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Muhammad Qasim

Determinants of Farm Income and Agricultural Risk Management Strategies

The Case of Rain-fed Farm Households in Pakistan's Punjab

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This work has been accepted by the faculty of Economics and the faculty of Organic Agricultural Sciences of the University of Kassel as a thesis for acquiring the academic degree Doktor der Agrarwissenschaften (Dr. agr.).

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DEDICATION

Dedicated to my parents, who wished to see me a highly educated person.

Perhaps, without their prayers and inspiring motivations, it would not have been possible for me to accomplish this task.

ABSTRACT

Agriculture is the backbone of Pakistan's economy. In 2009-10 it contributed 21 percent to its GDP and employed 45 percent of its labor force. Still the continuous increase in the population on the one hand and the stagnancy of agricultural production on the other hand has resulted in a gap between demand and supply of agricultural products. In the irrigated agricultural production system of Pakistan, crop intensification, mono-cropping, conventional soil management practices, and the mismanagement of water resources have caused the deterioration of land and water resources which resulted in the declining land and water resources. Pakistan's rain-fed agriculture is of risky and subsistence nature with low land and labor productivity, but it has some potential advantages over irrigated agriculture. Cropping intensity (85 %) in rain-fed areas is lower than in irrigated areas and therefore those land resources are less degraded.

The present research explores the reasons for the low productivity of rain-fed agriculture and the risky nature of agriculture of *Pothwar* region in Pakistan with a focus on the determinants of overall farm income and major crop yields of rural households. Moreover the research also aims at exploring the major risk sources of agriculture causing the low farm income as well as risk management strategies for coping with these risks. The field survey was conducted in 2009 in the districts of Rawalpindi and Chakwal in the rain-fed areas (*Pothwar* plateau) of Punjab province of Pakistan. The farm level data of 210 farm households were collected by personal interviews, using a structured questionnaire. The data were analyzed by employing a linear form of the Cobb Douglas Production Function to find out the determinants of farm income and of major crop yields. Factor analysis was applied, by using SPSS software, to find out major risk sources and risk management strategies.

The results show that the size of operational land holding is inversely proportional to per acre farm income. The irrigated area, off-farm income, number of livestock, cost incurred on livestock, hired labor, and tractor ownership show a significant positive correlation with farm income. Irrigated area and the respective prices of crops have positive effects on the yield of the major crops of the area. The seven important

agricultural risk sources are markets, catastrophe, lack of information, weather and lack of insurance, price fluctuation, droughts and diseases, and financial risks. The six factors sorted for risk management strategies include planning and policy, infrastructure development, research and information management, diversification and off-farm employment generation, financial management and security, and input management. The farm households were categorized into three distinct groups on the basis of risk factors' cluster analysis: risk averse (49.5 % farmers), risk neutral (31.0 % farmers) and risk seekers (19.5 % farmers).

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ABBREVIATIONS

Ag. GDP	Agricultural Gross Domestic Product
BARI	*Barani* Agricultural Research Institute
C.D	Crop Diversity
CDFP	Cobb Douglas Production Function
CDI	Crop Diversity Index
C.I	Cropping Intensity
DAAD	German Academic Exchange Service
FAO	Food and Agriculture Organization
FR	Farm Revenue
GDP	Gross Domestic Product
G.M	Gross Margins
Ha	Hectare
HEC	Higher Education Commission
IR	Farm Size and Productivity Inverse Relationship
L.P	Labor Productivity
Ld.P	Land Productivity
OLS	Ordinary Least Squares
MP	Marginal Productivity
NP	Net Profit
OECD	Organisation for Economic Co-operation and Development
PARC	Pakistan Agricultural Research Council
PIDE	Pakistan Institute of Development Economics
PKR	Pakistan Rupee
SAWCRI	Soil and Water Conservation Research Institute
SMEs	Small and Medium Enterprises
SPSS	Statistical Package for Social Sciences
TC	Total Cost
TFP	Total Factor Productivity
TR	Total Revenue
UN	United Nations
UNDP	United Nations Development Program
VIF	Variance Inflation Factor
WB	World Bank
WCED	World Commission on Environment and Development

CHAPTER 1: INTRODUCTION

The major objective of this study is to find out the determinants of rain-fed farm income, major crop's yield, risk sources and risk management strategies in rain-fed agriculture. This introductory chapter explains the problem considered, its importance and relevance. In addition, its background in Pakistan's context is presented.

