Wheat Productivity, Efficiency and Sustainability: A Case Study of Faisalabad.

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CERTIFICATE

It is certified that this thesis titled **"Wheat Productivity, Efficiency and Sustainability; A Case Study of Faisalabad"** submitted by Mr. Muhammad Ali is accepted in its present form by the Department of Economics, Quaid-i-Azam University, Islamabad as satisfying the requirement for partial fulfillment of the degree of Master of Philosophy in Economics.

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Dedicated to my Supervisor,

Family and Friends

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Chapter No.1

INTRODUCTION

Pakistan is a developing country with rich and vast natural resources and has great potential for producing all types of food commodities. Agriculture sector plays directly or indirectly an important role in the economic growth. Its importance can be analyzed through three ways: first, it provides food to consumers and fibers for domestic industry; second, it is a source of scarce foreign exchange earnings; and third, it provides a market for industrial goods. A high ratio of population directly or indirectly depends upon this sector. Labour engagement is increasing in this sector in coming years.

1.1 ROLE OF AGRICULTURE SECTOR IN THE ECONOMY

Agriculture sector is playing a pivotal role in providing food to the fast-growing population of the country. According to the 1998 census, the total population of Pakistan is 130 million with 2.6 percent growth rate due to which there is net addition of 3.4 million people each year. From the independence the population has increased to fourfold while the production of wheat, the major food crop, has increased only 2.9 fold. Due to which import of wheat is increasing day by day. Tremendous efforts have been carried out to narrow the gap between population growth and food production.

According to Pakistan Economic Survey 2007-08, agriculture sector contributes 21 percent to GDP and employs 44 percent of the workforce. Its importance can be realized through that two-third's of Pakistan's population lives in rural areas and their livelihood heavily depends upon this sector. According to economic survey, agriculture sector performed poorly in 2007-08 by growing at 1.5 percent against the target of 4.8 percent. Many factors contribute the poor performance like poor performance of other agriculture sections major crops, forestry, livestock and fishing are main factors.

1.2 ROLE OF WHEAT CROP IN THE COUNTRY

Due to stable food item, wheat is grown almost every part of the country. It contributes 12.7 percent to the value added in agriculture and 2.6 percent to GDP. Wheat was cultivated almost 8448 thousand hectares in 2005-06 while it increased to 8578 in 2006-07 showing 1.1 percent to 1.0 percent respectively.

The Punjab province hosts about 56 percent of the total population while its share is 26 percent of the total area of the country. Its 60 percent area is under cultivation, which comes to about 56 percent of the country's total cultivated area. Its share in the GDP growth is increasing per annum. It plays a prominent role in the Pakistan's economy. As population is increasing, the food dependency also increases.

For our current analysis, we have selected district Faisalabad which comprises of four tehsiles namely; Chak Jhumra, Tandianwala, Samundri and Jaranwala. Faisalabad is the third populated city at country level as well as province level. The district Faisalabad has total area of 58.56 square kilometer. It lies between longitude 73 and 74 east, latitude 30 and 31.5 north, at an elevation of 605 feet above sea level. There is no natural boundary between Faisalabad and the adjoining Districts. Lower Chenab canal is the main source of irrigation water, which meets the requirements of 80% of cultivated land. The soil of

Faisalabad is fertile due to which many crops like wheat, sugarcane, cotton, rice, maize, jawar, bajra etc. are cultivated in the area. We want to analyze the main determinants of wheat production at overall as well as tehsil level and also the main factors contributing to wheat efficiency.

Many studies have been done on the improvement in resource use efficiency. After Schultz's (1964) poor but efficient hypothesis proved invalid. It is an alternative and less costly source of increasing productivity. If Schultz's hypothesis had been confirmed, an increase in farm productivity would only have been achieved through increased use of inputs and technology introduction. While on the other hand if inefficiency prevails, the increased productivity might be achieved through efficient use of the existing resources and addressing the socio-economic and institutional factors confounding it.

According to Ahmad and Bravo-ureta (1995) have the view that productivity growth and the use of additional factors of production are two major sources of expansion in agriculture production. Kalirajan and Fan (1991) say that the research and development are the main forces behind technological change and innovations create new or improved inputs and techniques of production, while, education, experience, and expand infrastructure are consequence for improving the system's efficiency. The later requires technological capability like technical, managerial and institutional skills.

The agriculture sector in Pakistan's economy is performing low than the population growth rate and also due to some technical reasons, poor and backward technology, limited use of modern inputs, lack of financial resources, lack of strong public and private institutions etc. According to Mulat *et al.* (1997), the ability of a country to achieve growth in agricultural productivity and output depends on its ability to use the available resources efficiently and make an efficient choice among alternative paths of technical changes.

Farrell (1957) was the first person who used the measure of production efficiency. His production efficiency measure was able to overcome the problem associated with the traditional average productivity measures. He further proposed that the efficiency measured in a relative performance rather than the absolute performance. He had made some distinction between the technical efficiency / inefficiency and allocative efficiency / inefficiency. He elaborates that the technical inefficiency arises when less than maximum output is obtained from a given set of factors and allocative inefficiency arises when the factors are used in proportions which do not lead to profit maximization.

1.3 OBJECTIVES OF THE STUDY

The general objective of this study is to examine the farm level efficiency as well as productivity in wheat crop. The specific objectives of the study are to:

- Estimate the main factors contributing to wheat productivity.
- Estimate the farm-level efficiency of wheat production and identify the sources of efficiency.
- Analyze the area under different crops which include cash crops, fodder crops and area under fruits.

1.4 CONTRIBUTION OF THE STUDY

Our study is different from the previous studies due to following reasons:

- We have incorporated the number of irrigation from each source, we have considered the three mostly used sources; canal, tube-well and canal tube-well mixed irrigation.
- The number of deep ploughing per acre (tractor deep ploughing).
- We have incorporated wheat sown late after 20 November as proportion of wheat area.
- To see the impact of wheat production in orchard, we have incorporated wheat sown in orchard and also wheat in fellow land.
- What is the impact on wheat production through sowing methods; we have analyzed the line method in the study.
- For technical inefficiency, we have considered education of the decision maker farmer as well as his specialization along with higher education of family members and his specialization. Education is in years while specialization is that if farmer or family member has agriculture degree or science degree.
- For agriculture extension role in the technical inefficiency, we have incorporated the number of farmers' visits to agriculture extension during wheat crop.

1.5 ARRANGEMENT OF THE STUDY

The remaining portion of the study is organized as follows. In chapter 2, we review the existing literature on wheat productivity, efficiency and sustainability with empirical findings of the studies. In chapter 3, we present data description and variables information. In chapter 4, we present the method of estimation. In chapter 5, we have presented the results and discussion of our analysis and chapter 6 deals with summary and conclusion.

Chapter No. 2
LITERATURE REVIEW

2.1 INTRODUCTION

Efficiency is the most widely used concept in economics. Efficiency is measured by the comparison between the observed output and the feasible (frontier) output. The scarcity of resources is the main factor that makes the improvement in efficiency so important to an economic agent or to a society.

In other words, efficiency, productivity, technology growth, and economic growth are widely and interchangeably used. Although there are similarities and linkages among them, they are not equivalent. The conceptualization and measurement of efficiency relies on the specification of a production function. The production function represents the maximum output attainable from the use of a given level of inputs. The production function describes production performance and productivity is the measure of it.

Productivity is defined by Harsh *et al.* (1981) as the ability of a unit of an input to produce a certain level of output. Thus, it shows how efficient a farmer is in the use of that particular input given while the range of alternative technologies available to him Farrel (1957) was the first person who used the measure of production efficiency. His production efficiency measure was able to overcome the problem associated with the traditional average productivity measures. He further proposed that the efficiency measured in a relative performance rather than the absolute performance. He had made some distinction between the technical efficiency / inefficiency and allocative efficiency /

inefficiency. According to Farrell (1957) narrates that the technical inefficiency arises when less than maximum output is obtained from a given set of factors and allocative inefficiency arises when the factors are used in proportions which do not lead to profit maximization.

Technical efficiency of the farms is also related by a wide range of factors like socio-economic and demographic factors. This relationship was defined by Timber (1971), Kalirajan and Flinn (1983), Lingard *et al.* (1983), Shapiro and Muller (1977). These researchers include land use, credit availability, land tenure and household labor's education. Different researchers have used different factors to identify the elements due to which there prevails technical inefficiency. Parikh *et al.* (1995) introduces the other environmental and non-physical factors like information, experience, and supervision as important for efficiency.

2.2 IMPACT OF FERTILIZER AND WATER ON PRODUCTIVITY

There are different economic theories relevant to productivity presented by Hulten (2000) and Easterly & Levine (2001) which show that productivity is the pioneer element for sustainable long-term economic growth.

In agriculture sector particularly for wheat crop, water and nitrogen are important for good production. The water and nitrogen relevant factors was analyzed by Timsina *et al.* (2001) and also nitrogen uptake, nitrogen-use efficiencies, nitrogen balance for rice-wheat systems analyzed. There is positive relationship between nitrogen and yield for rice and wheat crops respectively. They further analyzed that the increase in productivity of rice-wheat systems depends upon many factors like the choice of appropriate cultivars, timely planting, large inputs of inorganic nitrogen fertilizer, management of water and nitrogen. The delayed seeding reduces wheat yields.

For the fertility of land, nitrogen is essential due to which yield increases. The positive relationship between quality of irrigation water and productivity was analyzed by Battese (1998). He further suggests that there is need of regular monitoring of weather, crop performance, irrigation water, soil as well as plant mineral nitrogen for further understanding the growth, productivity, Nitrogen use efficiencies and balance in rice-wheat systems.

2.3 RELATIONSHIP BETWEEN FARM SIZE AND PRODUCTIVITY AND POSSIBLE REASONS

The relationship between farm productivity and size has an importance element in agriculture sector. The debate of inverse relationship between farm size and productivity started with Sen's (1962) seminal work using India's Farm Management Survey Data. Several studies like Sen (1962), Mazumdar (1965), Rao (1966), Saini (1971), Bardhan (1973), Bharadwaj (1974), Chaddha (1978), Bhalla, (1988) and Barret (1994) are in favor of the inverse relationship between farm size and productivity.

Mixed results are observed in case of developing countries. As in the case of Indian agriculture Khusro (1964), Sahota (1968), Huang and Bagi (1984), Sidhu (1974) and Ray (1985) found that productive efficiency did not differ across different farm size categories. The other studies by Yotopoulos *et al.* (1970), Lau and Yotopoulos (1971) and Bagi (1987) showed the inverse relationship between farm size and efficiency. While no evidence of relationship between farm size and efficiency was explored by Squire and Tabor (1991), and Pinheiro (1992).

The study by Masterson (2007) analyzes the relationship between farm size and productivity. He argues that the smaller farms have low net farm income per hectare and more technical efficient than larger farms. The rising shares of household labor employed in agriculture result in lower productivity and efficiency. The share of family labor in total labor is significantly negatively correlated with both the amount of physical capital and the amount of land owned by the household.

Byiringiro (1995) analyzes the case of Rwanda and concludes that as farm size tends to increase, the farm productivity decreases. Small farms have a lower opportunity cost related to labour and a high shadow price of land compared to larger farms due to constraints to access land and labour market opportunities. They are further affected by land quality due to erosion (average annual soil loss), percentage of area fertilized and investment in soil conservation, and by the share of high value crops in gross value output. The theory predicts that farm productivity which is measured by marginal factor products will differ over farms using different levels of inputs like marginal productivity of a given amount of labour will be greater on a farm with a large landholding. The inverse relationship between farm size and land productivity has been important in land reform debate in developing countries who are suffering growing land constraints, supporting the smallholder whose technique factor bias uses shrinking land resources more productively.

The explanation of the inverse relationship was given by Ellis (1993) and Barret (1994); they classified it in following possible categories:

- The existing relationship can be a consequence of market failures (imperfections). The shadow prices of factors of production differ with the size of the farm. The farmers will tend to apply more of the factor to which they have easy access, for which they face a very low shadow price which was analyzed by Blarel *et al.* (1989). For example, the presence of a dual labor market where smaller farms face a cheaper imputed labor cost analyzed by Feder (1984).
- The other factor can be due to the consequence of decreasing returns to scale. Bardhan (1973), Barnum and Squire (1978) analyzes that production function in developing countries are nearly constant returns to scale.
- The relationship may be due to the result of a superior efficiency of smallholders with respect to the intensity of utilization of land as a resource. It depends upon the land use intensity. The larger farms underutilize their land (they do not farm all the available land) and the cropping pattern (crop composition), whereas smaller farms allocate a higher propulsion of their holding to high value crops that usually make use of a substantial amount of their labor force and land quality. While the smallholders improve their land (soil conservation investments, manure, mulch) more than large holder; and multiple cropping, which is mostly used by smaller farms.

