combination of different nutrients. However, total amount of fertilizer (NPK) being used is less than the recommended level and therefore, negative coefficient of NPK cannot be refer to higher use of fertilizer as usually argue rather coefficient of NPK in our case is negative because of improper combination of NPK. The improper combination of NPK will not only affect the productivity of soil but it can also affect the quality of ground water in the long run. (Nguyen and Giang, 2000); (Lathrop *et al.*, 2003); (Abedullah *et al.*, (2007) found negative relationship between Fertilizer use and rice output in Punjab rice study. On the other hand, Erhabor and Ahmadu, (2012) also found negative relationship between fertilizer and rice of output in Nigerian rice study.

The estimated coefficient of seed variable is positively and statistically significant at 1 percent level. The results demonstrate that there is a positive associative between seed use and rice output. Increased in seed usage as a result increases rice yield. The same results are acquired by [(Islam *et al.*, 2005); (Ahmadu and Erhabor, 2012); (Idiong, 2007); Myint and Kyi, 2005)].

The irrigation variable is an important factor for rice productivity. The estimated results demonstrate that the coefficient of irrigation variable is positively and highly significant at 1 percent level. The coefficient of irrigation hours reveal that output of rice might be increased further by increasing the availability of irrigation water in the study area. It is consistent with other studies (Ali and Flinn, 1989); (Castillo *et al.*, 1983) which demonstrate that rice is a water intensive crop and required comparatively more water than other crops.

The estimated variable usage of weedicide is positively and highly significant at 1 percent level. This implies that, as farmer use more weedicide spray it would lead to increase the rice productivity positively. This result is according to our expectation because growth of weeds tends to reduce rice yield. So farmers of study area very much conscious about weeds effects on rice production. The result is in line with [(Bakash *et al.*, 2006); (Hassan, 2005); (Abedullah *et al.*, 2010); Chaudary *et al.*, 2002)].

The estimated coefficient labor hour is positive and highly significant at 1 percent level. This result is according to our expectation implies that increase in labor hour would lead to increase rice output. This is, however, contradictory to the general phenomenon of the existence of surplus labor in agriculture sector of Pakistan. The same results is acquired by [Ahmadu and Erhabor 2012); (Abedullah *et al.*, 2007); (Akintola *et al.*, 2009); (Desilva, 2005)].

The coefficient of tractor hours for land preparation is negatively significant at 10 percent level but it is not clear that why it is so. The coefficient of tractor is 0.1094 with negative sign implies that by increasing one percent of tractor hour, the yield decline by 10.94 percent. Abedullah *et al.*, (2010) found negative relationship between tractor hour and rice yield in Punjab study area. Whereas, Singh *et al.*, (2013) and Backman *et al.*, (2011) found positive association between tractor hour and rice yield in the study area of Nepal and Bangladesh.

The estimated coefficient of Farm yard Manure is negative and statistically significant at 1 percent level. However, it exhibits negative impact on productivity. Manure is the traditional fertilizer and largely used by farmers in Punjab areas because of its easy accessibility and low cost. However, the result indicates that excess use of manures have negative impact on rice yield. The same results found (Akond and Dutta, 2013); (Myint and Kyi, 2005).While, Rehman *et al.*, (2012) found positive association between manure and rice yield.

The coefficient of pesticide use is negative and statistically significant at 1 percent level in this study. This implies that excessive use of pesticide will lead to reduce rice output. It might be due to the fact that due to heavy pest infestation has occurred which is making the spray ineffective. It is consistent with other studies Nimoh *et al.*, (2012), on the other hand, Onoja and Achike (2010) and Hidayah and Susanto (2013) found positive relationship between Pesticide use and rice output in Nigeria and Indonesian rice studies.

The estimated coefficient of insecticide variable is positively significant at 1 percent level in the study area. The value of insecticide coefficient is 10.36 which imply that as one percent increase in insecticide usage as a result increases rice output by 10.36 percent. The result is in line with [(Tiamiyu *et al.*, 2009); (Hidayah and Susanto, 2013); (Mia *et al.*, 2012)].

Some of the square terms in Translog production model is statistically significant with some having negative and other having positive signs. The square terms of NPK ratio, tractor hour and pesticide, FYM are statistically significant at 1 and 5 percent level and maintaining a negative sign both at initial and later stages. It means that as continue to increases NPK ratio, tractor hour, pesticide and FYM lead to decreases rice output both at initial and later stages.

On the other hand, area under rice crop, seeds, weedicides and dummy variable Con/Direct seeded rice sowing, irrigation hour and labor hour are significant and maintaining a positive sign in both stages. It means that as continue to increases area under rice crop, seed, weedicide , direct seeded sowing method, irrigation hour and labor hour lead to increase rice output both at initial and later stages.

The estimated coefficient insecticide has positive sign at the initial stage, while on the second stage insecticide variable is statistically significant with negative sign. It means that an increase in insecticide lead to increase rice output at initial stage but at later stage rice output decreases as continue to increases.

In this study two interaction term for the translog production frontier model are statistically significant with some having positive and other have negative signs. The negative value of cross terms indicates a substitute relationship between two inputs. In addition, the positive value reflects that complementary relationship exists between two inputs. It is observed that Conventional/Direct seeded rice and Area under rice, Conventional /Direct seeded rice and NPK, Conventional/Direct seeded rice and seed, Irrigation hour, labor hour, weedicide, tractor hour, Farm yard manure and pesticide is significant at 1 percent level with positive signs. The result implies that conventional/Direct seeded rice have a complementary relationships with area under rice crop, NPK ratio, seed, Irrigation hour, weedicide, labor hour, tractor hour, FYM and Pesticide. It shows that these combinations have a positive effect on rice output.

However, Conventional/Direct seeded rice and insecticide is statistically significant with negative sign. It implies that Conventional/Direct seeded rice has a substitutive relationship with insecticides. It reflects that this combination has a negative effect on rice output.

Area under rice crop and NPK ratio, Area under rice crop and irrigation hour, Area under rice crop and weedicide, Area under rice crop and labor hour, Area under rice crop and Tractor hour, Area under rice crop and FYM and Area under rice crop and seeds, Area under rice crop and pesticides is statistically significant at 1 percent level with positive signs. This implies that Area under rice crop have a complementary relationship with NPK ratio, seed, Irrigation hour, weedicide, labor hour, Tractor hour and Farm yard manure and pesticide. These combinations have a positive effect on rice output. While, Area under rice crop and insecticides is statistically significant at 1 percent level with negative sign. It implies that Area under rice crop has a substitutive relationship with insecticides. This combination has a negative effect on rice output.

In addition, NPK ratio and seed, NPK ratio and irrigation hour, NPK ratio and weedicides, labor hour, tractor hour, FYM and pesticides are highly significant with positive signs. It means that NPK ratio have a complementary relationships with seed, irrigation hour, weedicides, labor hour, tractor hour, FYM and pesticides. These combinations have a positive effect on rice output. On the other hand, NPK ratio and insecticide is highly significant at 1 percent level with negative sign. It indicates that insecticide variable has a substitutive relationship with rice output. On the other hand, this combination has a negative effect on rice outputs.

The estimated cross term of Seed and irrigation hour, seed and labor hour, seed and tractor hour, seed and weedicide, seed and FYM ,seed and pesticides are statistically significant at 1 percent level with positive signs implies that seed have a complementary relationships with irrigation hour, weedicide, labor hour, tractor hour and FYM and pesticides. These combinations have a positive impact on rice output. However, Seed and insecticide are significant at 1 percent level with negative sign which indicates that seed has a substitutive relationship with insecticide. This combination has a negative impact on rice output.

The other estimated cross terms of Irrigation hour and insecticide is statistically significant at 1 percent level with negative sign. It implies that Irrigation is a substitute to insecticides. The estimated coefficients of Irrigation hour and Farm yard manure, labor hour, tractor hour, weedicides and pesticide are statistically significant at 1 percent level with positive signs indicates that irrigation is a complementary to farm yard manure, labor hour, tractor hour and weedicides and pesticides.

On the other hand, weedicide and labor hour, Weedicide and tractor hour, Weedicide and FYM, insecticides and pesticides is statistically significant at 1 and 5 percent level with positive signs. It reveals that weedicides is a complementary to labor hour, tractor hour, FYM, insecticide and pesticide.