1.1 Problem Statement

The total agriculture area remained almost constant in Pakistan since its creation in1947 as land utilization for urbanization and land degradation due to water logging and salinity, have balanced the expansion in the cultivated area that has come off from the development of irrigation infrastructure. Continuous population increase against largely unchanged land and water resources between 1970 and 2009 have resulted in the decline of per capita arable land and water availability. Agricultural land availability came down from 0.44 to 0.17 hectare per capita during this period and per capita water availability dropped from 5,650 m^3 to 1,400 m^3. The development in water resources did not keep pace with the rise in cropped area due to increasing cropping intensity[1]. This increased, at national level, from 95.2 percent in 1981 to 112.2 percent in 2009, whereas in Punjab province it rose from 113.8 percent in 1981 to 135.8 percent in 2009 (Government of Pakistan 2009). In this scenario strategies and practices for crop productivity enhancement and natural resources conservation are crucial to meet the food requirements of growing population.

The major reasons for low productivity and the reliability of farm income include the non-availability of improved inputs (seeds), inefficient fertilizer use, weed infestation, shortage of irrigation water, drought and seasonal variation of rainfall, inadequate research efforts and inefficient extension services (Ashraf et al., 1999, Ashfaq et al. 2003 and Ashraf 2004). In the irrigated agricultural production system of Pakistan, crop intensification, mono-cropping, conventional soil management practices, and

[1] Cropping Intensity is defined as the ratio of total cropped area or total sown area in both cropping seasons i.e. summer and winter to the total cultivated area expressed in percentage.

poor on farm water management have caused deterioration the land and water resources. This scenario reduced much of productivity effects of Green Revolution technological change. The sustainability of this intensification strategy is being questioned in the light of mono-cropping and heavy use of inputs and water resources. This resulted in slowdown in land and water productivity and the degradation of resource base. Another important factor for the low agricultural land productivity is practicing of traditional farming techniques and lack of investment for adoption of improved agricultural production technologies because the majority of farmers is resource poor and have small land holdings. Fuel and other agricultural input prices (seeds, pesticides and fertilizer) have been increasing at a much higher rate than those in other sectors over last decade (2000-09), which puts pressure on the production cost of food and other agricultural commodities (Afzal and Shahid 2009).

The population of Pakistan has increased from 33 million to 170 millions since its inception to 2009, making it the sixth most populous country in the world. The population grew at an average rate of 3 percent p.a. from 1951 until the mid-1980s. The growth slowed to an average rate of 2.6 percent p.a. between 1985 and 2000 and to 2.2 percent during 2000–2010. The population growth rate (2.1 %) during 2010 is still higher than the average global population growth rate (Government of Pakistan 2010). It is estimated that the population (of year 2010) will double by the year 2025, which may increase the prevalent gap between domestic supply and demand of food products.

The continuous increase in the population and slow growth in agricultural production due to natural resource degradation has resulted in gap in agricultural food items demand and supply. Productivity improvement and the use of additional factors of production would lead to expansion in agricultural production but they are difficult to arrange because of land and water resources' degradation. In this scenario productivity improvement with the existing resources by increasing farm efficiencies is a more efficient and attainable option (Iqbal et al. 2001). Research and development are considered to be the main forces behind technological change while education, experience, and expanded infrastructure are necessary for improving the system's efficiency (Kalirajan and Fan 1991). There is need to explore the factors responsible for the overall low agricultural productivity in Pakistan.

1.2 Risk in Agriculture

Agriculture is often characterized as a relatively high risky and uncertain sector of economy. There are many risk and uncertainty causing factors in agriculture. They are classified as the production, marketing and financial risks (Boehlje and Eidman, 1994). Some of production and marketing risk and uncertainty components include severe weather (drought/frost attack, hail-storm and wind-storm), inputs quality, pest's/diseases attacks, input/output price fluctuations (Yesuf and Randy 2008), labor shortage at required time, new technologies failure, machinery breakdowns in unexpected situations and changes in government policy. These factors are the main causes of farm production and income fluctuations. Financial risk is the risk being unable to meet farm liabilities with the cash generated by the farm and is determined by the dispersion of net cash flows, the level of debt and other pools of resources (Madai 2008). It becomes more significant when farm households heavily depend on credit sources for investment on their farms.