- The other major factors relevant to the relationship are region-specific variables. According to Bhalla and Roy (1988) the common factors are soil fertility or quality. They further narrates that a region with better land and difference in prices and wages attracts more people while the regions with higher wages attract more settlers. For example, Barrett and Christopher (1994) shows that the observed relationship in Madagascar is a result of the risk in prices faced by farm.

According to Bhalla and Roy (1988) land degradation is the main factor that intensifies the inverse relationship and some authors argue that it is due to the result of the loss in the quality of land. They show that by controlling the effect of the quality of land, the inverse relationship between farm-size and productivity weakens or disappears.

Using cross-regional data from Indian agriculture, Deolalikar (1981) found that the inverse relationship between yields and farm size holds for traditional agriculture but does not hold for agriculture experiencing technological change. In the post-Green Revolution period, land productivity is mainly a function of cash inputs like fertilizer and improved seeds while it depends less on the amount of labor used. The results are confirmed also by Rao and Chotigeat (1981). They show that land and labor have a negative effect on the elasticity of gross value of output per unit of land while capital has a positive effect. The net effect depends on which of the two effects is the largest. The farms employing more hired labor and using more nontraditional inputs (fertilizers, high-yielding varieties, improved ploughs and tractors) and larger holdings have higher productivities.

Feder (1984) analyzed the relationship in the context of labor supervision and credit constraint. He elaborates that the negative relationship folds when there is high supervision cost of hired labor by family labor and access to credit is conditioned by the size of the holding (as collateral). Thus, labor input would be identical across farm and consequently yields would not be affected by farm size.

The study by Brummer *et al.* (2003) reveals the measurement of productivity and efficiency change in Chinese farming sector over the reform process in the 1980s and 1990s. They found that in the more market-oriented reform period in the mid 1980s productivity and technical efficiency increased while productivity growth and technical efficiency slow in the mid 1990s when market orientation of the reforms was reduced and self-sufficiency as a major goal reappeared on the political agenda. Fan and Kalirajan (1991) has analyzed productivity change in Chinese agriculture into technical, allocative efficiency and technical progress. According to his analysis 70 % of the observable productivity growth over the period 1965-86 could be explained by an increase in input use. The remaining part is due to equal shares from technical efficiency.

The existing inverse relationship between farm size and productivity is not much prominent in Pakistan. Very few researchers have tried to discover the relationship for Pakistan. The first study was conducted by Khan (1979) using 732 irrigated farms in the Indus basin for the year 1974 by using production technique and concluded that the large farmers get higher output per acre. While the other study Khan and Maki (1979) for wheat and rice crops found no significant farm size-based difference in efficiency. Mahmood and Haque (1981) concluded that the smallest and the largest farm size categories were the most efficient and equally productive while the middle farmers were relatively inefficient. Chaudhry *et al.* (1985) indicates the inverse relationship between the farm size and productivity for Pakistan.

Ahmad and Qureshi (1999) analyzed the relationship using data of 1997-98 for Punjab province of Pakistan and concluded that the inverse relationship prevails in the overall Punjab province but not for all of its regions. Gujranwala and Multan regions show no significant association. The main factors for the inverse relationship are the more intensive use of inputs per cultivated area as well as a high level of cropping intensity on small farms. While technical efficiency is positively related to the farm size which implies that the larger farmers realize greater potential output from the given level of inputs and technology.

2.4 IMPACT OF EDUCATION, AGE, EXPERIENCE AND EXTENSION ON PRODUCTIVITY AND TECHNICAL EFFICIENCY:

Human capital and education are the most important factors for economic growth for any country. Their role in agriculture also may not be denied. While other factors like age, experience etc. also important in the context of agriculture sector.

Various studies have incorporated the impact of education on productivity and efficiency. There are two groups, one has a positive view point about education that education increases productivity and efficiency while the second group negates this findings. The study by Asadullah and Rahman (2005) analyze this effect in Bangladesh using a large dataset on rice producing households. For internal as well as external returns to education was analyzed by using a full set of proxies for farm. The external effect is investigated in the context of rural neighbourhoods. According to their findings, for rice productivity and boosting potential output, household education significantly reduces production inefficiencies but there is no evidence of externality benefit of schooling in farm production.

The relevant studies on the determinants of farm productivity and efficiency related to different countries are largely inconclusive on the question of a positive return to education. The studies in the favour of positive impact of education on farm productivity by Ali and Flinn (1989), Wang *et al.* (1996), and Seyoum *et al.* (1998) conclude that there is significant role of farmer's education in raising farming efficiency in Pakistan, India, China, and Ethiopia, respectively. On the other hand, Battese and Coelli (1995) and Llewelyn and Williams (1996) fail to identify any significant impact of farmers' education on farming efficiency in India, and Java-Indonesia, respectively. Hasnah *et al.* (2004) analyzed a significantly negative impact of education on technical efficiency in West Sumatra-Indonesia. According to Hossain *et al.* (1990), Weir and Knight (2004) and Asfaw and Admassie (2004) say that there is some agreement in the literature that education significantly influences adoption of technological innovations in agriculture. According to them, the main reason of the difference in the return of education is the cross-country variation in the nature of technology underlying agricultural production.

The studies using data from Asian countries tend to find a positive return to education in farm work while such effect is often lacking for Latin America and Africa. According to Deb (1995), Wadud and White (2000), Coelli et al. (2002) and Rahman (2004) did not find any significant effect of education on production efficiency. The only study that reports a positive education effect on farm efficiency is Sharif and Dar (1996) by using 100 household samples from Bangladeshi village.

Bravo-Ortega and Lederman (2004) analyze the agricultural productivity through different aspects. According to them, electricity generating capacity per capita has had positive effects on agricultural total factor productivity (TFP), whereas roads and credit availability have had negative effects worldwide while the total factor productivity (TFP) growth is positive in the developing world. Literacy has also important effect on agricultural productivity.

Msuya and Ashimogo (2005) elaborate the technical efficiency of sugarcane production of Tanzania and found that there is positive relationship between age, education and experience with technical efficiency. There are many factors which affect technical efficiency. The age, origin of the farmer, educational level, and farm area are significant at the 10% and 5% levels of significance. The older farmers are more efficient than younger farmers which are due to good managerial skills that they have learnt over time. So the authors suggest that the younger farmers should be encouraged to work with older farmers. Better-educated farmers were found to be more efficient than the less educated while migrant farmers are to be less efficient.

According to Duraisamy (1992) education and extension has positive impact on agriculture production by analyzing the Indian and Tamil Nadu paddy regions area. He has further analyzed that the labour, fertilizer, animal input, capital and land has also positive effect on the agricultural productivity.

Backman and Lansink (2004) analyze experimental data set of fertilizer field trials at different locations of cereals production in Finland over the period 1977–1994 of different soil types. They analyzed that clay is the most mineral efficient and productive soil; silt and organic soils are the least efficient and productive soils.

In case of Pakistan, Ali and Flinn (1989) using the profit frontier approach found an average economic efficiency of 69 percent for the Basmati rice farmers in Punjab using data from Gujrawala district. Farmer's education, lack of credit facility, late application of fertilizer, and irrigation constraints were considered to be the factors for low efficiency. The analysis of Battese *et al.* (1993) using wheat data from Faisalabad, Attock, Badin and Dir shows that technical inefficiencies exist in three of these districts that are Faisalabad, Badin and Dir. The study suggests that the adoption of new technology and a good agricultural extension system are required to enhance the efficiency of the wheat farmers.

There are many factors that affect technical efficiency like farmer's education; credit, age, experience, owner/tenant and the extent of land fragmentation are the ones. Parikh *et al* (1995) using cost function found an average inefficiency of about 12 percent. The study concluded that the small farmers were more efficient than the large farmers and by education, extension service and credit could reduce inefficiency.

2.5 IMPACT OF TRACTOR PLOUGHING AND BULLOCK PLOUGHING ON PRODUCTIVITY AND EFFICIENCY

There is dramatic increases in rice output and productivity in Vietnam due largely to market reform, inducing farmers to work harder and use land more efficiently analyzed by Tom Kompas (2004). The farms in the main rice growing regions, those with larger farm size and farms with a higher proportion of rice land ploughed by tractor are more efficient, suggesting the need for additional reforms to augment productivity. The other study by Battese and Coelli (1995) analyzes the impact of operated land, proportion of the operated land that is irrigated, total hours of family and hired labour, the hours of bullock labour used and costs related to the value of fertilizer, manure, pesticides, machinery etc. on the Indian paddy farmers 1975-76 to 1984-85 productivity. There is positive relationship to all these except bullock labour due to the fact that it is used more extensively in years of poorer rainfall when yields are lower. For inefficiency analysis, they use the age, schooling (years of formal schooling of the primary decision maker) and year (the year of the observation involved). Age has positive impact which indicates that the older farmers are more inefficient than the young ones. While the negative impact of schooling implies that farmers with greater years of schooling tend to be less inefficient. The negative coefficient of year relates that the inefficiencies of production of the paddy farmers tended to decline throughout the ten-year period.

The study conducted by Sharma and Leung (2000) based upon Indian carp production for efficiency for 1994-95 relates that there is positive impact of adoption carp culture as a primary activity on technical efficiency. While the more experienced farmers and owner-operated farmer are more efficient than less experienced and tenant-operated ones. Seed, organic manure, labour; feed has positive impact on the productivity. Primary activity, experience, owner-operated, pond area, fish management, water management and feed management analyzed for technical efficiency. The analysis shows that semi-intensive/intensive farms are technically more efficient compared with extensive ones relative to their respective technologies. Fish management practice for extensive farms, the adoption of recommended fish, water and feed management practices has positive impact on technical efficiency.

The age of decision maker farmer may have a positive or negative effect upon inefficiency. Farming experience can be achieved with increasing age reduce inefficiency. However some older farmers are less receptive and more conservative adopting new technologies and practices.

The study of cane growing farmers by Khanna (2006) analyzes education, land area, discharge of tube-well and distance of plots from the water source for technical inefficiency. Technical efficiency are the highest on plots where water is sourced from a privately owned tub-well, followed by plots serviced by partnered tube-wells and lowest on plots where water is bought.

Byerlee (1992) has narrated a sequential process of technical change that is useful in the analysis of the sources of productivity gains in wheat production which comprises upon four phases. In the period of pre-Green Revolution Phase, the gains in productivity per unit area are modest and the area expansion is the main source of wheat production increases. In the green revolution phase, due to availability of modern varieties enable a dramatic jump in productivity even with modest levels of purchase inputs and management practices. In the First Post-Green Revolution Phase, farmers move toward improving allocative efficiency by adjusting the use of purchased inputs toward their optimal levels. In the Second Post-Green Revolution Phase, farmers achieve greater technical efficiency in using available purchased inputs through better use of non-purchased inputs such as information and management skills. Farmers' accumulated experience with a technology leads to a better understanding of the technical relationships between inputs and outputs, hence information and management skills substitute for greater input use.

The study by Wadud and White (2002) highlights some determinants of technical inefficiency of farms in Bangladesh. Although all these inputs like land input, labour cost, irrigation, fertilizer, pesticides cost has positive impact on productivity. According to them, land as an input has major influence on output. Age of the farmer, farmer's years of schooling, land fragmentation, irrigation infrastructure, and environmental degradation have been incorporated for technical efficiency and concluded that age, year of schooling, irrigation increases technical inefficiency while land fragmentation and environmental degradation reduces technical inefficiency.

Battese *et al.* (1996) analyzed Pakistan data for 1986-87 to 1988-89 for measurement of productivity and efficiency of wheat farmers. They have used land, labour, amount of hired labour, fertilizer, hours of land preparation, tractor plowings, wheat seed sown, owner/tenant and year as inputs and determined age, school, adult (ratio of adult males to the total household size), year as important determinants of inefficiency.

2.6 SUSTAINABILITY

Agriculture sector plays a pivotal role in any country's economy. All agriculture products carry its own benefits but wheat is a stable item which has the most important for any country. Its productivity has positive impact on all sectors but it should be efficient and sustainable. Sustainability is a key element in production because without it, productivity does not have any importance. If there is production of any product at efficient level along with sustainable element then it should be positive impact on all sectors of any country.