The estimated coefficient of labor hour and tractor hour, labor hour and Farm yard manure, insecticide and pesticide is highly significant with positive signs. The result reveals that Labor hour is a complementary to tractor hour, FYM, insecticide and pesticide.

The estimated parameter of farm yard manure and insecticides, FYM and pesticide are statistically significant at 1 percent level with positive signs. This positive sign shows that input variable farm yard manure have a complementary relationship with insecticides and pesticides.

The estimated variable insecticide and pesticide are highly significant with positive sign indicates that insecticide is a complementary to pesticide.

IV-II. iii <u>Cost Frontier and Allocative Efficiency Estimates:</u>

Table 18 shows the result of both the OLS and MLE estimates. In total 90 parameters are estimated in the stochastic cost frontier model including 77 in the stochastic cost frontier model and 11 in the inefficiency model and remaining two parameters sigma squared and gamma relate to variances of the random variables. The estimates of γ is 0.98 and it is statistically significant at the one percent level (Table 18).This implies that about 98 percent variation in the total rice production cost are due to difference in their cost efficiencies. Out of 90 parameters are estimated out of which 89 variables are statistically significant.

Table 18: OLS and Maximum likelihood estimates of Translog Stochastic Cost Frontier:

		OLS		Frontier Function	
Variables	Parameters	Coefficient	t-ratio	Coefficient	t-ratio
Stochastic Cost Frontier					
Constant	β_0	32.21**	2.48	86.56***	9.64
Ln(Pesticide Cost)	β1	10.18***	2.576	26.15***	15.57
Ln(Seed Cost)	β2	66.00***	29.22	19.15***	3.58
Ln(Fertilizer Cost)	β3	20.02***	13.67	38.21***	71.18
Ln(Land Preparation cost)	β4	-15.54***	-3.064	-10.49***	-14.20
Ln (Irrigation cost)	β5	11.66***	5.010	70.29**	2.37
Ln(Farm Yard Manure Cost)	β6	32.61***	33.86	15.94*	1.78
Ln(Weedicide Cost)	β7	11.29***	4.064	24.71***	23.45
Ln (Insecticide Cost)	β8	-55.03^{ns}	-2.41	-41.34^{ns}	-2.84
Ln(Harvesting Cost)	β9	22.45***	25.40	73.58***	-1.87
Ln(Labor Cost)	β10	78.53***	14.38	63.23***	-14.23
Ln(Rice Output)	β11	22.21***	30.01	47.92***	37.00
0.5*ln(Pesticide cost)^2	β12	40.84***	2.236	18.57***	22.47
0.5*ln(Seed cost)^2	β13	45.11***	22.34	13.64***	14.99
0.5*ln(Fertilizer cost)^2	β14	39.88***	27.24	12.95***	14.81
0.5*ln(Land Preparation cost)^2	β15	-46.00***	-3.076	-23.27**	-2.07
0.5*ln(cost of irrigation)^2	β16	17.80***	4.07	15.03***	11.44
0.5*ln(Farm Yard Manure cost)^2	β17	36.68***	8.10	60.59***	6.11
0.5*ln(weedicide cost)^2	β18	18.70***	4.236	16.82***	21.78
0.5*ln(insecticide cost)^2	β19	86.78***	3.02	10.71***	13.04
0.5*ln(Harvesting cost)^2	β20	50.78***	5.81	73.78***	3.41
0.5*ln(Labor cost)^2	β21	36.73***	7.43	59.83***	7.10
0.5*ln(Rice output)^2	β22	13.82***	7.30	15.91***	3.35
Ln(Pesticide cost*seed cost)	β23	26.03**	6.31	51.13***	17.34
Ln(Pesticide cost*Fertilizer Cost)	β24	17.58***	11.10	63.54***	8.76
Ln(Pesticide cost*Land preparation cost)	β25	58.19***	28.17	26.89***	20.73
Ln(Pesticide cost*	β26	31.23***	26.53	28.87***	4.90

Irrigation cost)					
Ln(Pesticide cost*FYM cost)	β27	10.54***	15.97	20.98***	24.12
Ln(Pesticide cost*weedicide cost)	β28	16.02***	19.40	14.63***	16.64
Ln(Pesticide cost*Insecticide cost)	β29	52.47***	16.21	10.42***	18.63
Ln(Pesticide cost*harvesting cost)	β30	71.60***	13.57	30.27***	5.98
Ln(Pesticide cost*Labor cost)	β31	29.53***	13.10	68.97***	3.44
Ln(Pesticide cost*Rice output)	β32	83.60***	26.67	16.11***	5.05
Ln(seed cost*Fertilizer cost)	β33	10.51***	15.52	34.47***	4.27
Ln(Seed cost*Land Preparation cost)	β34	19.00***	18.47	30.98***	4.32
Ln(Seed cost* irrigation cost)	β35	33.98***	12.30	12.82***	21.10
Ln(Seed cost* FYM cost)	β36	94.74***	19.05	17.68***	7.66
Ln(Seed cost*Weedicide cost)	β37	51.27***	7.37	14.19***	19.88
Ln(Seed cost*Insecticide cost)	β38	34.06***	22.64	36.80**	2.27
Ln(seed cost*Harvesting cost)	β39	19.47***	17.19	16.09***	7.32
Ln(seed cost*Labor cost)	β40	25.33***	26.96	11.29***	10.83
Ln(seed cost* Rice output)	β41	58.89***	11.11	37.21***	43.31
Ln(Fertilizer cost*Land preparation cost)	β42	74.30***	13.92	50.22***	16.68
Ln(Fertilizer cost*Irrigation cost)	β43	85.05***	8.06	42.27***	7.62
Ln(Fertilizer cost*FYM cost)	β44	43.41***	19.13	42.94***	21.46
Ln(Fertilizer cost*weedicide cost)	β45	10.57***	5.24	30.34***	4.45
Ln(Fertilize cost*Insecticide cost)	β46	74.51***	3.76	40.95***	6.34
Ln(Fertilizer cost*harvesting cost)	β47	99.87***	3.07	26.51***	13.91
Ln(Fertlizer cost*labor cost)	β48	50.66***	12.24	35.62***	3.45
Ln(Fertilizer cost*Rice output)	β49	69.89***	9.98	47.76***	19.72
Ln(land preparation cost*irrigation cost)	β50	33.35***	15.04	19.53***	14.59

Ln(land preparation cost*FYM cost)	β51	20.54***	15.09	11.02***	13.00
Ln(land preparation cost*weedicide cost)	β52	38.65***	19.56	76.93***	18.57
Ln(land preparation cost*insecticide cost)	β53	78.86***	19.95	14.60***	16.61
Ln(land preparation cost*harvesting cost)	β54	65.80****	18.82	22.98***	24.48
Ln(land preparation cost*labor cost)	β55	14.05***	89.25	15.45***	24.78
Ln(land preparation cost*Rice output)	β56	23.11***	15.40	17.44***	20.81
Ln(Irrigation cost*FYM Cost)	β57	13.32***	97.83	44.02***	15.46
Ln(Irrigation cost*weedicide cost))	β58	82.92***	85.24	10.63***	12.33
Ln (Irrigation cost*Insecticide cost)	β59	10.36***	53.62	88.70***	23.87
Ln (Irrigation cost*harvesting cost)	β60	81.93***	60.61	79.56***	42.12
Ln (Irrigation cost*labor cost)	β61	86.77***	34.92	19.03***	34.39
Ln (Irrigation cost*Rice output)	β62	29.67***	18.45	27.71***	18.49
Ln(FYM cost*weedicide cost)	β63	26.27***	12.54	19.46***	48.67
Ln(FYM cost*Insecticide cost)	β64	-11.10***	-37.65	-10.63***	-11.43
Ln(FYM cost*harvesting cost)	β65	22.07***	28.10	86.05***	21.84
Ln(FYM cost*labor cost)	β66	64.09***	19.40	10.63***	11.04
Ln(FYM cost*Rice output)	β67	61.13***	23.93	73.13***	41.84
Ln(weedicide cost*Insecticide cost)	β68	61.68***	25.73	99.02***	11.04
Ln(weedicide cost*harvesting cost)	β69	30.24***	23.15	57.38***	24.97
Ln(weedicide cost*labor cost)	β70	13.92***	92.10	88.96***	16.57
Ln(weedicide cost*Rice output)	β71	30.52***	11.71	37.81***	6.53
Ln(Insecticide cost*harvesting cost)	β72	30.40***	11.01	18.60***	20.90
Ln(Insecticide cost*Labor cost)	β73	10.09***	4.74	19.35***	2.31
Ln(Insecticide cost*Rice output)	β74	10.41***	28.25	49.82***	24.47
Ln(Harvesting cost*labor cost)	β75	73.61***	4.92	20.07***	3.94

Ln(Harvesting cost* Rice output)	β76	37.99***	7.31	21.82***	2.83
Ln(labor cost*Rice output	β77	25.87***	3.20	37.31***	6.95
Variance Parameters					
Sigma Square	δ^2			94.21***	24.25
Gamma	γ			98.00***	35.08
Log Likelihood Function		**21.39**		**41.48**	

***:1% significance, **: 5% significance,*: 10% significance

The estimated coefficient of different input variables estimated with MLE and OLS technique are reported in Table 18. The estimated coefficient of pesticide cost variable is positive and highly significant at 1 percent level according to our expectation. This result exhibits that an increase in pesticide cost would significantly lead to increase cost of rice output. The result is in line with [(Umaru *et al*; 2013), (Ohajianya and Enarem; 2012)].