Risk strategies are defined as the methods applied to remove or reduce partly the effects of risk factors in agriculture. Risk management strategies are used by farm entrepreneurs to reduce the effects of risk factors and survive in adverse farm production conditions. The selection of good risk strategies depends on the farm operator, the financial situation and risk attitudes of farmer. Risk strategies are commonly grouped into production, marketing and financial responses (Kay and Edwards, 1994; Hardaker et al., 1997; Musser, 1998). Production responses generally act by diversifying the farm production activities to reduce the variability in production and farm income. Marketing responses may include the strategies to reduce price variation risks. Financial responses emphasize the farm capacity to reduce risk by increasing equity capital ratio to total assets (Martin 1996) and increasing the off-farm income sources. Financial responses, such as insurance, may also transfer risks to others (Patrick, 1998).

Agricultural production in low-income countries is generally less diversified, focusing on rain-fed staple crop production and raising livestock-activities, which are risky in nature. Because of the poorly developed and the absence of credit and insurance markets, it is difficult for farm households to pass any of these risks to a third party. Farm households base their investment and production decisions, in part, on the perceived risk of failure (Yesuf and Randy 2008). Consequently farm households tend to be reluctant to adopt new agricultural technologies even when expected net returns are high (Yesuf and Randy 2008). A better understanding of risk behaviour is essential for identifying appropriate farm-level strategies by low-income farmers for adaptation to climate change.

The first possible risk management instrument in agriculture is to increase farm efficiency by minimizing risk through better management practices and the organization of production activities. This can be done by the timeliness of performing operations, practicing preventative maintenance and monitoring production activities more closely to ensure problems detected early enough to take corrective measures. The second choice is to reduce the production variability by adding or changing enterprises through diversification or integration. The possible operation regarding this may be the selection of low risk production activities, efficient farm resource allocation and the maintenance of reserve production factors. Cold storage is a possible option to avoid the price fluctuation risks.

1.3 Importance and Relevance of Research

Although the agriculture in the rain-fed *Pothwar* (Northern Punjab) is of subsistence and risky nature having low land and labor productivity yet it has some advantages as compared to that of irrigated area. Cropping intensity (85 %) in this area is relatively lower (Govt. of Punjab 2009) as compared to irrigated areas and therefore soil structure, organic matter, soil fertility and other resources are relatively less degraded. The gap between the fertility yield at farmer's field and potential yield at research institutes experimental fields is bigger in rain-fed areas as compared to irrigated agriculture (United Nations Pub. No. UN PAK/FAO/2000/1 and Govt. of Punjab 2009). These areas have been historically neglected in the agricultural research and extension policies of Pakistan, due to water shortage and their small contribution to total agricultural GDP. This reveals that these areas have a potential and importance for increasing the overall agricultural production to meet the ever increasing food demand of Pakistan's population and reducing the net food import of country.

The present study is conducted in the *Barani* Punjab Cropping Zone (*Pothwar* plateau), the northern part of Punjab province of Pakistan. The agriculture of area is mainly characterised by pure rain-fed conditions of risky nature (Yousaf 2007). The majority of farmers are performing at subsistence level. Agricultural production in this area is vulnerable to drought, erratic rainfall and other extreme weather conditions (Ashraf et al., 1999 and Ashraf 2004). The vulnerability of rain-fed agriculture to extreme weather conditions results in substantial income risk for rural farm households. However the farm household have no insurance arrangements or any subsidy from government to avoid a disaster (Khan et al. 2004). The low agricultural productivity of area and its risky nature demands the research investigation for exploring the determinants of farm income and major crops yield at farm level. Akcaoz and Ozkan (2005) conducted study on farmers' attitude towards risk sources and strategies in the Cukutova region of Turkey. This region revealed the higher crop yield variability and climate of region has a significant impact on its agricultural production. The aim of study was to find out risk sources and management strategies important for governmental agricultural policy formulation. These characteristics of agricultural production (yield variability and climate impact on agricultural production) of Cukutova region match with those in the study area. This depicts the importance of knowledge about farm households' risk attitudes regarding agricultural risk sources and risk management strategies to formulate the appropriate government policy for the agricultural production improvement of area.