2.6.1 The Evolution of Thinking on Sustainability

Sustainability has long history since 1798 when Malthus pointed out that if population growth continues unrestrained, it would lead to starvation and war. While environmental concerns about limits to growth began to emerge in the 1950s and 1960s, which stimulated different debates about future scenarios. In the 1960s, there was an environmental risk caused by agriculture, driven in particular by Carson (1963) in his book *Silent Spring*. In the 1970s, there was report on "Limits to Growth" by Meadows *et al.* (1972) who analyzed the problems faced by the societies when environmental resources were overused, depleted or harmed. He further suggested that there is need for different types of policies to generate sustainable economic growth. At that time, sustainable development was defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". The concept implied both limits to growth and the idea of different patterns of growth.

2.6.2 Concept of Agricultural Sustainability

Various terms are used which imply greater sustainability in agricultural systems than in prevailing systems. According to Pretty (2002) each emphasizes different values, priorities and practices.

The main aspects on agriculture sustainability are as, first interpretation depends upon the types of technology in particular settings, especially strategies that reduce reliance on non-renewable or environmentally harmful inputs. These are ecoagriculture, permaculture, organic, ecological, low-input, biodynamic, environmentally-sensitive, community-based, farm-fresh and extensive strategies. There is much debate upon this issue that whether agricultural systems using some of these terms actually qualify as "sustainable".

Second term relevant to sustainability in agriculture systems is viewed in terms of resilience (the capacity of systems to buffer shocks and stresses) and persistence (the capacity of systems to carry on). It implies the capacity to adapt and change as external and internal conditions change. Cernea (1991) and DFID (2002) have analyzed the environmental aspects to include first economic and then wider social and political dimensions such as:

- Ecological

It relates that the most important elements are to reduce negative environmental and health externalities, enhance and use local ecosystem resources, and preserve biodiversity.

- Economic

From agricultural sustainability aspect is to assign value to ecological assets, and also to include a longer time frame in economic analysis. According to them, subsidies are necessary because it promote the depletion of resources or unfair competition with other production systems.

- Social and political

There are many concerns about the equity of technological change. Agricultural sustainability is associated with farmer participation, group action and promotion of local institutions, culture and farming communities at local level. While at the higher level, the concern is for enabling policies that target poverty reduction.

According to Tilman *et al.* (2002) and Pretty (2004) suggest that new incentives and policies are necessary for the sustainability of agriculture if we are to meet the demands of improving yields without comprising environmental integrity or public health. According to World Bank report (2003), public policy should internalize all costs and benefits in the prices of production inputs for agriculture's efficiency and sustainability. It can be achieved through improving pricing mechanisms for irrigation water, facilitating land market development, eliminating distorting taxes and subsidies on agrochemical inputs, including fertilizers.

Sources of yield growth in wheat are investigated based on a stylized framework of technical change by Rejesus *et al.* (1999). They have further analyzed that the relative contribution of input intensification to yield growth has reduced in recent years and is likely to continue to decline in the future. The major source of yield growth in wheat during the medium to long term is due to improved efficiency of input use, rather than input intensification, through sustainable wheat production practices rather than pure input increases. The wheat output can be increased by adoption of newer and better modern varieties based on advances in wheat breeding while the wide crossing and biotechnology could improve the stability of wheat yields in the intermediate term; their long-term impact on yield under optimal conditions is less certain. For better or necessary gains in wheat yield, the better technological techniques should be adopted. Investment in wheat research is necessary to achieve production levels consistent with constant or slowly declining real world wheat prices.

The study by Mohiuddin *et al.* (2007) narrates a broad quantitative analysis of efficiency and sustainability of maize cultivation at farmers' field. They have further explored that there are high potentials for adoption of maize in that particular region due to agro-climatic point of view. The study revealed that all farmers used hybrid maize and the rate of changes the area, production and yield of maize increased dramatically after the release of hybrid varieties. The study further reveals that the farmers in the study area have failed to show their efficiency in using the resources but the farmers was obtained technical efficiency (98%). For the better maize production the credit at low interest, supply of inputs at fair prices, availability of post harvest technology and pesticide are important measures. According to them, seed, irrigation, urea, manure, human labour and ploughing have positive impact on maize productivity as well as efficiency.

The other study by Munir et al. (2002) using farm level data of Pakistan for 1997-98 estimated stochastic frontier function and found that there is positive relationship between wheat productivity and higher and balanced use of fertilizer nutrients. Wheat productivity is greater for having more reliable irrigation systems. While the efficiency analysis indicates the average technical efficiency about 68 percent which concludes that an average farmer is producing 32 percent less than the achievable potential output. The technical inefficiency is negatively related with the farm size which shows that the larger farmers possess higher education and having greater access to better irrigation arrangements, extension services. They also apply higher doses of chemical fertilizer with more balanced nutrients. The farmers have greater access to credit and close to the markets are more efficient than other ones. They further conclude that there is considerable scope to enhance output and productivity by increasing production efficiency at the relatively inefficient farms and sustaining the efficiency of those operating at or closer to the frontier. The Punjab farmers are relatively more efficient than other ones belonging to Sindh and NWFP because Punjab farmers are better off and easy to access irrigation and agricultural extension facilities and also are more educated.

2.7 EMPIRICAL EVIDENCE

In the present section, we provide the empirical work done on the subject. There are different studies on the subject in various developed as well developing countries like Pakistan. We narrate the empirical findings of various studies in the following table which is self-explanatory.

Table 2.1 Summary of Empirical Findings

Author (s)	Countries and Time Periods	Measurements	Major Findings
Sahota	Uttar Pradesh and Bombay, India (1968)	Allocative Efficiency	• Estimated on an average capital value of 0.8 for bullock labor and 1.05 for fixed capital.
Barnum and Squire	India (1978)	Allocative Efficiency	• Estimated a capital value of 2.7 for variable inputs (presumably fertilizer) and concluded that the farmers were allocatively efficient.
Hussain and Young	Pakistan (1985)	Allocative Efficiency	• Estimated a capital value of 13.5 and 1.8 for fertilizer and irrigation inputs, respectively.
Bliss and Stern	Palanpur, India (1982)	Allocative Efficiency	• Estimated a capital value of 3.5 for fertilizer inputs.
Parikh *et al.*	Northwestern, Pakistan (1995)	Technical Efficiency	• Technical inefficiency estimated at 11.3%. At the aggregate level, inefficiency was attributed to under use of hired labor, fertilizer, manure, as well as the overuse of animal labor.
Hussain,	Northern, Pakistan(1989)	Technical Efficiency	• Technical inefficiency estimated at 31%. Factors that significantly influence efficiency are new seed, seed treatments, density, and knowledge score.
Johnson *et al.*	Ukraine (1994)	Technical Efficiency	• Technical inefficiency estimated at 13–16% for grain farms (including wheat) from 1986 to 1991.

(Continued)

Author (s)	Countries and Time Periods	Measurements	Major Findings
Aly *et al.*	Illinois, USA (1987)	Technical Efficiency	• Total combined inefficiency estimated at 42%, with 25% attributed to technical inefficiency.
Huang and Bagi	Haryana, India (1984)	Technical Efficiency	• Technical inefficiency estimated at 11%, but did not explain sources of inefficiency.
Fan and Kalirajan	Northern China (1991)	Technical Efficiency	• Technical inefficiency estimated at 28% in 1985.
Azhar	Pakistan 1991	Technical Efficiency	• Estimated that one additional year of schooling leads to a 1.28% increase in farm output of farmers using modern varieties.
Butt	Irrigated Pakistan (1984)	Technical Efficiency	• Primary education increased productivity 7% and secondary education by 10.7%. Strong positive interaction of education and fertilizer use.
Jamison and Moock	Nepal (1984)	Technical Efficiency	• Education impact on productivity as the completion of at least 7 years of schooling increased productivity in wheat by 27–31%.
Pudasaini	Bara District, Nepal (1976)	Technical Efficiency	• Higher education has also positive impact as an additional year of education was found to increase output by 1.3%. The coefficient of education on agricultural productivity was estimated at 1.4%.

(Continued)

Author (s)	Countries and Time Periods	Measurements	Major Findings
Feder *et al.*	Haryana, India (1987)	Technical Efficiency	• Education increased wheat productivity by 1% per year of schooling. The training and visit extension system also increased productivity by 9%.
Sidhu and Baanante	Punjab, India (1979)	Technical Efficiency	• An additional year of farmer education makes an estimated contribution of 1.7% in wheat production. Coefficient of education on agricultural productivity estimated at 3.6%.
Chaudhri	Punjab, Haryana, and Uttar Pradesh, India (1976)	Technical Efficiency	• Coefficient of education on agricultural productivity estimated at 11.5%. Estimated increase in output per additional year of education was 6.47%.
Yotopolous	Greece (1967)	Technical Efficiency	• The coefficient of education on agricultural productivity was computed as 13.8%.
Battese and Broca	80 wheat farmers in Pakistan, 1986-87 to 1988-89 and 1990-91 (1997)	SPF with technical inefficiency effects (one-stage approach)	• The main factors for technical inefficiency are age, school, owner/tenant, constrained by credit availability and year.
Alyarez and Gonzalez	82 Spanish dairy farms, 1986-1995 (1998)	SPF with residual analysis (two-stage approach)	• Age, artificial meadow, genetic level, other familiar income sources and area are main contributors in technical inefficiency.

(Continued)

Author (s)	Countries and Time Periods	Measurements	Major Findings
Arnade and Carlos	International (1998)	International Agricultural Efficiency and Productivity	• Multifactor agricultural productivity for seventy countries is calculated using a programming method. Productivity measures are divided into indices that measure technical efficiency and technical change. • Agriculture in many developing countries is technically inefficient but technical change has had a greater impact on agricultural productivity. • Multifactor productivity is declining in many developing countries where both agricultural output and the use of some agricultural inputs have rapidly grown. • The level of education in a country and research services are factors which can explain differences in agricultural productivity growth between countries.
Battese and Coelli	125 Indian paddy farmers, 1975-76 to 1984-85 (1995,1996)	SFP with technical inefficiency effects (one-stage approach)	• The main determinants of technical inefficiency are Age, schooling and year.
Battese *et al.*	139 wheat farmers in Pakistan, 1986-87 to 1988-89 and 1990-91 (1996)	SPF with technical inefficiency effects (one-stage approach)	• Age, school, adult (ratio of adult males to the total household size) and year are main determinants of technical inefficiency.

(Continued)

Author (s)	Countries and Time Periods	Measurements	Major Findings
Gaofen Han *et al.*	East Asia and the rest of the world (2003)	Productivity, Efficiency and Economic Growth	• This study compares the sources of growth in East Asia with the rest of the world, using a methodology that allows one to decompose total factor productivity growth into technical efficiency changes (catching up) and technological progress. It applies a varying coefficients frontier production function model to aggregate data for the period 1970-1990, for a sample of 45 developed and developing countries. • Results are consistent with the view that East Asian economies were not outliers in terms of total factor productivity growth. Of the high-performing East Asian economies, our methodology identifies South Korea as having the highest total factor productivity growth, followed by Singapore, Taiwan and Japan. • Methodology also allows us to separately estimate technical efficiency change, which is a component of total factor productivity growth, and we find that, in general, the estimated technical efficiency of the high-performing East Asian economies was not out of line with the rest of the world.
Ferrantino and Ferrier	239 firms from Indian vacuum-pan sugar industry1980-81 to 1984-85 (1995)	Stochastic Production Function with residual analysis (two-stage approach)	• Determinants of inefficiencies are, organizational from (private, cooperative or public); length of the factory's crushing season in days (duration); experience; domestic equipment only, foreign equipment only.

Chapter No. 3
DESCRIPTIVE ANALYSIS

3.1 HISTORY OF THE DISTRICT FAISALABAD

Faisalabad is a city located in Punjab, Pakistan which was came into being in 1988. It was formerly known as Lyallpur. Faisalabad is the third largest city in Pakistan with an estimated 2006 population of 2.6 million (city proper). The entire district had a population of about 5.4 million in 1998. It is an important industrial centre which is located in the Punjab province, west of Lahore. The city-district of Faisalabad is bound on the north by the districts of Gujranwala and Sheikhupura, on the east by Sahiwal, on the south by Toba Tek Singh and on the west by Jhang.[1]

Its land is fertile and fruitful. It plays a pivotal role in the economy of Pakistan. The other main employment section of the district is agriculture sector and almost 44 percent people are attached to this sector. Due to fertile land, many crops are harvested in the district like wheat, sugarcane, cotton, rice, fruits and fodder crops. The most important crop is wheat which contributes 12.7 percent to the value added in agriculture and 2.6 percent of GDP.