The coefficient of seed cost is also positive and highly significant. It means that there is a positive association between seed cost and cost of rice output. This means that a rise in seed cost would significantly lead to increase cost of rice output. The same results are acquired by [(Bashir *et al*; 2005); (Donkoh *et al*, 2013)].

This study finds other important variables which play a significant role for increasing the cost of rice output. The estimated result reveals that Fertilizer cost, Irrigation cost, Farm yard Manure cost, weedicide cost, harvesting cost, labor cost and Rice output variables is positive and significant at 1 and 5 and 10 percent level. The results reveal that these estimated variables have a significant positive impact on cost of rice output. It means that Cost of rice production are heavenly depends on seed cost , Pesticide cost, Fertilizer cost, Irrigation cost, FYM cost, weedicide cost, harvesting cost, labor cost and Rice output.

The coefficient of land preparation cost is negative and significant at 1 percent level in this study. The negative sign shows that there is an inverse relationship exists between input variable land preparation cost and cost of rice output. On the other hand, the coefficient of insecticide variable is negative but insignificant in this study. It is not clear that why it is doing so.

The square term of all input variables are statistically significant. The square values of the inputs help us to know the effect on cost of rice output of the continuous use of the inputs costs: pesticides cost, seed cost, fertilizer cost, irrigation cost, FYM cost, weedicide cost, harvesting cost, labor cost and Rice output maintaining a positive sign in both stages. It means that as continuously increases in the pesticides cost, seed cost, fertilizer cost, irrigation cost, FYM cost, weedicide cost, harvesting cost, labor cost and Rice output would lead to increase cost of rice output both at the initial and later stages. On the other hand, the land preparation cost still maintaining a negative sign at 5 percent level both at the initial and later stages. It means that as continuously increases in the land preparation it would lead to decrease cost of rice output both at the initial and later stages.

However, since the estimated coefficient of insecticide variable is insignificant with negative sign but the square term of insecticide variable is significant at 1 percent level with positive sign indicates that at the later stage cost of rice output increases due to continue to increase in insecticide cost.

The estimated results show that all interaction terms are statistically significant at 1 and 5 percent level for the Translog specification. The interaction terms tell us the substitutability or complementary of the variables. A parameter with a positive sign indicates that the two variables are complementary, while a parameter with a negative sign means that the variables are substitutes

The interaction terms of pesticide cost and seed cost, pesticide cost and fertilizer cost, pesticide cost and insecticide cost, pesticide cost and land preparation cost, pesticide cost and irrigation cost, pesticide cost and farm yard manure cost, pesticide cost and weedicide cost, pesticide cost and harvesting cost, labor cost and Rice output are statistically significant at 1 percent level with positive signs. This means that pesticide cost is complementary to seed cost, insecticide cost fertilizer cost, land preparation cost, irrigation cost, FYM cost, weedicide cost, harvesting cost, labor cost and Rice output.

The other estimated interaction terms of seed cost and fertilizer cost, seed cost and land preparation cost, seed cost and irrigation cost, seed cost and FYM cost, seed cost and weedicide cost, seed cost and insecticide cost, seed cost and harvesting cost, seed cost and labor cost, seed cost and Rice output are statistically significant at 1 and 5 percent level with positive signs. The positive signs indicates that seed cost is complementary to fertilizer cost, seed cost, land preparation cost, irrigation cost, FYM cost, weedicide cost, insecticide cost, harvesting cost, labor cost and Rice output. This represents that these combinations have positive effect on cost of rice output.

The cross terms of fertilizer cost and land preparation cost, fertilizer cost and irrigation cost, fertilizer cost farm yard manure cost, fertilizer cost and weedicide cost, fertilizer cost and harvesting cost, fertilizer cost and labor cost, fertilizer cost and Rice output are significant at 1 percent level with positive signs. This indicates that fertilizer cost is a complementary to land preparation cost, irrigation cost and FYM cost, weedicide cost, harvesting cost, labor cost and Rice output.

While, the interaction parameter of fertilizer cost and insecticide cost is statistically significant at 1 percent level with negative sign. This negative sign implies that fertilizer cost is a substitute to insecticide cost.

The interaction parameters of land preparation cost and irrigation cost, land preparation cost and farm yard manure cost, land preparation cost and weedicide cost, land preparation cost and insecticide cost, land preparation cost and labor cost, harvesting cost and Rice output are statistically significant at 1 percent level with positive signs. This implies that land preparation cost is a complementary to irrigation cost, farm yard manure cost, weedicide cost, insecticide cost and labor cost, harvesting cost and Rice output.

The other interaction parameter of irrigation cost and farm yard manure cost, Irrigation cost and weedicide cost, and insecticide cost, irrigation cost and harvesting cost, irrigation cost and labor cost, irrigation cost and Rice output are statistically significant at 1 percent level with positive signs. It indicates that irrigation cost is a complementary to farm yard manure cost, weedicide cost, insecticide cost, harvesting cost, labor cost and Rice output.

The interaction parameters of farm yard manure cost and weedicide cost, farm yard manure cost and harvesting cost, FYM cost and labor cost, FYM cost and Rice output is highly significant with positive signs. It indicates that farm yard manure cost is a complementary to weedicide cost, harvesting cost, and labor cost and Rice output. However, since the parameters of farm yard manure cost and insecticide cost is statistically significant at 1 percent level with negative sign. It indicates that farm yard manure cost is a substitute to insecticide cost.

The cross term of weedicide cost and insecticide cost, weedicide cost and harvesting cost, weedicide cost and labor cost, weedicide cost and Rice output are significant with positive signs. This indicates that weedicide cost is a complementary to insecticide cost, harvesting cost, and labor cost and Rice output. These combinations have a positive influence on cost of rice output.

The estimated interaction parameter of Insecticde cost and harvesting cost, insecticide cost and labor cost, insecticide cost and Rice output are statistically significant at 1 percent level with positive signs. It indicates that insecticide cost is a complementary to harvesting cost, labor cost and Rice output.

The coefficient of cross term labor cost and Rice output is statistically significant at 1 percent level with positive sign. This exhibits that a labor cost is a complementary to Rice output. This combination has a positive influence on cost of rice output.

IV- II. IV. <u>Inefficiency Model:</u>

In order to examine the factors of efficiency, we estimated the technical and allocative inefficiency model by using equations where inefficiency is assumed to be the dependent variable. Inefficiency model results are given in Table19.