1.4 Research Objectives

Keeping in view the importance of rain-fed agriculture the present study is designed to explore the possible reasons, other than weather, for low agriculture productivity in the area. Moreover, the major determinants of overall farm household income and major crops yield are investigated. The research is also aimed at exploring the major agriculture risk sources causing the low yield in agriculture and important risk management strategies proposed by the farmers of study area. The main research questions addressed in the research study include: What is the level of overall farm income and the yield of major crops in the *Pothwar* region? What are the major factors affecting farm household income? What are the important factors affecting major crops yield in the study area? What agriculture risk sources and risk coping strategies are most important for rain-fed farm households?

The specific objectives of research are as follows:

1. To estimate the overall farm income and yield of major crops in the study area
2. To study the determinants of farm income especially in the context of production diversity and off-farm income
3. To estimate the determinants of yield of major crops in the study area
4. To find out the major agricultural risk sources and coping strategies of farm households in the *Pothwar* region
5. To suggest recommendations, based on finding, to frame policy to improve overall farm productivity, rain-fed household farm income and risk coping strategies.

1.5 Organization of Thesis

Thesis is spread over ten chapters. Chapter 1 introduces the study. It includes problem statement, risk in agriculture, importance and relevance and research objectives. Chapter 2 tells the theoretical background of study showing important farm household production theories and explains production function used in the study. Chapter 3 denotes the current state of research that includes the studies on agricultural diversification, off-farm work, agricultural risk sources and management strategies, the determinants of farm income, sustainable agriculture, production variability and the advantages of mixed farming, agricultural growth and crop shifts, research for poverty alleviation in marginal areas, farm size and land productivity Inverse Relationship (IR), the determinants of wheat production and studies regarding *Pothwar* region. Chapter 4 is about the agriculture of area including the geography of Pakistan, the economic importance of agriculture sector, the natural and geographic conditions of study area, the economic structure of rural area, demographic characteristics, the climate and weather of Rawalpindi and Chakwal districts, the agricultural land utilization status of *Pothwar* region, farm size situation, the production status of major crops of area, the livestock composition of study area and the importance of wheat as the staple diet of area. Chapter 5 is about the materials and the research methods used in thesis which include data sources, analytical tools and farm production functions.

Chapter 6 depicts the results about the composition of sample farmers, education and experience of farm household members, farm characteristics and cropping pattern, cropping intensity, crop diversity, livestock composition, farm mechanization and irrigation sources, the sources and extent of agricultural information, marketing and agricultural credit, and farm household labor. In Chapter 7 results about the cost of production of major crops and factor productivity analysis are presented. Chapter 8 describes the determinants of farm income and major crops (wheat, groundnut, chickpea and mustard) yield and factor analysis for risk sources and risk management strategies. Chapter 9 presents the comprehensive discussion of overall salient findings of research study. The salient findings are evaluated in the light of present investigation research hypothesis and the previous research studies in the relevant field. Chapter 10 presents the summary of results, and conclusions and policy recommendations based on the main empirical results of study. Moreover, directions for future research are discussed. The recommendations on the basis of the empirical results are presented for agricultural research and extension institutions, and development planners for formulating policies regarding rain-fed agriculture.

CHAPTER 2: THEORETICAL FRAMEWORK

Any attempt to fit a production function immediately confronts specification problem i.e. choosing arguments and the algebraic form of function. Economic theory provides mainly generic conditions for specification and the empirical evidence literature provides for guidance in specifying a function to describe a particular production process. Satisfactory specification must consider the technological conditions governing the process.

2.1 Farm Household Production Planning

Farm production theory begins with the farmer as an individual decision maker who is concerned with questions like how much labor to devote for the cultivation of each crop, how much to be spend purchase inputs, which crops to grow in which fields and so on. It thus depends upon the idea that farmers can vary the level and kind of farm inputs.

Three kinds of relationships between farm, inputs and outputs are important for the 0economic decision making. This corresponds to three main steps in the construction of farm theory and is as follows:

1) The varying level of output corresponding to the different levels of variable inputs is called the “factor-product” or “input-output relationship”. This is the physical relationship between inputs and output to which all the other aspects of production process are ultimately related.
2) The varying combination of two or more inputs required to produce a specified output is called “factor-factor relationship”. This may also be called the method or the technique of production.
3) The varying outputs which can be obtained from a given set of farm resources are called “product-product relationship”. It is also known as “enterprise choice”.