3.2 PROCEDURE OF SAMPLE SELECTION AND DATA STATISTICS

The current study is based upon primary data collected through questionnaire[2] from the Faisalabad district. For our study, we have selected this area due to its importance in the

[1] Pakistan Population Census Organization (1998), World Gazetteer estimate (2006).
[2] Detailed questionnaire is presented in Appendix.

economy of Pakistan and also due to a large number of populations are attached to this sector and grow various crops from wheat to fodder. The other reason is to analyze the impact of advanced techniques used in agriculture sector in this region. Our study is mainly relevant to wheat crop although we have also collected data related to other crops like sugarcane, cotton, rice etc. Wheat is a stable food in Pakistan and is grown over a large area. Our main objective is to analyze the trend of wheat production, its efficiency and sustainability with various factors contributing to wheat production.

According to Government of the Punjab report (2007), the total population of Punjab is 89036 thousand with 3454 union councils from which 974 are urban and 2490 rural respectively. It further explores that Faisalabad has 2408 thousand population with 3.58 percent per annum average growth. The total cropped area of the Punjab is 15174 thousand hectares in 2005-06.

Faisalabad district has four tehsils namely; Samundri, Tandianwala, Jaranwala and Chak Jhumra. We have used multistage random sampling technique and selected two tehsils from the district Faisalabad, namely; Chak Jhumra and Samundri. The overall number of union councils in the district is 289 with 28 in Samundri and 15 in Chak Jhumra as well.[3]

We have randomly selected two union councils as the representative of our study from each tehsils. So, the total numbers of union councils are four which are selected for this analysis. The survey is conducted in the month of July-August 2006-07 in the harvesting

[3] Government of the Punjab Report, (2007) by Bureau of statistics planning and development department, Union council report (2005).

season of the wheat crop. The total number of randomly selected villages from the four unions' councils is twelve; three was selected from each union council respectively. It is tried to gather maximum information through questionnaire from decision maker farmer's name and education to distance from farm to market as well as extension officer etc. The all houses in the village are interviewed based upon number of houses in the village. For example, for sixty farmers if we have selected the first house and for second farmer, we have selected the 5th one for interview and if he is not farmer then we dropped him from our analysis and picked the next one. The other main objective is that we have interviewed only farmer not any other ones. So, the total sample size is 720 farmers; 360 from each tehsil and 60 from each village.

The selected two tehsils Chak Jhumra and Samundri has fertile land although there is some area which is affected by various problems like salinity and water lodging. The details of them are summarized in the following tables.

Table 3.1 Number of union councils, villages, population, houses in Chak Jhumra and Samundri

Tehsil Name	Union Councils	No. Villages/Mohallas/Colonies	Population	No. of Houses
Chak Jhumra	15	77	2,61,907	41,702
Samundri	28	180	6,25,082	95,733
Total	**43**	**257**	**8,86,989**	**1,37,435**

Source: Union council's headquarters report (2005).

Faisalabad district has 289 union councils from which 15 are Chak Jhumra and 28 Samundri as well. Chak Jhumra and Samundri have 77 and 180 villages, mohallas and colonies respectively. From these 43 union councils, we have selected four union councils for our analysis as representative of Faisalabad as well as tehsils level. The further details are illustrated in table as well as graph.

Figure No. 1 Population of Chak Jhumra and Samundri

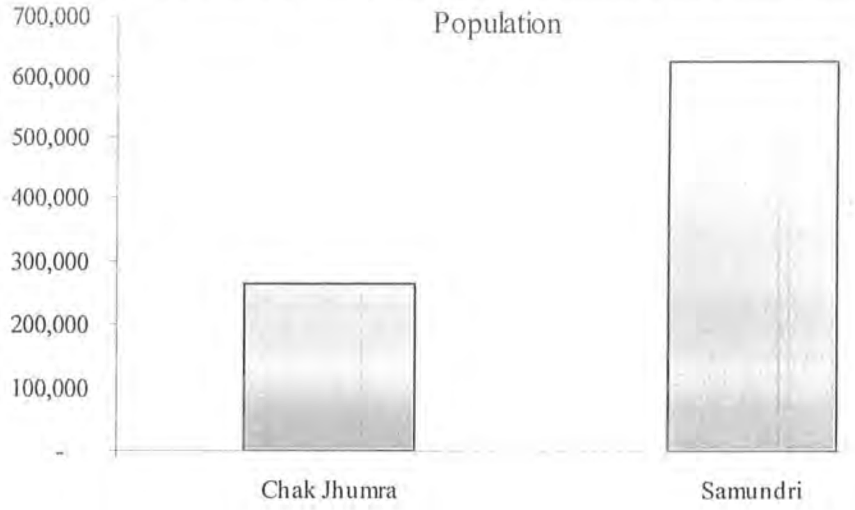
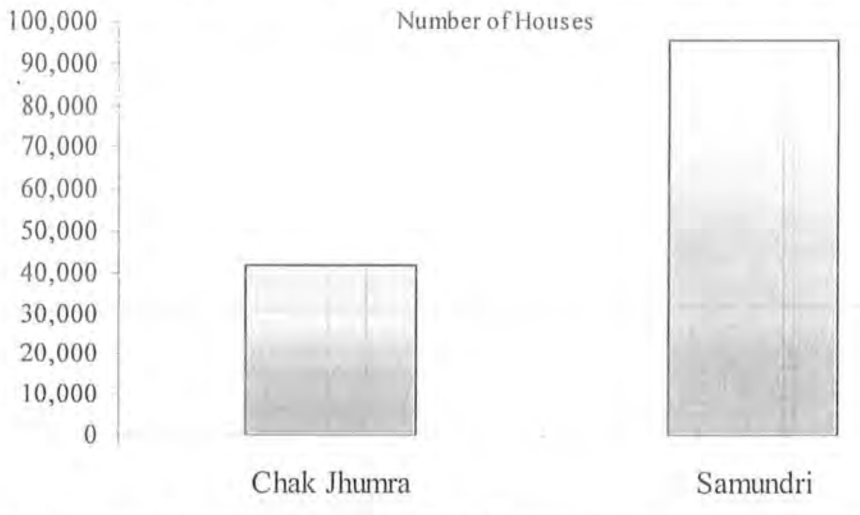


Figure No. 2 Number of Houses of Chak Jhumra and Samundri



Source: Union Council report prepared by the respective council's secretary (March 2005)

The above graph shows that the tehsil Samundri is greater than Chak Jhumra through all aspects. Chak Jhumra has 261,907 populations along with 41,702 houses while Samundri tehsil has 625,082 and 95,733 respectively with 77 and 180 villages /mohallas/colonies.

On the other hand, the socio-economic profile of Chak Jhumra and Samundri are as follows.

3.3 CHAK JHUMRA

Chak Jhumra is a town near the city of Faisalabad situated near the Rakh Branch canal. It is a sub-division of Faisalabad district and has a tehsil municipal administration. Chak Jhumra town consists of 15 union counsils. It is connected to different cities like Salarwal, Shahkot, Chiniot and Faisalabad. Its land is fertile although there is some logging and waste area in the tehsil. A sizeable population is attached to power looms for their livelihood. The other main source of livelihood of the people is agriculture sector. Its area is irrigated through three main sources, canal, tube-well and canal tube-well mixed. Jhang Branch and Rakh Branch are the two main canals which irrigates the area although other sources are also used. The Rakh Branch Canal was dug in 1892. Rakh Branch starts from canal Lower Chenab. While Lower Chenab comes out from Head Khanki at the river Chenab. It passes and distributes water to Hafizabad, and Faisalabad etc. The other canal which irrigates the area is the Jhang Branch that originates from the Lower Chenaab. It is the longest canal of which irrigates a large part of the area of Faisalabad, Jhang and Toba Tek Singh. The randomly selected union councils from this tehsil are 9 and 10 respectively whose details are as follows.

3.3.1 Union Council No. 9

Total number of villages in this union council is five with 6,350 houses and 27,700 populations. The detail of each village is as following:

Table 3.2 Villages Names, Population and Number of Houses of Union Council No. 9

Sr. No.	Village No.	Village Name	Current Population	No. of Houses
01	102 JB	Burj Mandi	10,000	2,000
02	103 JB	Barnala	10,000	2,000
03	106 JB	Khachiean	3,700	1,000
04	109 JB	Nanilian Wala	2,000	600
05	110 JB	Sukhwala Hawali Baby Wala	2,000	750
Total			**27,700**	**6,350**

Source: Union council's headquarters report (2005).

3.3.2 Union Council No. 10

This union council consists of five villages with 19,936 populations and 2,645 houses. From these five villages 23 JB has the greater population as well as houses with 7,274 and 864 respectively than any other ones.

Table 3.3 Village Names, Population and Number of Houses of Union Council No.10

Sr. No.	Village No.	Village Name	Current Population	No. of Houses
01	20 JB	Khankay	3,528	593
02	23 JB	Bhattian	7,274	864
03	24 JB	Lahorian	3,866	428
04	25 JB	Stoywala	4,126	548
05	467 JB	Chodhrian	1,142	212
Total			**19,936**	**2,645**

Source: Union council's headquarters report (2005).

The total population of union council 9 and 10 are 47636 with 8995 houses respectively.

3.4 SAMUNDRI

The present site of Samundri city was Chak No. 533.G.B in 1887. Later on it was named Samundri after the name of a nearby pond. Up to 1904, it was a tehsil in District Jhang. With the creation of Layallpur District the Samundri tehsil was transferred to 'this District. Total area of the tehsil was 4, 99,462 acres which was reduced to 2, 22,005 acres as a result of its bifurcation in 1994. The lands of the tehsil Samundri are irrigated by Gogera and Burala branch canal. All villages of the tehsil carry G.B. with their Chak numbers. Sugar cane is the major cash crop of the area. Wheat, cotton and vegetables are also grown in the area. Samundri is situated at a distance of 45 K.M. from Faisalabad. There are 28 union councils in this tehsil among which two are randomly selected which are 116 and 125. The detail of these tehsils is as follows.

3.4.1 Union Council No. 116

Union council 116 has four villages whose people's most livelihood is based upon agriculture sector because most of them are attached to this sector. Its population is 21,652 with 3,435 houses as well. The further detail of the union council is given below:

Table 3.4 Villages Names, Population and Number of Houses of Union Council No. 116

Sr. No.	Village No.	Village Name	Current Population	No. of Houses
01	468 GB	468 Gb	4,752	895
02	469 GB	469 Gb	5,637	936
03	470 GB	470 Gb	7,995	1,068
04	472 GB	472 Gb	3,268	536
Total			**21,652**	**3,435**

Source: Union council's headquarters report (2005).

3.4.2 Union Council No. 125

The union council 125 has seven villages along with 17,952 populations and 2,944 households as well. The detail is as follows:

Table 3.5 Village Names, Population and Number of Houses of Union Council No.125

Sr. No.	Village No.	Village Name	Current Population	No. of Houses
01	168 GB	Siraj	2,756	500
02	169 GB	Theekran	2,997	465
03	385 GB	385 Gb	2,305	280
04	438 GB	Perth	2,048	274
05	461 GB	Badowall	1,607	175
06	462 GB	Essa Naghri	1,767	250
07	463 GB	463 Gb	4,472	1,000
Total			**17,952**	**2,944**

Source: Union council's headquarters report (2005).

In these union councils, the farmers mostly grow sugarcane, wheat, cotton and rice at some area. Most of the people in the area are attached to agriculture sector. The most populated village is 463 GB with 4,472 populations with 1,000 houses as well.

From these four unions' councils, we further analyzed 12 villages by selecting three villages from each union council respectively. From each village, we have randomly selected sixty farmers for agriculture information particularly wheat product, its production detail per acre and inputs used for its production. We have also gathered the other relevant information like education of the decision maker farmer, his age, experience of farming, higher education of any family member etc. The randomly selected villages' details are as following:

Table 3.6 Randomly Selected Villages' Names, Population and No. of Houses

Sr. No.	Village No.	Village Name	Current Population	No. of Houses
01	23 JB	Bhattian	7,274	864
02	24 JB	Lahorian	3,866	428
03	25 JB	Stoywala	4,126	548
04	103 JB	Barnala	10,000	2,000
05	106 JB	Khachiean	3,700	1,000
06	109 JB	Nanilian Wala	2,000	600
07	168 GB	Siraj	2,756	500
08	438 GB	Perth	2,048	274
09	463 GB	463 GB	4,472	1,000
10	468 GB	468 Gb	4,752	895
11	469 GB	469 Gb	5,637	936
12	470 GB	470 Gb	7,995	1,068
Chak Jhumra selected villages total			30,966	5,440
Samundri selected villages total			27,660	4,673
Overall			**58,626**	**10,113**

Source: Union council's headquarters report (2005).