Table 19: Inefficiency Model:

	Technical Inefficiency			Allocative Inefficiency	
Variables	**parameters**	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Constant	δ_0	-30.09***	-10.90	-51.09***	-5.81
Education	δ_1	-16.70***	-10.64	-50.65***	-6.85
Experience	δ_2	-12.90***	-5.44	-33.30***	-10.35
Owner	δ_3	-59.19***	-17.64	-46.04***	-10.33
Tenant	δ_4	-24.02***	-17.52	-12.51***	-12.53
Market Distance	δ_5	26.99***	20.32	21.80***	20.48
Selling agency	δ_6	-67.65***	-22.77	-48.52***	-4.92
Credit Access	δ_7	-42.19***	-13.21	-53.98***	-8.09
Tractor	δ_8	-12.73***	-6.39	-45.93***	-9.14
Tube well	δ_9	-19.46*	-1.86	-45.41**	-2.42
Extension services	δ_{10}	-62.35**	-2.23	-55.41***	-2.57
Family size	δ_{11}	63.77***	8.37	40.04***	5.64

***:1% significance, **: 5% significance,*: 10% significance.

The parameter of farmer education is negatively significant at 1 percent level in both technical and allocative inefficiency indices. According to our expectation coefficient of education is negative but significant implies that investment on human capital is a great tool to improve efficiency in rice producing area. Rice farmers with greater year of schooling tend to be more technically and allocatively efficient. This result is very clearly demonstrates that the farmer education emerges as an important factor in enhancing the agricultural productivity. This result is in line with [(Battese, 1996); (Wadud, 2003); (Abedullah, 2010); (Hassan, 1991); (Ahmad, 2001); (Chaudary *et al*., 2002); (Coelli, 1996); (Battese *et al*., 1996); (Ali and Flinn, 1989) and (Bakash, 2006)]. According to

Ahmad *et al.*, (2002) educated farmers usually have better access to information about prices, and the state of technology and its use. Better-educated people also have higher tendency to adopt and use modern inputs more optimally and efficiently.

The parameter estimates of experience of farmers are negatively and statistically significant at 1 percent level in both TIE and AIE indices. The result implies that experience is inversely related with inefficiency, as year of experience increases the farm efficiency increases. Huffman, (2001) also supported the views that farmers with more farming experience had greater technical and allocative efficiency. The same results is in line with [(Bakash *et al.*, 2006); (Backman *et al.*, 2012); (Ahmadu and Erhabor, 2012); Idoing (2007)].

The parameter estimates of owner used as Dummy variable. Dummy variable showing the value of owner is equal to one if the farmer is owner, otherwise zero. The AIE and TIE coefficient of the owner variable is negative but significant at 1 percent level. The result implies that owners are technically and allocatively efficient. The results reveal that farm efficiency would significantly increases if farmer is owner.

The parameter estimates of Tenant used as Dummy variable. Dummy variable showing the value of tenant is equal to one if farmer is a tenant, otherwise zero. The coefficient of tenant is negative and significant at 1 percent level in both TIE and AIE indices. The results reveal that tenant is technically and allocatively efficient. Tenural arrangement is one of the important factor and playing a significant role in determining the farm level efficiencies. According to Chuadhary (2002) the tenants mostly hold small area under cultivation and are generally under economic pressure paying the rent of land, facing high variable cost also have a pressure to save something for their family survival. Hence, all these factors make tenants are responsible to struggle more to achieve high level of production.

The estimated parameter of market distance is positive and statistically significant at 1 percent level in both TIE and AIE indices. The result implies that farm to market distance variable has a significant and positive association with inefficiency. As farm to market distance increases farmer inefficiency also increases. The same results is in line with (Joseph and Fasakin; 2012) and (Ahmad *et al.*, 2002). This result implies that the farm efficiency and thus the productivity would significantly increase with development of market and road infrastructure. Better access to roads expands output markets on the one hand and increases demand for modern inputs on the other hand [Ghura and Just, (1992)]. According to FAO and IFA (1999), the utilization of purchased inputs would have been higher in developing countries if the supply outlets are made available to the farming communities at a walking distance.

The estimated parameter of selling agency is used as Dummy variable. Dummy variable showing value is equal to one if farmer sell rice yield in market, zero value showing if farmers sell in village. The coefficient of selling agency in both technical and allocative inefficiency indices is negative and statistically significant at 1 percent level. The results reveal that those farmers selling rice yield in market are more efficient as compare to those farmers who selling rice yield in village. The reason behind that if farmers selling rice crop in market farmers may be able to get right prices of rice output as compared to sale of crop in village. Chaudhary, (1995) reported that right prices in agriculture causes the rapid growth in farm yield.

The estimated parameter of credit access variable used as dummy variable (1 for Access, 0 for Non Access) is negative and significant at 1 percent level in both TIE and AIE models. The results implying that the relaxation of financial constraint of the farmers increases farming efficiency. According to Ahmad *et al.*, (2002) the reason for negative association between credit access and inefficiency is that the adoption and use intensity of purchased inputs usually depends on the adequacy of the working capital. This is specifically true for the marginal farmers operating very small holdings in developing countries like Pakistan. They are the one who are fascinated in the vicious circle of financial hardships. The credit availability eases these financial constraints and helps in buying inputs and thus their application at the proper time. This result is in line with [(Idiong, 2007); (Yabe and Hoang, 2012); (Anthony and Achike; 2010), (Ali and Byerlee, 1991); (Seyoum *et al*., 1998); (Rahman *et al*., 2003)].

The estimated parameter of tractor is used as dummy variable. Dummy variable shows value of tractor is equal to one if farmer is a tractor owner, otherwise zero if farmer hire tractor on rent. The coefficient for the tractor ownership dummy is negative and statistically significant at 1 percent level in both TIE and AIE models. The results reveal that those farmers having their own tractor are technically less inefficient than those farmers who do not have their own tractor.

The parameter estimate of tube well is used as dummy variable. Dummy variable shows value of one, if farmer is a tube well owner, otherwise zero. The coefficient of tube well ownership dummy is negatively significant at 10 percent and 5 percent level in both TIE and AIE indices. The reason for this relationship it may be due to the fact that farmers who have their tube well able to provide timely supply of water throughout the cropping season. Especially, the application of seed and fertilizer depends on the farmers to controlled water supplies.

The parameter estimates of extension services are used as dummy variable. Dummy variable showing value of Extension =1 if the farmer consulted the extension services or any other agricultural expert for guidance, otherwise zero. Coefficient of extension agent is negatively and statistically significant at 5 percent and 1 percent level. The results reveal that the coefficient of extension visits is negatively associated with inefficiency in both TIE and AIE models. According to Backman *et al.*, (2012) extension visits enable the farmers to learn better farm management methods and more efficient uses of limited resources. According to Chaudhary *et al.*, (2002) farmers who are in touch with the agricultural extension department in order to seek advice are more efficient in agricultural production. The same results reveal that [(Anthony and Achike, 2010); (Hidayah and Susanto, 2013)].

The estimated parameter family size is positively significant at 1 percent level. The results reveal that household size is positively associated with inefficiency. The same results reveal that (Mia *et al.*, 2012); (Anthony and Achikie, 2010)].

IV- II. V. <u>Technical Efficiency Analysis:</u>

The frequency distribution of estimated technical efficiency for rice farmers is provided in Table 20. The estimated technical efficiency of rice farmers ranges from 0.34 to 0.97 shows that there is a great potential exist for rice farmers to increase per acre rice yield. The results demonstrate that mean technical efficiency turned out to be 86% at the aggregate level.

Table.20 Frequency Distribution of Technical Efficiency of Rice Farmers:

Over all			Conventional Rice Farmers			Direct Seeded Rice Farmers		
Efficiency Level	(F)	%	Efficiency Level	(F)	%	Efficiency Level	(F)	%
<0.20	0	0	<0.20	0	0	<0.20	0	0
0.21-0.30	0	0.00	0.21-0.30	0	0	0.21-0.30	0	0
0.31-0.40	2	0.67	0.31-0.40	2	1.33	0.31-0.40	0	0
0.41-0.50	1	0.33	0.41-0.50	1	0.67	0.41-0.50	0	0
0.51-0.60	5	1.67	0.51-0.60	3	2.00	0.51-0.60	2	1.33
0.61-0.70	16	5.33	0.61-0.70	13	8.67	0.61-0.70	3	2.00
0.71-0.80	21	7.00	0.71-0.80	10	6.67	0.71-0.80	11	7.33
0.81-0.90	154	51.33	0.80-0.90	72	48.00	0.80-0.90	82	54.67
>0.90	101	33.67	>0.90	49	32.67	>0.90	52	34.67
Total	300	100.00	**Total**	150	100.00	**Total**	150	100.00
Mean	**0.86**		**Mean**	**0.85**		**Mean**	**0.87**	

If we examine separately technical efficiency of rice farmers in Conventional and direct seeded field, the results reveal that mean technical efficiency of conventional farmers are 85 percent and Direct seeded farmers technical efficiency are 87 percent. This indicates that those farmers cultivate rice in Direct seeded field are 2 percent more technically efficient than those farmers who cultivated rice in Conventional field.