This method of farm production achieves analytical relevance when placed in the context of farm households’ goals and the resource constraints of individual farm. In reality farm household have several goals e.g. long term income stability, family food security, the achievement of certain preferences in consumption, the fulfilment of social obligations and others.

2.2 The Production Function

The production function defines the physical relationship between output (Y) and any number of production inputs ($X_1, X_2, \ldots, X_n$):

$$Y = f(X_1, X_2, \ldots, X_n) \quad (2.1)$$

Typically, the concern is only with one or more variable inputs. Other inputs and the state of technology remains the same. This is written as

$$Y = f(X_1, X_2, \ldots, X_m)\bar{X}_{n-m} \quad (2.2)$$

Where $X_1, \ldots, X_m$ are variable inputs while all other inputs (other than 1,2,3….,m inputs) are held constant. The precise equation of production function depends on the kind of input response under study and the degree of abstraction from actual production processes. However the whole production functions must satisfy two conditions to make economic sense for deciding about the production level i.e. the marginal physical product should be positive and it should be declining.

For any given production function y = (x_1, x_2, .., x_m), it is a generally the case that is at least up to some maximum point:

$$\partial y/\partial x_i = f_i \geq 0 \quad (2.3)$$

For all factor inputs i = 1, 2, …., m. In other words, adding more units of any factor input will increase output (or at least not reduce it). However, it is also common in neoclassical production theory to impose the “quasi-concavity” of production function. It is often the case in economics that the quasi-concavity assumption implies:

$$\partial^2 y/\partial x_i^2 = f_{ii} < 0 \quad (2.4)$$

For all i = 1, .., m, i.e. diminishing marginal productivity of ith factor.

Diminishing marginal productivity (MP) means the more we add of a particular input, all others factors remaining constant, the less the additional unit employment contributes to overall output. This concept performs the same function in production as diminishing marginal utility did in utility functions. In many real situations the production function operates during the stage where MP is lesser as compared to AP and is positive which shows the diminishing marginal returns to the scale.

According to neoclassical economics, optimal production levels are touched when marginal productivities match marginal costs. Perfect factor markets ensure an optimal allocation of different production factors which will lead to these maximal productivities. While applying this theory to farming it implies that inputs and production factors such as land, labor and capital are allocated in such a way that yields (output per land unit) and productivity (output/input) are maximal and virtually equal for all farms. Yet, factor and product markets are imperfect in countries with poor infrastructure and the transaction costs (farmers need to incur in order to reach input and output markets) are significant. This partly explains why an inverse relationship between the size of production and productivity is found in several developing areas (Lipton, 2010) contradicting the theories of economies of scale.

2.3 Farm Household Production Theories

Development economics' contributions have mentioned the difference between practically observed farm household production choices and efficient behaviour as predicted by standard neoclassical farm production theories. The effect of market failures, institutional arrangements, and the risk management strategies adopted by farm households provided some of explanations for this difference.

Agricultural production is significantly dependent on the farmer's performance while poverty, among them, is disproportionately concentrated. Therefore, understanding the determinants of modes of production is a primary concern for evolving any poverty alleviation strategy. Farmers are located in largely dominant economic and political system that could affect their production behaviour. They are partially engaged in markets, which are often imperfect or incomplete (Ellis 1992, 9–10). Hunt (1991) identifies peasant farms as both production and consumption units. A proportion of produce is sold to meet their cash requirements and financial obligations, and a part is consumed by them.

The models that include the consumption goals of households into the microeconomic models of farm households' decision making are called agricultural "household models". They have become popular for explaining the behaviour of farm households in both perfect and incomplete market contexts (Taylor and Adelman

2003). The farm household behaviour is influenced by several natural market and social uncertainties in developing countries. This has raised some complexities in terms of understanding their production decisions. Seeking to insure household members against the hunger and impoverishment is of great importance to any rural farm family in a less developed country (Dasgupta 1993).

The risk behaviour of farm household is determined not only by individual preferences but also by the availability of institutions that facilitate risk bearing (Roumasset 1976). Where institutional arrangements provide imperfect insurance, households will self-protect themselves by exercising cautious approach in their production decisions (Morduch 1995). All these factors formulate farm households' production choices and explain why vulnerable farmers are often observed to sacrifice expected profits for greater self-protection. This is because risk management is costly, and will differ across households at different points in the wealth distribution, with subsequent implications in terms of efficiency losses and poverty traps (Eswaran and Kotwal 1986, Morduch 1994).