The most populous village from both tehsil is 103 JB with 10,000 population and 2, 000 houses which is under union council no. 11 of tehsil Chak Jhumra. Its people are attached with government sector as well as agriculture sector. They mostly grow the sugarcane, wheat, a little area of rice and fodders like maize, jawar, bajra etc. The randomly selected twelve villages population is 58,625 along with 10, 113 houses.

3.5 DESCRIPTIVE ANALYSIS OF THE DATA

Faisalabad is the most populated city of Pakistan and its land is fertile. For our analysis, we have selected this city as the main study area. Different crops are cultivated in this area. Wheat is the major crop in the area. Most of the selected people grow wheat in their land lower or higher area depending upon market price, cost of production and their family size. The other crops include sugarcane, rice, cotton, maize, bajra, jawar etc. Firstly, we elaborate the education level in the area that how much people are literate, illiterate at what level.

Table 3.7 Farmers and Family Members' Education Level

Level of Education	Overall		Chak Jhumra		Samundri	
	Farmer Education	Family member's Education	Farmer Education	Family member's Education	Farmer Education	Family member's Education
Illiterate	366	335	169	191	197	144
Literate	354	385	191	169	163	216
Up to Primary	76	34	16	12	60	22
Up to Metric	210	207	132	86	78	121
Up to Intermediate	41	76	24	32	17	44
Up to Graduation	18	53	14	29	4	24
Up to Master	8	15	4	10	4	5
Above than Master	1	0	1	0	0	0

Table 3.7 shows the farmers education level as well as family member education at different stages from primary to higher level. It also identifies the number of persons in each category as well as number of literate and illiterate ones. The family members are more literate than farmers at overall analysis while in Chak Jhumra family members are less educated as compared to Samundri. Most farmers in the area are more education at than family members up till matriculation but above it, the farmers' family members are more educated than farmers. There is custom of early marriage in the area due to which a person is engaged to marriage and cannot study further. If a farmer has some educated, he does not marry his sons and provide them to study them for higher level due to which the family members are more educated from intermediate to master level at overall level.

Table 3.8 Tenancy Status, Waste Area and Operational Area (in acres)

Type of tenancy	Overall	Chak Jhumra	Samundri
Owned	5858	3097.55	2760.8
Leased Out	170	170.00	0
Leased In	854	535.40	318.5
Shared Out	48	33.70	14.40
Shared In	193	138.04	71.1
Waste	132	82.70	48.8
Operational	6548	3455.05	3093.4

Table 3.8 indicates the tenancy status in the selected area that how much farmers has what type of land. It further analyzes that there is a large number of area which is under owned that is 5,889 in 2005-06 while it has decrease in 2006-07 with 5,858 acres. Chak Jhumra farmers have higher owned area than Samundri. The other main category of farmers in Faisalabad is who has leased in area which has 856 acres area in 2005-06 while it has decreased in 2006-07 slightly as indicated in the above table at all levels. There is no change in the shared in area at overall and individual level as is shown the table 3.8.

The operational area has increased from 6,538 acres to 6,548 in 2005-06 and 2006-07 respectively at overall as well as individual level. There is no farmer in Sammundri who has leased out any part of his land while in Chak Jhumra some farmers have leased some area. In the following table we are elaborating the persons who fall in the above categories as number of persons at overall as well as individual level.

Table 3.9 Tenancy Status in the Area as Number of Persons in Each Category

Type of tenancy	Overall	Chak Jhumra	Samundri
Owned	699	359	340
Leased Out	34	34	0
Leased In	147	93	54
Shared Out	17	14	03
Shared In	30	17	13

Table 3.9 indicates the number of persons who belongs to each category of tenancy status from owned area to share in area. The most farmers of the area have their owned lands who are 700 out of 720 in 2005-06 and there is no significant change in 2006-07. The

other main people are who has leased in area which is more in Chak Jhumra than Samundri. These are the two main category of the tenancy in the area.

Table 3.10 Area in Acres as Irrigated Through Various Sources

Sources of irrigation	Overall	Chak Jhumra	Samundri
Canal	520.9	470.9	50
Tube well	1127.2	1011.8	115.4
Canal+ Tube well	4909.65	1981.65	2928
Total Area	**6557.75**	**3464.35**	**3093.4**

The canal and tube well are the main source of irrigation in Faisalabad district although there is slightly reduction of this source of irrigation at all level. The area irrigated from canal and tube well has decreased from 6,890 to 4,909 acres in 2005-06 and 2006-07 respectively and also at tehsiles level. The other most important source is tube well both at district as well as tehsile level as is shown in the above table. Although canal is the most widely used source but in our analysis a meager farmers depend upon this source as in Sammundri only 58 and 50 acres are irrigated in 2005-06 and 2006-07.

Table 3.11 Number of Farmers Using various Source of Irrigation

Sources of irrigation	Overall	Chak Jhumra	Samundri
Canal	60	53	07
Tube well	120	107	13
Canal+ Tube well	602	252	350

According to above table, it is shown than most of people in the area canal plus tube well is most used source of irrigation. The people of the area when asked why they this source more than other ones. They told that canal water is available at low level which does not fulfill their requirement for wheat crop due to which they have to use the other source of irrigation. There is small proportion of the people who uses canal irrigation although it has significant role in wheat crop for maximum production.

Table 3.12 Cash Crops in the Area (in acres)

Crops type	Overall	Chak Jhumra	Samundri
Basmati (Paddy)	695.4	290.4	405
Irri (Paddy)	1	1	0
Sugarcane (Fresh)	633.3	539.3	94
Sugarcane (Ratoon)	1627.8	982.5	645.3
Cotton	617.5	62.6	554.9
Total Area	3575	1875.8	1699.2

The major cash crops are basmati, sugarcane and cotton in the area. Basmati crop area decreased at all level but in Sammundri it has creased slightly from 389 acres to 405. While the sugarcane (fresh) has decreased drastically from 1102 to 633 in 2005-06 and 2006-07 respectively at all level. The sugarcane (ration) has increased in both years. Only a meager area is under cotton area in Chak Jhumra while a large portion is grown in Sammundri. If we analyze the overall area of these crops then it has increased at all level.

Table 3.13 Number of Cash Crops Farmers in Each Crop

Crops type	Overall	Chak Jhumra	Samundri
Basmati (Paddy)	548	233	315
Irri (Paddy)	01	01	0
Sugarcane (Fresh)	387	311	76
Sugarcane (Ratoon)	653	340	313
Cotton	253	21	232

Most of the people in the area grow most of sugarcane than other crops because it is less labourious and considered as cash crops. The number of people who grow sugarcane has decreased as fresh but ratoon grower has increased at all levels. The other main crops are basmati, cotton. The number of basmati grower decreased because it needs a plenty of water and also needs special attention like to provide fertilizer as well as pesticides whose prices are increased. Due to these reasons, the number of farmers has decreased to grow this crop.

Table 3.14 Major Fodder Crops (in acres)

Types of Fodder	Overall	Chak Jhumra	Samundri
Maize	935.4	536.4	399
Jawar	661.5	378.8	282.7
Bajra	500.5	344.7	155.8
Spring Maize	9.5	9.5	0
Berseem	563.9	407.1	156.8
Lucerne	105.2	66.8	38.4
Total	**2776**	**1743.3**	**1032.7**

The fodder related crops is decreased at all level from 2910 to 2776 and at individual level from 1821 to 1743 and from 1089 to 1032 at overall, Sammundri and Chak Jhumra in 2005-06 to 2006-07 respectively. The major fodder crop is maize which is sown at a large level because farmer has incentives to use it as animal fodder as well as for home purposes.

Table 3.15 Number of major fodder crops grower farmers in each crop

Types of Fodder	Overall	Chak Jhumra	Samundri
Maize	603	327	276
Jawar	608	334	274
Bajra	490	318	172
Spring Maize	04	04	0
Berseem	579	340	239
Lucerne	251	129	122

Almost all farmers in the area have some type of cattle due to which they grow different types of fodders like maize, jawar, bajra, spring maize, berseem, lucerne etc. Some people grow maize for fodder as well as home purposes to use it as food. The above table shows that most of the farmers grow maize and jawar as fodders. Berseem and Lucerne are also cultivated by a larger number of farmers in the area.

Table 3.16 Vegetables and other Related Products (in acres)

Types of vegetables & oilseeds	Overall	Chak Jhumra	Samundri
Mash	0.2	0	0.2
Mung	14.7	2	12.7
Gram	0.6	0	0.6
Masoor	4.4	0	4.4
Oilseeds Sunflower	4.6	0	4.6
Rapeseed/Canola	50	0.6	49.4
Chillies	6.1	0.6	5.5
Onion	17.1	2	15.1
Tomato	3.6	0	3.6
Potato	17.4	0	17.4
Peas	84.9	31	53.9
Sesame (till)	175.1	34.5	140.6
Total	**378.7**	**70.7**	**308**

The vegetables and other related area is also decreased in Faisalabad as well as at tehsil levels. The oilseed sesame occupies a large portion of land which it is cultivated. The main vegetable crop is a peas which is sown in Faisalabad region.

Table 3.17 Number of vegetables and other related crops grower farmers

Different vegetables and oil seed	Overall	Chak Jhumra	Samundri
Mash	01	0	1
Mung	12	01	11
Gram	01	0	1
Masoor	03	0	3
Oilseeds Sunflower	05	0	5
Rapeseed/Canola	48	01	47
Chillies	33	05	28
Onion	58	06	52
Tomato	04	0	4
Potato	19	0	19
Peas	75	04	71
Sesame (till)	137	32	105

Farmers also grow a various types of vegetables for their own as well as for market purposes to earn money. Peas are grown by a large number of farmers at overall in

Faisalabad but most of the Samundri areas' farmers grow it. The other vegetables related products like chillies, onion, tomato, potato, gram, masoor, till etc. are also grown by the farmers in Faisalabad although their ratio has decreased. When farmers are asked why they have reduced to produce such products, they have the reason that their cost has increased while their prices does not increased to cover the costs. It is generally observed that farmers do not get the right reward of their products in the market.

Table 3.18 Various Types of Fruits (in acres)

Major fruits	Overall	Chak Jhumra	Samundri
Orange	72.3	23.7	48.6
Mango	20	19	1
Guavava	93.6	11.4	82.2
Total Area	**185.9**	**54.1**	**131.8**

Fruits also occupy an enough area in Faisalabad. The main fruits which are planted are orange, mango and guavava. Fruits area in acres also decreased slightly in Faisalabad as well at tehsil level.

Table 3.19 Number of various fruits grower farmers in the area

Major fruits	Overall	Chak Jhumra	Samundri
Orange	43	13	30
Mango	05	04	01
Guavava	55	08	47

A large number of farmers also grow various types of fruits in the area. The main fruits are orange, mango and guavava although some others also grown like watermelon, peacot etc. There is slightly increase in the number of guavava growers in the area. Total wheat area is 3260 acres in the area.

Chapter No. 4
METHODOLOGY

4.1 INTRODUCTION

A simple measure of efficiency is defined by Debreu (1951); later Farrell (1957) redefined the concept of efficiency. According to Farrell (1957) there are two widely used methods of measuring the efficiency, first the non-parametric data envelopment analysis and second the parametric stochastic frontier analysis.

The non-parametric method initiated as data envelopment analysis (DEA) by Charnes *et al.* (1978) builds on the individual evaluation as explained by Farrell (1957). The method extends the engineering ratio approach to efficiency measures from a single-input, single-output efficiency analysis to multi-input, multi-output situations. In contrast to the parametric approach, DEA does not require any assumptions about the functional form. Other hand Aigner *et al.* (1977) and Meeusen and Broeck (1977) independently proposed the stochastic frontier production function approach models.

Coelli *et al.* (2002) argue that a researcher can safely choose any of the methods since there are no significant differences between the estimated results.

Methods which are used for measuring technical, allocative and cost inefficiency are commonly referred to as frontier approaches. There are two main methods non-parametric originated from operations research, and econometric approaches. Murillo-Zamorano (2004) provides an account of advantages and shortcomings of each one of these methods. In nonparametric approaches like Data Envelopment Analysis (DEA), the frontier is considered as a deterministic function of the observed variables but no specific functional form is imposed. Moreover, non-parametric approaches are generally easier to estimate and can be implemented on small datasets. On the other hand, parametric methods allow for a random unobserved heterogeneity among different farmers but need to specify a functional form for the cost or production function. The main advantage of such methods over non-parametric approaches is the separation of the inefficiency effect from the statistical noise due to data errors, omitted variables etc. Another advantage of parametric methods is that these methods allow statistical inference on the significance of the variables included in the model, using standard statistical tests. In non-parametric methods on the other hand, statistical inference requires elaborate and sensitive re-sampling methods like bootstrap techniques.