It is observe that an aggregate level majority of rice farmers (48%) operated at technical efficiency level between 81 to 90 percent. 6.67 and 8.67 percent of rice farmers lies between71-80 and 61-70 percent of the technical efficiency level. Furthermore, the analyses expose that about

32.67 percent of sample farmers are operating close to the frontier with the technical efficiency of more than 90 percent. Around 4 percent of rice farmers are operated below 60 percent of technical efficiency level.

In addition, 67.34 percent conventional and 65.33 percent direct seeded rice farmers originated to be at efficiency level of less than 90 percent. Around 6.67 percent conventional and 7.33 percent direct seeded farmers operated at efficiency level between 71 and 80 percent. The results further reveal that 32.67 percent conventional and 34.67 percent direct seeded farmers are operated close to the frontier level with technical efficiency of more than 90 percent. 8.67 percent conventional and 2 percent direct seeded farmers operated at efficiency level between 61-70 percent. 2 percent conventional and 0 percent direct seeded farmers operated below 50 percent efficiency level.

Over all the results reveal that high degree of technical inefficiency exist in the production of rice farms in Punjab. The Stochastic frontier results reveal that technical inefficiency turned to be 14 percent at the aggregate level and 15 and 13 percent for rice in conventional and direct seeded farms, respectively.

In other words, Rice farmers in Punjab can increase the production of rice 15 and 13 percent just by way of realizing efficiency, without increasing the quantity of inputs. The Stochastic frontier analysis has further reveal that 91 percent of the observed inefficiency are due to farmers inefficiency in decision making and only 9 percent of it is due to random factors that is outside the farmers control. Hence, it is possible for rice famers of study area to improve rice yield by 16 percent without increasing the level of inputs by using efficient management practices.

IV-II.VI. <u>Allocative Efficiency Analysis:</u>

The frequency distribution of predicted allocative efficiency for rice producers is given in table 21 the overall estimated allocative efficiency of rice farms ranges from 0.17 to 0.48. The mean allocative efficiency worked out to be 43% at the aggregate level. The results indicate that there is a great potential for rice farmers to reduce cost of inputs by 57 percent without reducing the level of output with existing technology.

Table 21: Frequency Distribution of Allocative Efficiency of Rice Farmers:

Over all			Conventional Rice			Direct Seeded Rice		
Efficiency Level	(F)	%	Efficiency Level	(F)	%	Efficiency Level	(F)	%
<0.20	2	0.67	<0.20	2	1.33	<0.20	0	0.00
0.21-0.30	6	2.00	0.21-0.30	4	2.67	0.21-0.30	2	1.33
0.31-0.40	42	14.00	0.31-0.40	28	18.67	0.31-0.40	14	9.33
0.41-0.50	250	83.33	0.41-0.50	116	77.33	0.41-0.50	134	89.33
0.51-0.60	0	0	0.51-0.60	0	0.00	0.51-0.60	0	0.00
0.61-0.70	0	0	0.61-0.70	0	0.00	0.61-0.70	0	0.00
0.71-0.80	0	0	0.71-0.80	0	0.00	0.71-0.80	0	0.00
0.81-0.90	0	0	0.80-0.90	0	0.00	0.80-0.90	0	0.00
>0.90	0	0	>0.90	0	0.00	>0.90	0	0.00
Total	300	100	**Total**	150	100.00	**Total**	150	100.00
Mean	**0.43**		**Mean**	**0.42**		**Mean**	**0.44**	

Table results shows that out of 300 farmers overall 83.33 percent farmers have allocative efficiency between 41-50 percent. 14 percent have allocative efficiency between 31-40 percent. Furthermore, out of 300 farmers only 2.67 percent famers have allocative efficiency less than 30 percent.

If we observe separatively allocative efficiency of rice under conventional and direct seeded farms the results reveals that mean allocative efficiency of conventional rice farmers are 42 percent and direct seeded farmers allocatively efficiency are 44 percent. This indicates that those farmers who cultivate rice under direct seeded rice field are 2 percent more allocatively efficient as compare to conventional rice farmers.

In addition, out of 300 farmers 77.33 percent and 89.33 percent conventional and direct seeded farmers have allocative efficiency between 41-50 percent. In addition, 9.33 percent and 18.67 percent conventional and direct seeded farmers have allocative efficiency between 31-40 percent. Furthermore, 1.33 percent conventional and 4 percent direct seeded farmers have allocative efficiency below 30 percent.

Overall the results indicates that if sample farmers operated rice at full efficiency levels they can reduce, on an average cost of inputs by about 57 percent without reducing the level of output with maximum technology. In addition on an average conventional farmers and direct seeded farmers if operated at efficiency level they can reduce average cost of input 58 percent(conventional famers) and 56 percent (Direct seeded farmers) without reducing the output with maximum technology.

IV-II.VII. Economic Efficiency Analysis:

Frequency distribution of economic efficiency of rice farmers are given in table 22. The results reveal that mean economic efficiency of rice farmers are 37%. Furthermore results indicate that estimated economic efficiency of rice farmers ranges from 0.06 to 0.47. Overall the results indicate that sample farmers could bring down rice cost of production by 63%.

Table: 22: Frequency Distribution of Economic efficiency of Rice farmers:

Over all			Conventional Rice			Direct Seeded Rice		
Efficiency Level	(F)	%	Efficiency Level	(F)	%	Efficiency Level	(F)	%
<0.21	12	4.00	<0.21	10	6.67	<0.21	2	1.33
0.21-0.30	25	8.33	0.21-0.30	14	9.33	0.21-0.30	11	7.33
0.31-0.40	153	51.00	0.31-0.40	74	49.33	0.31-0.40	79	52.67
0.41-0.50	110	36.67	0.41-0.50	52	34.67	0.41-0.50	58	38.67
0.51-0.60	0	0.00	0.51-0.60	0	0.00	0.51-0.60	0	0
0.61-0.70	0	0.00	0.61-0.70	0	0.00	0.61-0.70	0	0
0.71-0.80	0	0.00	0.71-0.80	0	0.00	0.71-0.80	0	0
0.80-0.90	0	0.00	0.80-0.90	0	0.00	0.80-0.90	0	0
>0.90	0	0.00	>0.90	0	0.00	>0.90	0	0
Total	300	100	**Total**	150	100	**Total**	150	100
Mean	**0.37**		**Mean**	**0.36**		**Mean**	**0.38**	

Overall the result shows that out of 300 farmers, majority of famers have economic efficiency between 31 to 40 percent. 36.67 percent famers have economic efficiency between 41 to 50 percent. 8.33 percent farmers have economic efficiency between 21 to 30 percent. Only 4 percent farmers have economic efficiency less than 21 percent.

If we examine separatively economic efficiency of conventional and direct seeded farmers the results reveal that majority of conventional and direct seeded farmers have economic efficiency lies between 31percent to 40 percent. Furthermore, the results indicate that 9.33 percent conventional farmers and 7.33 percent direct seeded farmers have economic efficiency between 21 to 30 percent. 6.67 percent conventional farmers and 1.33 percent direct seeded farmers have economic efficiency less than 21 percent. 36.67 and 38.67 percent Conventional and Direct seeded farmer have economic efficiency between 41 to 50 percent. Not any conventional farmers have economic efficiency greater than 50 percent.

On the whole the results reveal that Direct seeded farmers are 2 percent more efficient economically as compared to conventional farmers. In addition, Overall results indicate that on average 64 percent Conventional farmers and 62 percent direct seeded farmers can bring down cost of production without reducing the level of output and can achieve maximum output without increasing inputs by using efficient management practices.

Chapter 5

Conclusion and Policy Implications

V.1. Conclusion:

The main objective of this study is to identify the factors which are affecting the productivity and efficiencies of rice crop in Pakistan. This study is basically a primary research where cross sectional data has been used. For the collection of data the most reliable instrument of Primary research "Questionnaire" has been used. Through Questionnaire information has been collected from respondents. The respondents of the study are those farmers who cultivate rice by using conventional or direct seeded method. This study information has been collected from total 300 sample farmers. Total 150 farmers have been selected who cultivate rice through traditional method and 150 farmers who cultivate rice through Direct seeded method. All of these farmers have been selected from the five rice growing districts of Punjab namely: Gujranwala, Hafizabad, Vehari, Sheikhupura and Jhang.