The basic idea of stochastic frontier production function approach is that, the production frontier has an error term with two components, one for random effects beyond the control of the producer (weather, etc.) and another for technical inefficiency, which is under the individual's control. The strengths of the stochastic frontier approach are that it deals with the stochastic noise and permits statistical tests of hypotheses pertaining to the structure and the degree of inefficiency. In efficiency analysis, it is not only the level of inefficiency that is important, but the identification of the socio-economic and institutional factors that cause it.

According to Coelli *et al.* (2002) even though the approaches for the identification of these factors may vary to some extent with the methodology employed, the most commonly followed procedure in both approaches is what is usually referred to as the two-step procedure. First, the efficiency or an inefficiency index is estimated. Second, the inefficiency or efficiency index is taken as a dependent variable and is then regressed against a number of other explanatory variables that are hypothesized to affect efficiency levels.

4.2 FRONTIER PRODUCTION FUNCTION

A production function is the technological relationship between the level of inputs and resulting level of output. Neoclassical production function describes by Kalirajan and Shand (1999) is the best technique that estimates the frontier production function. The production function is as follows.

$$Y_i^* = f(X1_i, X2_i, ...Xm_i, \beta, V_i, -U_i) \qquad i = 1,2,........N \qquad 1$$

Where Y_i^* and X_i are output and inputs at the frontier of *ith* farmer, β is the parameter to be estimated and *f(.)* is the production frontier. While V_i is the stochastic (white noise or symmetric error) error term which is independently and identically distributed $N(0,\sigma_v^2)$. These are factors outside the control of the firm. U_i is a one-sided error (asymmetric noise) representing the technical inefficiency of *ith* farmer, it is non-negative random variables which are independently and identically distributed as $N(0,\sigma_u^2)$ i.e. the distribution of U_i is half normal. $|U_i| > 0$ reflects the technical efficiency relative to the frontier production function. $|U_i| = 0$ for a farmer whose lies on the frontier and $|U_i| < 0$ for a firm whose production lies below the frontier. In the neoclassical framework, it is assumed that the farmer operates at the optimum level of technical efficiency.

4.3 TECHNICAL EFFICIENCY

In the description above, technical efficiency is an output oriented measure of technical inefficiency and can be defined as:

TE_i= Observed Output / Maximum attainable output= Y_i / Y_i^*

Or

$$TE_i = Y_i / f(X1_i, X2_i, ...Xm_i, \beta, V_i, -U_i) = \exp(-U_i) \qquad 2$$

Where Y_i is the observed farm output and Y_i^* is maximum possible output using the given level of inputs and $f(X1_i, X2_i, ...Xm_i, \beta, V_i, -U_i)$ represents output at the frontier. For the inefficiency terms, there are a number of assumptions to their distribution for example normally distributed, exponential, truncated normal and normal gamma. According to Kumbhakar and Lovell (2000) shows that qualitative estimates are not sensitive to the type of distributional assumptions made. However, quantitative estimates are sensitive but their rankings do not change across the different distributions. So, there is no consensus that which distributional form to use. The half normal distribution has been widely used in the efficiency literature.

In general production function includes the Cobb-Douglas and Constant Elasticity of Substitution (CES) production function. The Cobb-Douglas production function is as follows.

$$LnY = \beta_0 + \sum \beta_i LnX_i - U_i + V_i \quad 3$$

The Cobb-Douglas is a special case of the translog production function. According to Bauer (1990) the separation of stochastic and technical inefficiency effects in the model, a distributional assumption has to be made for U_i. From the literature on technical efficiency estimation, different distribution assumptions have been proposed:

- Aigner *et al.* (1977) proposed an exponential distribution i.e. $U_i \sim N(\mu_1, \sigma_u^2)$.
- Jondrow *et al.* (1982) suggested a half-normal distribution truncated at zero i.e. $U_i \sim N(0, \sigma_u^2)$.
- Greene (1990) suggested a two-parameter Gamma / normal distribution.

According to Coelli *et al.* (1998), there are no a priori reasons for choosing one distributional form over the other, and all have advantages and disadvantages. For example, the exponential and half-normal distributions have a mode at zero, implying that a high proportion of the farms being examined are perfectly efficient. The truncated normal and two-parameter gamma distribution both allow for a wider range of distributional shapes, including non-zero modes.

4.4 ESTIMATION OF PRODUCTION FUNCTION

In this analysis, we have used two-stage approach and used Stata 8.2 version. At first stage, we have estimated stochastic half-normal frontier production function. While at second stage, we have regressed the firm-level technical inefficiency components. The model specifications are as follows

$$Ln(Yield) = \beta_o + \beta_1 Ln(Operare) + \beta_2 Ln(Ncanirrg) + \beta_3 Ln(Ntubittg) + \beta_4 Ln(Canubirrg)$$
$$\beta_5 Ln(Ndep\log) + \beta_6 Ln(Qytsed) + \beta_7 Ln(Pn) + \beta_8 (Chem) + \beta_9 Ln(Latesown)$$
$$\beta_{10} Ln(Whetorh) + \beta_{11} Ln(Cotonf) + \beta_{12} (Wsf) + \beta_{13} Ln(Wsl) + \beta_{14} Ln(Lab) + V_i - U_i \qquad ......4$$

Where:

Variables	Variable detail
Yield	Is wheat output per acre in maunds (1 maund=40kg)
Operare	Operational area in acres (farm size)
Ncanirrg	The number of canal irrigation
Ntubirrg	The number of tube-well irrigation
Cantubirrg	The number of canal plus tube-well irrigation
Ndeplog	The number of deep ploughing (tractor ploughing)
Qytsed	Quantity of seed used in kg per acre
Pn	P/N ratio[1]
Chem	If farmer used Chemical then d=1 otherwise 0
Latesown	Late sown area after 20 November as proportion of wheat area
Whetorh	Wheat sown in orchard as proportion of wheat area
Cotonf	Wheat sown after cotton crop as proportion of wheat area
Wsf	If wheat sown in fellow then d=1 otherwise 0
Wsl	If farmer has sown wheat through line method then d1=1 otherwise 0
Lab	Total labour used in wheat crop (sowing time + harvesting time)

All variables included in frontier production function are in log form.

[1] P/N is generated as number of fertilizer bag used per acre with photos and nitrogen component with their respective ingredient.

4.5 MEASURING THE TECHNICAL EFFICIENCY

For technical inefficiency, we have estimated the following function:

$$V_t = \gamma_0 + \gamma_1 Age + \gamma_2 Operare + \gamma_3 Edufr + \gamma_4 Spscd1 + \gamma_5 Hedufm + \gamma_6 Spfsd2 + \gamma_7 Owner + \gamma_8 Leastenantd + \gamma_9 Nfrmvisi \quad \ldots\ldots\ldots\ldots 5$$

Where:

Variables	Variable detail
Age	Is the age of decision maker farmer in years
Operare	Operational area (farm size) in acres
Edufr	Education of decision maker farmer in years
Spscd1	If the decision maker farmer has agriculture or science degree then d1=1 otherwise zero
Hedufm	Higher education of family member in years
Spfsd2	If family member has agriculture or science degree then d2=1 otherwise zero
Ownerd	If farmer has owner land then d=1 otherwise zero
Leastenantd	If farmer has leased tenant then d=1 otherwise zero
Nfrmvist	Number of farmer's visits to agriculture extension during wheat crop season

Technical inefficiency also estimated to analyze the factors contributing to it at overall as well as tehsil level.

Chapter No. 5

RESULTS AND DISCUSSION

5.1 INTRODUCTION

In this chapter, we illustrate the results that we have estimated for wheat productivity, efficiency and sustainability in Faisalabad. The maximum likelihood estimates of the parameters of the stochastic frontier production and inefficiency model are estimated using stata 8.2 version and applied two-stage approach in our analysis. At first stage, we have estimated the stochastic half-normal frontier production function for overall as well as tehsil level for comparison. At second stage, we have estimated farm specific inefficiency determinants at overall as well as tehsil level.

5.2 FRONTIER PRODUCTION ESTIMATION AND HYPOTHESES TESTING

We have used stata 8.2 version for this study. Before going to examine the parameter estimates of the frontier production function and the factors associated to inefficiency of the farmers, we investigate the validity of the model used for the study. The results of the tests of hypotheses are presented in table 5.1. These tests are performed using generalized likelihood-ratio statistics, LR, which is defined as: LR = -2 ln [L(H_0) / L(H_1)], where L(H_0) and L(H_1) are the values of the log likelihood function under the specifications of the null and alternate hypotheses, respectively. The LR test statistic has an asymptotic chi-square distribution with degrees of freedom equal to the difference between the number of parameters in the unrestricted and restricted models.

Table 5.1 Tests of Hypotheses

Hypotheses	Log Likelihood Function	Test Statistics χ^2	Critical Value: χ^2 0.95	Decision
$H_0: \gamma_1=\gamma_2=...=\gamma_9$	836.87	406.12	50.77	Rejected
$H_0: \beta_1=\beta_2=...=\beta_{14}$	727.67	1425.14	109.63	Rejected
Tehsil one $H_0: \gamma_1=\gamma_2=...=\gamma_9$	402.75	357.03	44.63	Rejected
$H_0: \beta_1=\beta_2=...=\beta_{14}$	351.35	648.11	49.85	Rejected
Tehsil two $H_0: \gamma_1=\gamma_2=...=\gamma_9$	448.60	777.42	86.42	Rejected
$H_0: \beta_1=\beta_2=...=\beta_{14}$	402.19	889.48	68.42	Rejected

The first null hypothesis that is tested in H_0: $\gamma_1=\gamma_2=......=\gamma_9$, which narrates that the technical inefficiencies are not affected by the independent variables included in the model. This hypothesis is rejected which means that included variables has significant role in explaining technical inefficiency. The second hypothesis which is tested is $H_0: \beta_1=\beta_2=......=\beta_{14}$ which elaborates that variables included in the model do not explain variation in frontier function is also rejected and it is not different from traditional average production function, which can be estimated using OLS. For geographical variation effect, we have also tested hypotheses at tehsil level

5.3 PARAMETER ESTIMATES OF THE PRODUCTION FRONTIER AND THE ISSUE OF SUSTAINABILITY

The total numbers of variables estimated are 23 from which 14 are in the stochastic frontier production model and 9 in the inefficiency model. Out of these, stochastic frontier has 9 variables significant. While technical efficiency analysis, 7 are significant.

Table 5.2 Parameter Estimates of the Stochastic Production Frontier at overall level

Variables	Parameters	OLS Coefficients	Frontier Function Coefficients
Constant	βo	1.0845 (5.4232)***	1.2215 (5.69)***
Operare	β1	-0.0102 (1.3280)	-0.0125 (1.59)*
Ncanirrg	β2	0.0728 (5.3387)***	0.0775 (5.50)***
Ntubirrg	β3	0.0276 (1.0187)	0.0020 (0.07)
Ncantubirr	β4	0.0081 (0.7158)	0.0172 (1.46)
Ndeplog	β5	0.0325 (5.8569)***	0.0280 (5.25)***
Qytsed	β6	0.5586 (11.9198)***	0.5329 (10.85)***
Pn	β7	0.0244 (3.0567)***	0.0248 (3.02)***
Chem	β8	0.0632 (7.5414)***	0.05889 (6.61)***
Cotonof	β9	0.0107 (1.8922)*	-0.0033 (0.59)
Whetorh	β10	-0.0065 (0.4247)	0.0398 (2.90)***
Wsf	β11	0.0312 (2.7834)***	0.0304 (2.57)**
Latesown	β12	-0.0166 (1.6411)*	-0.0133 (1.27)
Wsl	β13	0.4132 (4.4476)***	0.0882 (0.91)
Lab	β14	0.0106 (0.3322)	0.0409 (1.23)
R-Squired		0.7168	

*Notes: t-statistics are in parentheses under the coefficients. Probabilities are in parentheses under the test statistics. * 10% level of significance, ** 5% level of significance, *** 1% level of significance.*

The table 5.2 demonstrates the overall results of frontier production function. The explanatory variables included within the analysis explain 71 percent variation. From these 14 explanatory variables, 9 are significant. On average wheat yield (production) is 28 maunds (one maund = 40 kg) per acre. The operational area (farm size) has significant inverse relationship with wheat output which confirms most of the studies analysis. The inverse relationship shows that as farm size increases output tend to reduce.

Three sources of irrigations are used as number of irrigation per acre through each source. The canal source of irrigation has positive and significant impact on wheat yield while on the other hand; number of tube-well as well as tube-well canal mixed irrigation has positive but insignificant impact. The magnitudes of the parameter estimated show that wheat productivity varies from one source to another. Canal and tube-well are the two main sources of irrigation. Some farmers use both sources simultaneously. The positive sign implies that as more numbers of canal irrigation applied, wheat output also increases. The reason is that there are many nutrients and chemicals in canal water which help the wheat output to increase. On the other hand, the other sources like tube-well or canal mixed tube-well irrigation also play their role. Although tube-well is more reliable source in agriculture sector yet it has insignificant impact on wheat output in our analysis. It may due to insufficient numbers of irrigation are used. The canal tube-well mixed irrigation has also positive but insignificant relationship with output. As one percent increase in the number of canal irrigation, wheat yield increases by 0.077 percent remaining other things same.

Land preparation is the main determinants for wheat productivity. There are two main ploughing methods in the area; the bullocks method (common ploughing) and tractor method (deep ploughing). We have used dummy variable for deep ploughing which is tractor ploughing which has positive and significant role in wheat productivity.

Seed is the major factor in wheat productivity. Quantity of seed used per acre has positive and significant impact on wheat yield. It increases wheat yield by 53 percent if we increase one percent quantity of seed. It further indicates that wheat yield can be increased by using quantity of more seed. On the other hand, the nutrients ratio (P/N) has positive but significant impact on wheat output as is shown in the above table.

Wheat crop is a stable food item and depends upon many inputs. Its output can be increased by using these inputs timely and properly. Chemical usage (pesticides) has positive role in wheat yield. Out of this productivity, .058 is due to chemical usage as is shown in the above table.

In almost every part of the country, the farmers grow different crops like sugarcane, cotton, maize, rice etc. and these crops take some time to be harvested. Due to it, the double cropping pattern is prominent. In Faisalabad, double cropping pattern also prevails. To see the impact of double cropping, we have taken only cotton and orchard for this analysis. In our analysis, wheat sown after cotton has insignificant inverse impact on wheat yield. Wheat is a shallow-rooted and heavily extracts nutrients in the upper 6 inches layer of the soil for its proper and efficient absorption. On the other hand, cotton is the deep-rooted crop and takes greater nutrient absorption area particularly in the lower soil layers. The more nutrients remain unused in the upper 6 inches' soil layer for the next crop in rotation like wheat but it is against our expectation.

Wheat sown in orchard has positive and significant relationship with wheat yield. However, wheat sown in fellow land has positive and significant impact on wheat output. When there is no crop harvested in land, its nutrients remains unused and when the next crop is sown, its yield may increase. So wheat in fellow land has positive and significant impact on wheat yield. It indicates that 0.030 variation in wheat yield is due to wheat sown in fellow land.

Wheat output is also affected by the sowing date. If wheat is sown late, its output is negative or less as expected and our analysis confirms it as is indicated in the above table. Byerlee and Siddiq (1994) has analyzed that a delay of one day in planting of wheat beyond the recommended sowing time reduces yield by 1 percent. In Pakistan, broadcast and line are two widely used wheat sowing methods. Most of the farmers uses broadcast method and very few uses the line method. In our analysis, wheat yield increases as more area is sown through line method. For the impact of labour in agriculture sector, we have used the labour used in wheat crop from sowing time to harvesting time. In Pakistan, most of the rural area depends upon agriculture sector. So many people attached to this sector. Wheat is the one crop in which labour is used. In our analysis, labour has positive impact on wheat yield.

In modern era, sustainability is widely used concept and its importance intensifies when it is used in wheat sustainability. The issues like poverty alleviation, food security and high population growth rates have created an emphasis on sustainability. Wheat is one of the most important food crops and its demand is increasing due to rapid population growth.

In our analysis, the variables like irrigation, fertilizer, chemical, quantity of seed etc show positive impact on wheat output. It further explores that farmers have a lot of opportunities to increase yield by right and proper allocation of inputs. On the other hand, farmers in the area have over fertilizer use. Moreover, the application of fertilizer is not only less than the desired / recommended quantities but its use is unbalanced. According to Zia *et al.* (1992) this kind of problems lead to negative net balance of all the major as well as micro nutrients in the soil. The situation would continue to worsen since the extraction of nutrient contents is faster than the rate it is being replenished. As a result, the wheat sustainability has to face a serious threat in ensuring food security in Pakistan.

The main inputs in wheat productivity like canal source of irrigation, land preparation through deep ploughing method, quantity of seed used, fertilizer, pesticide etc. have positive and significant role in wheat productivity and sustainability. To increase and attain wheat productivity and sustainability, the farmers have to use inputs properly and manageably. New techniques are to be used like sowing through line method etc.

Table 5.3 Parameter Estimates of the Stochastic Production Frontier for Chak Jhumra

Variables	Parameters	OLS Coefficients	Frontier Function Coefficients
Constant	βo	0.8585 (3.1650)***	1.2381 (4.11)***
Operare	β1	-0.0161 (1.4220)	-0.0174 (1.67)*
Ncanirrg	β2	0.0658 (2.8886)***	0.0717 (3.55)***
Ntubirrg	β3	-0.0235 (0.6807)	-0.0412 (1.28)
Ncantubirr	β4	0.0010 (0.0516)	0.0098 (0.59)
Ndeplog	β5	0.0292 (3.0531)***	0.0247 (3.09)***
Qytsed	β6	0.5814 (9.5516)***	0.4736 (7.39)***
Pn	β7	0.0400 (2.5176)***	0.0676 (4.46)***
Chem	β8	0.0728 (5.8737)***	0.0604 (4.86)***
Cotonf	β9	-0.0613 (0.9970)	0.0750 (1.29)
Whetorh	β10	-0.0240 (1.2564)	0.0249 (1.62)*
Wsf	β11	0.0547 (3.2051)***	0.0445 (2.7)**
Latesown	β12	-0.0127 (0.7590)	-0.0068 (0.44)
Wsl	β13	0.3304 (2.5229)***	0.2284 (1.71)*
Lab	β14	0.0837 (1.6117)*	0.1643 (3.1)***
R-Squared		0.7272	

*Notes: t-statistics are in parentheses under the coefficients. Probabilities are in parentheses under the test statistics. * 10% level of significance, ** 5% level of significance, *** 1% level of significance.*

To capture the geographical variation, we have also estimated stochastic function at tehsil level. Table 5.3 shows the tehsil Chak Jhumra analysis. At tehsil level, on average wheat output per acre is 28 maund. It indicates that there is no change in wheat output at overall as well as tehsil Chak Jhumra level. This model explains 72 percent variation in wheat yield which are due to these included variables. Wheat output is negatively and significantly related to operational area. It indicates that as farm size tend to increase, wheat yield decreases. It may be due to less care and management as farm size increases. On the other side, number of tube-well irrigation and late sown area factors decreases wheat output as is shown in the above table.

Wheat yield is positively related to number of canal irrigation, number of canal tube-well mixed irrigation, number of deep ploughing, quantity of seed, p/n ratio, pesticides, wheat after cotton, wheat sown in fellow land as well as wheat sown through line method. It indicates that with the increase of these inputs, wheat yield will increase. The number of tube-well irrigation has inverse relationship with wheat yield. The labour used at sowing time and harvesting time has positive and significant impact on wheat yield. As labour increases, output also increases. If there is one percent increase in labour, wheat yield increases by 16 percent.

Wheat sown after cotton is positive in Chak Jhumra that indicates that wheat output increases when is sown after cotton because cotton takes nutrients below 6 inches while wheat is a shallow-rooted crop which takes nutrients form 6 inches layer of the soil. So nutrients at 6 inches layer remain unutilized which is utilized by wheat. Due to these reasons, wheat output increases after cotton as is shown in table 5.3.

Table 5.4 Parameter Estimates of the Stochastic Production Frontier for Samundri

Variables	Parameters	OLS Coefficients	Frontier Function Coefficients
Constant	βo	1.4487 (4.6138)***	1.5825 (5.26)***
Operare	β1	0.0104 (0.9380)	0.0098 (0.93)
Ncanirrg	β2	0.0735 (4.4570)***	0.0811 (5.03)***
Ntubirrg	β3	0.1335 (2.9950)***	0.1357 (3.14)***
Ncantubirr	β4	0.0133 (0.9591)	0.0217 (1.6)*
Ndeplog	β5	0.0322 (4.7630)***	0.0310 (4.77)***
Qytsed	β6	0.4934 (6.5422)***	0.4738 (6.69)***
Pn	β7	0.0206 (2.3704)**	0.0181 (2.16)**
Chem	β8	0.0436 (3.8368)***	0.0432 (3.14)***
Latesown	β9	-0.0245 (1.9779)**	-0.0205 (1.72)*
Whetorh	β10	0.0466 (1.3458)	0.0338 (0.99)
Wsf	β11	0.0113 (0.7719)	0.0162 (1.12)
Cotonf	β12	0.0188 (3.2849)***	0.0181 (3.23)***
Lab	β13	-0.0656 (1.7025)*	-0.0917 (2.47)**
R-squared		0.7382	

*Notes: t-statistics are in parentheses under the coefficients. Probabilities are in parentheses under the test statistics. * 10% level of significance, ** 5% level of significance, *** 1% level of significance.*

The table 5.4 shows the stochastic frontier production function for tehsil Samundri and out these included explanatory variables, 11 are significant which explains 73 percent variation in wheat yield. Wheat yield is same as at overall and Chak Jhumra level. At Samundri level, operational area (farm size) has positive but insignificant impact on wheat yield. It indicates that there is no strong association with wheat output.

The factors that increase wheat yield at tehsil level are, number of canal irrigation, number of canal tube-well mixed irrigation, number of deep ploughing, quantity of seed used per acre, chemical usage, wheat sown after cotton, wheat sown in fellow land and fertilizer. If we use these inputs properly and through management way, wheat yield will increase. On the other hand, late wheat sown has inverse relationship with wheat yield as is shown in the above table and .020 less wheat is due to late sown. Labour used in wheat crop has significant negative impact on wheat productivity. Wheat yield is .091 less due to labour used. The reasons are due to intensive use of labour in this crop.

The number of canal irrigation is significant at one percent level, .081 and 0.21 wheat yield is due to canal irrigation and canal tube-well mixed irrigation respectively. While on the other hand, number of deep ploughing and quantity of seed used per acre explains .031 and .47 variation respectively. It indicates that wheat yield can be increased by using these inputs. Pesticide and fertilizer are the main factors in wheat productivity. These two variables are significant at 1 % and 5 % respectively. Wheat yield can be increased by .043 and .018 by using these factors.

5.4 COMPONENTS OF TECHNICAL EFFICIENCY OF WHEAT FARMERS

The technical efficiencies of the sample farmers of the area have been obtained by using equation 5. We have estimated technical inefficiencies effects at overall as well as tehsil level. There is 9 percent technical inefficiency in sampled farmers in Faisalabad. It indicates that the farmers are producing 9 percent less wheat output than potential level.

The parameters estimates of the variables used in the inefficiency model are presented in the following tables.

Table 5.5 Parameters Estimates of Inefficiency Effects Model at overall

Variables	Parameters	Coefficients
Constant	$\gamma 0$	3.3814 (210.47)***
Operare	$\gamma 1$	0.0533 (11.16)***
Age	$\gamma 2$	0.0003 (1.2)
Edufr	$\gamma 3$	-0.0339 (1.8)*
Spscd1	$\gamma 4$	0.0020 (3.12)***
Hedufm	$\gamma 5$	-0.0073 (0.51)
Spfscd2	$\gamma 6$	0.0030 (4.95)***
Ownd	$\gamma 7$	0.0644 (7.18)***
Leastentd	$\gamma 8$	-0.0232 (2.9)* **
Nfrmvistd	$\gamma 9$	0.0642 (11.07)***

*Notes: t-statistics are in parentheses under the coefficients. Probabilities are in parentheses under the test statistics. * 10% level of significance, ** 5% level of significance, *** 1% level of significance.*

The parameters estimates of the variables in the inefficiency model are presented in table 5.5. The operational area (farm size) positive and significant impact on farm inefficiency implying that as farm size increases, the farm efficiency declines. The reason for this relationship may be due to difficult to proper monitor the farm size and management deficiency. The age of the decision maker farmer has a positive effect on farm inefficiency. It indicates that as age increases, the farm efficiency decreases. The relationship may be due to the fact that the aged farmers may be not willing to take any risk and to adopt new techniques.