This research has been taken two analyses Descriptive and empirical analysis. The Descriptive analysis of this research first of all discusses the characteristics of rice determinants that capable the readers to develop a relatively more sensible attitude towards analysis that followed. This research is specially designed to study the impact of various factors on rice yield. The following factors included in this study are: Conventional rice/Direct seeded rice, Area under rice crop, NPK ratio, Seed use, Irrigation hour, weedicide liters per Acre, Labor hour, Total tractor hour for land preparation, Farm yard manure, Insecticide, Pesticide. This study also focuses on to identify the factors which influence on cost of rice output. For this purpose following factors is included in this study are: Pesticide cost, Seed cost, Fertilizer cost, land preparation cost, Irrigation cost, Farm yard manure cost, Weedicide cost, Insecticide cost, Harvesting cost, Labor cost and Rice output. The square and cross terms of these variables are also explained in this study.

In inefficiency model, the socio-economic and farm management factors included are: education, experience, Tenant, Market Distance, Selling agency, Credit Access, Tractor, Tube well, Extension services and Family size. This study also finds more important conclusion about those farmers who cultivate rice through Direct seeded method and achieve higher rice yield as compare to Conventional farmers. This study further concluded that wheat after direct seeded rice field positively effects on wheat yield as compare to Conventional rice field.

Descriptive analysis result shows that a large number of sample farmers are cultivated the area between 5-15 acres, respectively. Out of 300 farmers the most frequent form of land tenure is owner which is 92%. The average age of sample famers is 48 years. Average education of farmers is 10 years of education and average experience of farmers is 23 years. Average distance from farm to main market is 5km and average household of sample farmers is seven.

This analysis further explains the ownership pattern of sample farmers. The large number of farmer status is owner in this study area. The study result explains that large number of farmers own both tractor and tube well. Around 92% farmers use own tractor and tube well in farming area. On the other hand, around 8% small farmers use hired tractor and tube wells.

In addition, the large number of sample farmers cultivates only Basmati Rice in the field which is 60.4%. On average 86% farmers use broadcasting method for sowing seeds and 14% farmers use Drill method for sowing rice seeds.

Rice and wheat are the major crops of the Punjab. Conventional Rice method is a traditional method that is used for the cultivation of rice. On the other hand, Direct seeded method which is called a Dry method. It is a new technique which is being used now for the cultivation of rice. Survey results demonstrate that around 50% areas are planted under conventional method and 50% areas are planted under Direct seeded method.

This study Author used the Translog stochastic frontier approach to estimate the efficiencies in rice production. The Translog production function results demonstrate that rice productivity has a positive relationship when rice planted under direct seeded method. The results indicate that rice production per acre increases significantly when rice planted through direct seeded method. The results further explain that rice productivity have a positive relationship with area under rice crop. As increase in area would significantly lead increase rice yield. The parameter of NPK ratio is negatively associated with rice productivity. The irrigation variable is also an important factor for rice productivity. The results exhibits that the parameter of irrigation hour is positively associated with rice productivity. The reason for this relationship is that rice is a water intensive crop and required comparatively more water than other crops.

The Coefficient of seed is positively associated with rice productivity. As increases in seed ratio would lead to increase rice yields. In addition, weedicide is also an important factor for rice productivity. The estimated variable of weedicide is positive and highly significant. This implies that, as farmer use more weedicide spray it would significantly lead to increase rice productivity. On the other hand, the sufficient evidence implying that labor hour is also an important factor for rice productivity because rice is a labor intensive crop. The study results implying that there is a positive association lies between labor hour and rice productivity. As increases in labor hour would lead to increase rice output.

The study further results explain that the coefficient of farm yard manure, pesticide and tractor hour are also significant but carry negative sign. The result explains that an excessive use of farm yard manure, tractor hour and pesticide have adversely impact on rice output. In addition, Insecticde variable is positively associated with rice yield.

The study results reveal that the square terms of Area under rice crop, seed and Dummy variable Conventional and Direct seeded rice, irrigation, labor hour, weedicide, are statistically significant with positive signs. The positive signs indicate that increases in the quantity of all these inputs would significantly lead to increase rice output both initial and later stages

On the other hand the square terms of NPK ratio, tractor hour, FYM and pesticide are statistically significant and maintaining a negative signs both at initial and later stage. It means that as continue to increase NPK ration, tractor hour and pesticide would lead to decrease rice output both at initial and later stages.

The estimated coefficient insecticide has positive sign at the initial stage while, on the second stage the insecticide variable is significant with negative sign. It means that usage of insecticides would lead to increase rice output at initial stage but at later stage rice output would decrease as continue to increases.

In this study two interaction term for the translog production frontier model are statistically significant with some having positive and other have negative signs. The negative value of cross terms indicates a substitute relationship between two inputs. In addition, the positive value reflects that complementary relationship exists between two inputs.

The stochastic production frontier analysis reveals that 91% variation in output is due to technical inefficiency and only 9% variation in output is due to random factors it is due to outside the control of farmers.

This study also estimate the Allocative efficiency of farmers by using Translog cost frontier function. The main aim of this function is to identify the factors which influencing to increase cost of rice output.

Furthermore, the study results reveals that pesticide cost, seed cost, fertilizer cost, Irrigation cost, weedicide cost, FYM cost, labor cost and Rice output are statistically significant with positive signs. It indicates that pesticide cost, seed cost, fertilizer cost, irrigation cost, weedicide cost, FYM cost, labor cost, and Rice output have a positive association with cost of rice productivity.

The coefficient of land preparation cost, Farm yard manure cost is negatively significant. It means that land preparation cost and farm yard manure is negatively associated with cost of rice productivity. On the other hand, the result of the study found insignificant relationship between coefficient of insecticide and cost of rice productivity.

Furthermore, the estimated results of square terms concluded that square value of land rent cost, pesticides cost, seed cost, irrigation cost, fertilizer cost, weedicide cost, insecticide cost, harvesting cost, labor cost and Rice output maintaining a positive sign both at initial and later stage. It means that a continuous increase in all input variables cost as a result rice output also increases both at the initial and later stages. On the other hand, the land preparation cost still maintaining a negative sign both at the initial and later stages. On the other hand, square term of insecticide variable is positive and highly significant reveal that rice output increases as continue to increases in insecticides usage.

The stochastic cost frontier analysis results shows that 98 percent variation in cost of rice output is due to differences in their allocative efficiencies.

The results of technical and allocative inefficiency model concluded that education and experience are the important socio-economic factors that enhancing the rice productivity. Rice farmers with greater years of schooling tends to be more technically and allocatively efficient. Furthermore, the coefficient of owner, Tenant, selling agent, Credit Access, tractor, Tube well, Extension services are statistically significant with negative sign. It indicates that if farmers status is owner or tenant it would be less technical and allocatively inefficient. On the other hand, if farmers have access to financial constraints it increases farming efficiency.

In addition if farmers own tube well and tractor it would be technically and allocatively efficient. The results further reveals that if farmers sell crop in market instead of village it increases farming efficiency.

Inefficiency model reveals market distances variable and household size of farmers have positive relationship with farming inefficiency. The result implies that farm to market distance variable has a significant and positive association with inefficiency. The studies suggest that better access to roads expands output markets on the one hand and increases demand for modern inputs on the other hand.

The study also estimated technical, Allocative and economic efficiency of rice farmers. The efficiency result reveals that the average technical efficiency of rice farmers is turned to be 86 percent. It means that an average farmer is producing 14 percent less than the attainable potential output. The result also implies that those farmers cultivate rice through direct seeded method are comparatively more efficient than those farmers who cultivate rice through conventional farmers. The mean technical efficiency of direct seeded farmers is 87 percent and convention farmers are 85 percent. It means that direct seeded farmers are 2 percent more technically efficient than conventional farmers.

The results further reveal that on average allocative efficiency of rice farmers are 43 percent. On average, the allocative efficiency of direct seeded farmers tends to be 44 percent and 42 percent for conventional farmers. This result implies that Direct seeded farmers are 2 percent more allocatively efficient than conventional farmers.

In addition, on average the economic efficiency of rice farmers are 37 percent. This result implies that economic efficiency of direct seeded rice farmers are 38 percent and conventional farmers are 36 percent. It exhibits that direct seeded farmers are 2 percent more economically efficient than conventional farmers.

The overall results reveal that Direct seeded farmers are comparatively more technically, allocatively and economically efficient than conventional farmers. It may be due to the fact that Direct seeded field required less number of irrigation hour as compared to conventional field. Furthermore through direct seeded method farmers can save labor cost because this method is free from transplantation of rice. In addition, direct seeded rice fields receive higher yield by using better land preparation and by properly managing weedicide and insecticides problems as compare to Conventional rice fields. Hence, due to these reasons Direct seeded farmers are more technically, allocatively and economically efficient than conventional farmers.

V.II. Policy implications:

Over all the study results reveal that Direct seeded rice technique is more profitable for farmer in terms of yield and cost. Moreover, it is the modern cost saving technique that not only save water but also save labor cost as well as it increases the efficiency of farmers. By adopting Direct seeded technique farmers can get higher economic return.

- Government institutions as well as Agriculture research councils should organized conferences for the promotion of Direct seeded technology in front of Researchers, Extension department representatives. These conferences will be discussed briefly about merits and Demerits of Direct seeded method for sowing rice.
- Research Papers as well as books will be published on National and International journals for the promotion of direct seeding system for sowing rice. In addition, Agriculture Research council will be published IEC material on direct seeding system procedures which should be used in conferences and distributed among extension department representatives.
- Agriculture Research Council should design workshops for Extension department representatives. These workshops will give information to participants about procedures of dry rice method. After that, these trainers will give guidance to farmers about direct seeded system and its consequences.

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APPENDIX

Questionnaire

Efficiency Analysis of Rice Production in Pakistan under Dry and Puddle Conditions.

Personal Information:

Name__________ Age (years) ____________Education (years) __________

Experience (Years) ____________ Caste____________ Status____________

Migrated/Local_______________ Owner/ Tenant/Owner cum Tenants /Share Tenants __________________

Family Information (Numbers)

Children Male Less than 15 years	Children Female Less than 15 years	Adult Male 15-60 years	Adult Female 15-60 years	Male Greater than 60 years	Female greater than 60 years	Male farm worker	Female farm worker	Highest education level in the family

Land Holding (Acres)

Own Area	Rented In	Rented Out	Shared In	Shared Out	Operational Land Holding

Soil Type________ **Soil Fertility** ___________Good/Medium/Poor
Soil Test _______Yes/No

Cropping Pattern

Rabi Crops	Area (acres)	Kharif crops	Area (acres)
1. Wheat		1.Rice	
2. Fodder		2. Fodder	
3. Vegetables		3.Vegetables	
4. Others		4.Others	
5. Others		5.Others	

Rice area

Varieties	Area (acres)	Sowing Method			
		Conventional (acres)	Production (mds)	Dry Sowing (acres)	Production (mds)
Basmati Super					
Basmati					

385					
Basmati 386					
Coarse____					
Coarse____					
Coarse____					

Comparison of Conventional and Dry Rice Sowing

S.#	Operation	Conventional	Dry Rice Sowing
1.	Previous Crop		
2.	Soil type		
3	Rice Variety		
4	Dry Ploughing (No.)		
5	Pre-sowing Irrigation (Rauni)		
	Number		
	Time (hours/irrigation)		
6	**Puddling**		
	Wet Ploughing		
	Wet Planking		
	Transplanting Cost		
7	**Method of Sowing** 1. Board Cast 2. Drill Sowing 3.others		
8	Seed per acre (kgs)		
	Cost per kg		
9	**Irrigation** Number of Irrigation		
	1st Irrigation time (hours)		
	Source of 1st irrigation 1.Canal2.Tube well		
	Subsequent Irrigation No.		
	i)Canal No.		

	ii)Tube well No.		
	If canal irrigation time (hours)		
	If tube well irrigation time (hours)		
	Canal+tubewell consecutive use (hours)		
	Tube well type 1. Tractor driven 2. Peter engine		
	If tractor driven diesel consumption liter per hour. Delivery pipe ________inch. If peter engineHours power____________ Diesel consumption liter per hour_____ Delivery pipe____________inches Diesel Rate (Rs./liter)____________		
10.	Farm Yard Manure (trolleys No.)		
11	**Fertilizer**		
	DAP		
	Urea		
	Other (price/bag----------------------)		
	Other (price/bag----------------------)		
	Other (price/bag------------------------)		
12	Weedicide (price-------use acres liters--------)		
13	Insecticide (price-------use acres--------)		
14	Pesticide (price-------use acres--------)		
15	Harvesting Method 1. Manually 2. Combine		
16	Yield (maunds)		

Table: Labour and Time Requirements

Category	Traditional Planting	Dry rice Planting

	Male #	Female #	Male #	Female #
Basmati Rice				
Coarse Rice				
Time Requirements				
	Male hours/day	Female hours/day	Male hours/day	Female hours/day
Basmati Rice				
Coarse Rice				

Table: Impact on Wheat Crop

Category	Traditional Wheat sown	Sown after Dry rice
Timely Yes/No		
Planking #		
Manure #		
Tillage #		
Yield Maunds/acre		

Table: Prices

Item	Price per unit	Item	Price per unit
Dry Ploughing		DAP	
Dry Planking		Urea	
Wet Ploughing		FYM/trolley	
Wet Planking		FYM application per acre	
Transplantation Basmati		Weedicide/Insecticide Application	
Transplantation Irri		Manual Harvesting	
others		Combine Harvesting	
Leaser leveler		Rotavator	

Further Information

Tractor________ Yes/No. Tube Well_____________ Yes/No. Number of cattle ____________ Extension Services ______________ Yes/No. Sold at market/ Village_______________________ Credit facility _________________ Yes/ No. Distance from Main road____________________ Distance from main market (Km)__________ TechnologyInformationSource_____________________Future Intension regarding direct seeded technology______________________

Efficiencies level of each farm:

	Efficiency level of each farm						
Conventional Rice Farm	TE	AE	EE	Direct seeded rice Farm	TE	AE	EE
1	0.34	0.17	0.06	1	0.70	0.35	0.24
2	0.40	0.20	0.08	2	0.89	0.44	0.39
3	0.48	0.24	0.11	3	0.90	0.45	0.40
4	0.55	0.27	0.15	4	0.90	0.45	0.41
5	0.57	0.28	0.16	5	0.77	0.38	0.29
6	0.58	0.29	0.17	6	0.90	0.45	0.41
7	0.62	0.31	0.19	7	0.86	0.43	0.37
8	0.62	0.31	0.19	8	0.89	0.44	0.39
9	0.63	0.31	0.20	9	0.89	0.45	0.40
10	0.63	0.32	0.20	10	0.84	0.42	0.36
11	0.65	0.32	0.21	11	0.87	0.44	0.38
12	0.66	0.33	0.21	12	0.93	0.47	0.43
13	0.66	0.33	0.22	13	0.81	0.41	0.33
14	0.67	0.33	0.22	14	0.94	0.47	0.44
15	0.67	0.34	0.22	15	0.94	0.47	0.44
16	0.68	0.34	0.23	16	0.84	0.42	0.35
17	0.70	0.35	0.25	17	0.83	0.41	0.34
18	0.70	0.35	0.25	18	0.95	0.47	0.45
19	0.70	0.35	0.25	19	0.93	0.47	0.43
20	0.72	0.36	0.26	20	0.94	0.47	0.44
21	0.72	0.36	0.26	21	0.91	0.46	0.42
22	0.75	0.38	0.28	22	0.92	0.46	0.42
23	0.77	0.38	0.29	23	0.83	0.42	0.35
24	0.77	0.39	0.30	24	0.90	0.45	0.40
25	0.79	0.39	0.31	25	0.84	0.42	0.35
26	0.79	0.40	0.31	26	0.88	0.44	0.38
27	0.79	0.40	0.31	27	0.88	0.44	0.39
28	0.80	0.40	0.32	28	0.89	0.44	0.39
29	0.80	0.40	0.32	29	0.84	0.42	0.36
30	0.81	0.40	0.32	30	0.95	0.47	0.45
31	0.81	0.40	0.32	31	0.82	0.41	0.33
32	0.81	0.40	0.33	32	0.88	0.44	0.39
33	0.81	0.40	0.33	33	0.90	0.45	0.40
34	0.81	0.40	0.33	34	0.86	0.43	0.37
35	0.81	0.41	0.33	35	0.90	0.45	0.40
36	0.82	0.41	0.33	36	0.85	0.42	0.36
37	0.82	0.41	0.34	37	0.76	0.38	0.29
38	0.82	0.41	0.34	38	0.86	0.43	0.37