While on the other hand, the parameters estimates for decision maker farmer and his specialization, higher education of family member and its specialization demonstrate their role in efficiency analysis. The education of farmer is negative and significant at 10 percent level. This result very clearly shows that the decision maker farmers' education is an important factor in enhancing agriculture productivity. It further demonstrates that as education of decision maker farmer increases, technical inefficiency decreases. This result is as like Battese et al (1996) while Hussain (1989) found no relation between education and farm inefficiency. It is apparent that educated farmers usually have better access to information about prices, technology and its use. According to Ghura and Just (1992), better-educated people also have higher tendency to adopt and use modern inputs more optimally and efficiently.

On the other hand, decision maker farmers' specialization has significant positive impact on technical inefficiency. It indicates that as decision maker farmers' specialization increases, farm efficiency decreases. It may be due to the fact that most of the decision maker farmers have education up to matric and there is no such specialization at this level. The higher education of family member has also an important factor to decrease farm technical inefficiency as is shown in the above table while its specialization also has the same impact as decision maker farmers has. It further explores the fact that higher education of family members' specialization tend to increase technical inefficiency. Better-educated of and its specialization has no significant impact to reduce inefficiency.

Tenancy status is an important factor in determine the farm level inefficiency. The parameter estimate for tenancy shows that the leased-tenant is statistically more efficient than the owner. It may be due to the fact that an owner does not want to take any risk and no use of modern techniques while the leased-tenant takes any risk to improve its productivity. It also struggle more to achieve higher production potential.

For agriculture extension analysis, we have used farmers' visits to agricultural extension officer that is positive and significant. It indicates that farmers' visits to agriculture officer has no impact on farm efficiency but it increases inefficiency which confirms Hussain (1989) findings who found no significant relationship between agricultural extension and wheat production inefficiency.

Table 5.6 Parameters Estimates of Inefficiency Effects Model for Chak Jhumra

Variables	Parameters	Coefficients
Constant	$\gamma 0$	3.4077 (148.27)***
operare7	$\gamma 1$	0.0396 (5.95)***
age	$\gamma 2$	0.0003 (1.0)
edufr	$\gamma 3$	-0.0363 (1.04)
spscd1	$\gamma 4$	0.0024 (2.58)**
Hedufm	$\gamma 5$	-0.0284 (1.03)
spfscd2	$\gamma 6$	0.0034 (3.76)***
ownd7	$\gamma 7$	0.0762 (5.7)***
leastentd7	$\gamma 8$	-0.0253 (2.22)**
nfrmvistd27	$\gamma 9$	0.0526 (5.69)***

*Notes: t-statistics are in parentheses under the coefficients. Probabilities are in parentheses under the test statistics. * 10% level of significance, ** 5% level of significance, *** 1% level of significance.*

Farm size is positively related to technical inefficiency which shows that the large farmers are relatively more inefficient as compared to the small farmers. Like overall analysis, there is not much variation in tehsil Chak Jhumra. Education of decision maker farmer, higher education of family member and leased tenant are the main determinants of technical efficiency. All these factors reduce farm level technical inefficiency as is indicated in table 5.6 with negative sign.

On the other hand, age of decision maker farmer, decision maker farmers' specialization, higher education of family members' specialization, owner farmer and agriculture extension are the factors that tend to increase farm level technical inefficiency. It indicates that these factors reduce farm level technical efficiency.

Table 5.7 Parameters Estimates of Inefficiency Effects Model for Samundri

Variables	Parameters	Coefficients
Constant	γ0	3.3414 (148.05)***
operare7	γ1	0.070 (10.2)***
age	γ2	0.0002 (0.64)
edufr	γ3	-0.0285 (1.29)
spscd1	γ4	0.0020 (2.14)**
hedufm	γ5	0.0033 (0.2)
spfscd2	γ6	0.0031 (3.78)***
ownd7	γ7	0.0574 (4.79)***
leastentd7	γ8	-0.0142 (1.25)
nfrmvistd27	γ9	0.0713 (0.007491)

*Notes: t-statistics are in parentheses under the coefficients. Probabilities are in parentheses under the test statistics. * 10% level of significance, ** 5% level of significance, *** 1% level of significance.*

The parameters estimates for farm level technical inefficiency are presented in table 5.7 at tehsil Samundri level. The results show that only decision maker farmers' education and leased tenant farmers are the main determinants of farm level technical inefficiency which increases farm level technical efficiency.

On the other hand, the main determinants of farm level technical inefficiencies are operational area (farm size), age of decision maker farmer, decision maker farmers' specialization, higher education of family member, its specialization, owner farmer and agriculture extension. In further explores the fact that these factors increases farm level technical inefficiency as is shown in the above table.

Chapter No. 6

SUMMARY AND CONCLUSION

Faisalabad is the third main city of Pakistan and plays a pivotal role in the economy. The main employment section of the district is agriculture sector and almost 44 percent people are attached to this sector. Due to fertile land, many crops are harvested in the district like wheat, sugarcane, cotton, rice, fruits and fodder crops. Wheat and sugarcane are the major two crops in the area which are sown almost every area of the district. The most important crop is wheat which contributes 12.7 percent to the value added in agriculture and 2.6 percent of GDP. Wheat was cultivated almost 8448 thousand hectares in 2005-06 while it increased to 8578 in 2006-07 showing 1.1 percent to 1.0 percent respectively.

According to our analysis, a large number of farmers are illiterate and if literate, it's more ratio falls up to matric. The farmers have different tenancy status like owner, leased in and shared out farmers. The major portion of the farmers is owner in the area. The canal and tube-well are the major sources of irrigation in Faisalabad. The major fruits are orange, mango and guavava.

There is sufficient evidence of positive relationship between wheat productivity and higher and balanced use of fertilizer nutrients. Wheat productivity is significantly higher on farms where more number of canal irrigation is used as compared to tube-well .and canal tube-well mixed irrigation. Farm size has inverse impact on wheat productivity and efficiency. There are bullocks (common ploughing) and tractor (deep ploughing) methods in the sampled farm's area. Deep ploughing has positive and significant impact on wheat productivity. So, to increase wheat productivity, it is suggested to use deep ploughing method in land preparation for wheat crop.

On the other hand, wheat productivity has positive relationship with wheat after cotton. The reason is that wheat is shallow-rooted crop while cotton is deep rooted one. The sowing method is also important. Wheat sown through line method has positive impact on productivity. So, for higher wheat productivity, this technology is to be adopted. The other factors that increase wheat productivity are quantity of seed used, nutrients (fertilizer), pesticides (chemical usage) and labour used at sowing and harvesting time. All these factors lead to higher wheat productivity and sustainability. Labour used in the area varies from tehsil to tehsil level. In Chak Jhumra, it leads to significant higher wheat productivity while in Samundri level, it inversely affects wheat productivity.

The results of technical inefficiency analysis show that the average technical inefficiency in the area is 9 percent. Thus an average a farmer is producing 9 percent less than the achievable potential output. Technical inefficiency has positive relationship with farm size, age of the decision maker farmer, its specialization, higher family members' specialization, owner farmer and agriculture extension. These factors lead to increase farm level inefficiency in the area although there is some variation among these factors at tehsil level. The large farmers are technicaly more inefficient than small farmers. The owner farmers are also more technical inefficient than leased tenant. Consequently, the leased tenants put more effort and use modern technique to achieve higher output levels.

The prices of input and output play an important role in determining crop profitability, choosing appropriate production technologies and supply of agriculture commodities. According to Chhibber (1988) and Ghura and Just (1992) the price incentive is not an adequate tool to boost supplies of agriculture commodities. It can be achieved through continued investment in rural infrastructure (roads, markets and financial institutions etc.) and to enhance education of farmer at higher level as well as family members' education. There is need of improving agricultural research and extension facilities for higher wheat productivity and sustainability.

The study suggests that the policy makers and the planners to give top preferences to strengthen of rural and agricultural supporting institutions in order to enhance agricultural productivity and sustainability. Such efforts should particularly be targeted towards increasing welfare as of whole. The small farmers as well as large farmers should be helped in order to move not only along the production but also close to the frontier and to use intensively modern technique for higher wheat productivity and sustainability. There is highly need for a depth study to determine an optimal farm size in different cropping systems and provinces.

For the higher productivity and sustainability of cropping systems, the use of balanced nutrients like p/n, wheat sown in a recommended dates, wheat sown through advanced technique to avoid losses in wheat productivity should be used efficiently and properly.

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A sample survey conducted on wheat productivity, efficiency and sustainability ***(A case study of Faisalabad District)***

Date of interview: ……………………..

Village Name: ………………………………………….

Decision maker Farmer Name: ……………………….

Age: ………………………………………………….

Education of Farmer (in years): ……………… Specialization: ……………………

The higher education in the family members (in years): …………………

Specialization: ………………………

Experience of Farming (in years): ………………………

Farm Profile:

Farm Size:

Title to the operational area	**Area (in acres)**
1. Total area owned	
2. Area leased out	
3. Area leased in	
4. Area shared out	
5. Area shared in	
6. Waste Area**	

** Includes land under buildings, culture able waste, land not suitable of cultivation etc.

Operational area= 1+3+5-2-4-6= …………………………..

Operation Area by irrigation source (as above):

	Area (in acres)
Canal irrigated	
Tube well irrigated	
Canal + Tube well irrigated	
Other	

Tenancy Status: ……… (Owner = 1, Owner-cum-tenant = 2, Tenant = 3)

Soil Type: ……… (Clay loam = 1, Sandy loam = 2, Loam = 3, Sandy = 4)

Soil Fertility:……………. (Poor = 1, Average = 2, Good = 3)

Soil Problems: Total waterlogged area (in acres) …………………..

Total Saline area (in acres): ………………………

Cropping Pattern in Kharif:

Crop	**Area (in acres)**
Basmati (Paddy)	
Irri (Paddy)	
Maize (Grain)	
Cotton	
Sugarcane (Fresh)	
Sugarcane (Ratoon)	
Other	

(Continued)

Kharif Pulses	
Mash	
Mung	
Other	
Kharif Oilseeds	
Sesame (til)	
Other	
Kharif Fruits	
Kh. F-1	
Kh. F-2	
Kh. F-3	
Crop in Orchard	
Crop 1…………..	
Crop 2 …………..	
Crop 3 …………	
Kharif Fodder	
Maize	
Jawar	
Bajra	
Other	
Fellow land (in acres)	

Cropping Pattern in Rabi:

Crop	**Area (in acres)**
Total wheat area (in acres)	
Wheat variety 1……………	
Wheat variety2…………….	
Wheat variety3……………	
Spring Maize (grain)	
Other	
Rabi Pulses	
Gram	
Masoor	
Other	
Rabi Oilseeds	
Sunflower	
Rapeseed/canola	
Other	
Rabi Fruits	
Rb. F-1	
Rb. F-2	
Rb. F-3	

(Continued)

Crop orchard	
Crop 1	
Crop 2	
Crop 3	
Rabi Vegetables	
Chillies	
Onion	
Tomato	
Peas	
Other	
Rabi Fodder	
Oats	
Berseem	
Lucerne	
Other	
Fellow land (in acres)	

Wheat production practices:

Production Practices/Operations	**Wheat Area (in Acres)**			
	Area treated	Unit	Qty	Price/ cost
Land Preparation		Rs/acre		
Number of deep ploughing				
Number of hours spent per acre				
Number of common ploughing				
Number of hours spent per acre				
Number of irrigation				
Hours spent per irrigation				
Seed rate		Kgs/acre		
Seed treatment		Rs/acrea		
Time spent for seed treatment				
Seed source*				
Sowing (line method)		Rs/acrea		

(Continued)

Previous Crops in Wheat acreage:

	Wheat Area (in Acres)
Total Wheat area (in acres)	
Wheat sown in fellow	
Wheat after..................	
Wheat after..................	
Wheat after..................	

Wheat Area by Sowing dates:

Area sown before 15 Nov.	
Area sown 15 Nov-30 Nov.	
After 1 Dec.-15 Dec.	
After 15 December	
Wheat area infested /heavily with weeds	
Wheat area heavily lodged	
Wheat area infested with rust	

Use of Loans:

Can you obtain loan easily when needed? Yes / No

Have you received any loan during rabi?

Yes	No

If loan received then its details:

Purposes		
	Amount borrowed (Rs)	Service charges/interest
Purchase of seed		
Purchase of fertilizers		
Purchase of chemicals		
Other specify..............		

Technical help in crop production:

Agricultural Extension

- Do you know the Field Assistant of your village personally?

Yes No