39	0.82	0.41	0.34	39	0.85	0.43	0.36
40	0.83	0.41	0.34	40	0.94	0.47	0.44
41	0.83	0.41	0.34	41	0.91	0.46	0.42
42	0.83	0.41	0.34	42	0.95	0.48	0.45
43	0.83	0.41	0.34	43	0.87	0.44	0.38
44	0.83	0.42	0.35	44	0.95	0.47	0.45
45	0.83	0.42	0.35	45	0.69	0.34	0.24
46	0.84	0.42	0.35	46	0.95	0.48	0.45
47	0.84	0.42	0.35	47	0.91	0.46	0.41
48	0.84	0.42	0.35	48	0.86	0.43	0.37
49	0.84	0.42	0.35	49	0.90	0.45	0.40
50	0.84	0.42	0.35	50	0.92	0.46	0.42
51	0.84	0.42	0.36	51	0.92	0.46	0.42
52	0.84	0.42	0.36	52	0.92	0.46	0.42
53	0.85	0.42	0.36	53	0.89	0.45	0.40
54	0.85	0.42	0.36	54	0.94	0.47	0.44
55	0.85	0.42	0.36	55	0.92	0.46	0.42
56	0.85	0.43	0.36	56	0.89	0.44	0.39
57	0.85	0.43	0.36	57	0.89	0.45	0.40
58	0.85	0.43	0.36	58	0.93	0.46	0.43
59	0.85	0.43	0.36	59	0.73	0.37	0.27
60	0.86	0.43	0.37	60	0.93	0.46	0.43
61	0.86	0.43	0.37	61	0.93	0.46	0.43
62	0.86	0.43	0.37	62	0.94	0.47	0.44
63	0.86	0.43	0.37	63	0.72	0.36	0.26
64	0.86	0.43	0.37	64	0.93	0.46	0.43
65	0.86	0.43	0.37	65	0.91	0.46	0.41
66	0.87	0.43	0.38	66	0.93	0.46	0.43
67	0.87	0.43	0.38	67	0.93	0.47	0.44
68	0.87	0.43	0.38	68	0.94	0.47	0.44
69	0.87	0.44	0.38	69	0.92	0.46	0.42
70	0.88	0.44	0.38	70	0.90	0.45	0.40
71	0.88	0.44	0.38	71	0.92	0.46	0.42
72	0.88	0.44	0.38	72	0.94	0.47	0.44
73	0.88	0.44	0.39	73	0.80	0.40	0.32
74	0.88	0.44	0.39	74	0.89	0.44	0.39
75	0.88	0.44	0.39	75	0.80	0.40	0.32
76	0.88	0.44	0.39	76	0.91	0.46	0.41
77	0.88	0.44	0.39	77	0.91	0.46	0.42
78	0.88	0.44	0.39	78	0.85	0.42	0.36
79	0.89	0.44	0.39	79	0.88	0.44	0.39

80	0.89	0.44	0.39	80	0.90	0.45	0.41
81	0.89	0.44	0.39	81	0.88	0.44	0.39
82	0.89	0.44	0.40	82	0.95	0.48	0.45
83	0.89	0.44	0.40	83	0.86	0.43	0.37
84	0.89	0.45	0.40	84	0.95	0.47	0.45
85	0.89	0.45	0.40	85	0.90	0.45	0.40
86	0.89	0.45	0.40	86	0.88	0.44	0.38
87	0.89	0.45	0.40	87	0.84	0.42	0.35
88	0.89	0.45	0.40	88	0.85	0.42	0.36
89	0.89	0.45	0.40	89	0.91	0.46	0.41
90	0.89	0.45	0.40	90	0.86	0.43	0.37
91	0.89	0.45	0.40	91	0.86	0.43	0.37
92	0.89	0.45	0.40	92	0.93	0.47	0.43
93	0.90	0.45	0.40	93	0.87	0.43	0.38
94	0.90	0.45	0.40	94	0.86	0.43	0.37
95	0.90	0.45	0.40	95	0.86	0.43	0.37
96	0.90	0.45	0.40	96	0.82	0.41	0.34
97	0.90	0.45	0.40	97	0.92	0.46	0.42
98	0.90	0.45	0.40	98	0.88	0.44	0.39
99	0.90	0.45	0.41	99	0.89	0.45	0.40
100	0.90	0.45	0.41	100	0.89	0.45	0.40
101	0.90	0.45	0.41	101	0.76	0.38	0.29
102	0.91	0.45	0.41	102	0.89	0.44	0.39
103	0.91	0.46	0.41	103	0.93	0.47	0.44
104	0.91	0.46	0.42	104	0.91	0.45	0.41
105	0.91	0.46	0.42	105	0.82	0.41	0.34
106	0.91	0.46	0.42	106	0.91	0.45	0.41
107	0.91	0.46	0.42	107	0.82	0.41	0.34
108	0.92	0.46	0.42	108	0.91	0.46	0.42
109	0.92	0.46	0.42	109	0.73	0.37	0.27
110	0.92	0.46	0.42	110	0.87	0.44	0.38
111	0.92	0.46	0.43	111	0.95	0.48	0.45
112	0.92	0.46	0.43	112	0.82	0.41	0.33
113	0.92	0.46	0.43	113	0.52	0.26	0.14
114	0.93	0.46	0.43	114	0.69	0.34	0.24
115	0.93	0.46	0.43	115	0.86	0.43	0.37
116	0.93	0.46	0.43	116	0.88	0.44	0.39
117	0.93	0.46	0.43	117	0.89	0.44	0.39
118	0.93	0.46	0.43	118	0.87	0.44	0.38
119	0.93	0.47	0.43	119	0.74	0.37	0.27
120	0.93	0.47	0.43	120	0.90	0.45	0.41
121	0.93	0.47	0.43	121	0.78	0.39	0.31

122	0.93	0.47	0.44	122	0.91	0.45	0.41
123	0.93	0.47	0.44	123	0.88	0.44	0.39
124	0.94	0.47	0.44	124	0.91	0.46	0.42
125	0.94	0.47	0.44	125	0.83	0.41	0.34
126	0.94	0.47	0.44	126	0.90	0.45	0.40
127	0.94	0.47	0.44	127	0.78	0.39	0.30
128	0.94	0.47	0.44	128	0.85	0.43	0.37
129	0.94	0.47	0.44	129	0.94	0.47	0.44
130	0.94	0.47	0.44	130	0.93	0.46	0.43
131	0.94	0.47	0.44	131	0.92	0.46	0.43
132	0.94	0.47	0.44	132	0.81	0.41	0.33
133	0.94	0.47	0.44	133	0.89	0.44	0.40
134	0.94	0.47	0.44	134	0.89	0.44	0.39
135	0.94	0.47	0.44	135	0.56	0.28	0.16
136	0.94	0.47	0.45	136	0.81	0.41	0.33
137	0.94	0.47	0.45	137	0.87	0.44	0.38
138	0.95	0.47	0.45	138	0.90	0.45	0.40
139	0.95	0.47	0.45	139	0.90	0.45	0.41
140	0.95	0.47	0.45	140	0.89	0.45	0.40
141	0.95	0.47	0.45	141	0.88	0.44	0.38
142	0.95	0.47	0.45	142	0.91	0.46	0.42
143	0.95	0.48	0.45	143	0.88	0.44	0.39
144	0.95	0.48	0.45	144	0.91	0.46	0.42
145	0.95	0.48	0.45	145	0.96	0.48	0.46
146	0.95	0.48	0.45	146	0.87	0.43	0.38
147	0.95	0.48	0.45	147	0.88	0.44	0.38
148	0.95	0.48	0.46	148	0.88	0.44	0.39
149	0.96	0.48	0.46	149	0.87	0.44	0.38
150	0.97	0.48	0.47	150	0.85	0.43	0.36
Mean	**0.85**	**0.42**	**0.37**	**Mean**	**0.87**	**0.44**	**0.38**
Minimum	**0.34**	**0.17**	**0.06**	**Minimum**	**0.52**	**0.26**	**0.14**
Maximum	**0.97**	**0.48**	**0.47**	**Maximum**	**0.96**	**0.48**	**0.46**
Standard Deviation	**11.08**	**5.54**	**8.25**	**Standard Deviation**	**6.79**	**3.40**	**5.45**