2.4 Standard Theories of Farm Household Production Choices

There are three alternative economic theories of farm household production behaviour: a) Profit Maximization behaviour, b) Utility Maximization Theories, and c) Theories Considering Risk-Averse Farmers. Each approach assumes that farm households have an objective function to maximize, with a set of constraints. These theories are based on certain assumptions about the workings of wider economy within which farm production takes place.

2.4.1 Profit Maximizing Behaviour

Schultz's (1964) hypothesis that farm households are "poor but efficient" resulted in a long debate among economists and a new wave of empirical work was designed to test it. Referring explicitly to allocative efficiency and implicitly to technical efficiency, Schultz described the farm production mode as profit-maximization behaviour, where efficiency is defined in the context of perfect competition (i.e., where producers all apply the same prices, workers are paid according to the value of their marginal product, inefficient firms go out of business, and entrepreneurs display no diminishing marginal utility of money income).

Several studies have adopted the allocative efficiency criterion to test whether farms were profit maximizers with some contradictory results (Bliss and Stern 1982). Conflicting evidence apart, the main caveat in this approach is that profit maximization has both a behavioural content and a technical-economic content. Most work related to efficiency infers the nature of farm household behaviour by investigating economic efficiency. It is therefore concerned less with the way a farm household reaches its decisions than with decisions outcome as a firm. Economic work on farm household behaviour has only evolved with some criticisms of profit maximization theory, such as the existence of trade-offs between profit maximization and other household goals, and the role of uncertainty and risk in farm household production decisions.

The “farm profit-maximizing model” has been criticized on the ground that it overlooks the aspect of farm households’ self consumption needs in decision processes. The neoclassical agricultural household models, which include both the production and the consumption goals of farm households, became more popular. In reaction other economists have crafted the risk aversion theory, which states that the objective function of farm households is to secure the survival of household by avoiding risk.

2.4.2 Utility Maximization Theories

A number of utility maximization theories have been applied to farm production behaviour. The main difference between them and the theories of profit maximization is that utility maximization approaches encompass the dual character of farm households as both families and enterprises. These theories also take account of the consumption side of farm household decision making. The seminal work of Chayanov in the 1920s emphasized the influence of family size and structure on farm economic behaviour, through labor concept within the household in the absence of labor market (Chayanov 1966).

In expanding the scope of Chayanovian model and assuming perfect markets, the neoclassical farm household model became popular in the 1960s to explain the behaviour of farm households in simultaneous decision making about consumption and production. This model incorporates the notion of full household income (Becker 1965) and conceives the household as a production unit that converts purchased goods and services as well as its own resources into used values or utilities when consumed. In this way, the household maximizes utility through the consumption of all the available commodities (home-produced goods, market-purchased goods, and leisure) subject to full income constraints.

The model shows that if all markets are well functioning and all goods are tradable, prices are exogenous and production decisions are taken independently of consumption decision. In such conditions the decision making process could be regarded as recursive (or separable), because time spent on leisure and time used in production becomes independent. The utilization of family labor will be directly linked to the market-determined wage rate, and income is singled out as the only link between production and consumption (Singh et al. 1986). In the absence of labor market, as in the Chayanovian model, or any other missing market, the decision may not be recursive because the family will be left to decide about the percentage of total available time to be devoted to production (the difference being assumed to be used for leisure). Therefore, there is no separability between consumption and production. The decision process becomes circular as consumption affects income and income affects consumption. Hence, the validity of recursive modelling of household resource allocation depends on the household being a price taker and the absence of missing or imperfect markets (for output or input, including labor and capital).

Households operating in countries with poor infrastructure are likely to face more than one market imperfections which prevent first-best transactions and investments from taking place. The empirical analyses of recursivity in farm household decision making have generally produced negative results (Bardhan and Udry 1999). Hence, theoretical advances on farm household models with missing markets (de Janvry et al. 1991) have opened up a new research agenda for neoclassical economists: the household's objective is still to maximize (a discounted future stream of expected) utility from a list of consumption goods (including home-produced goods, purchased goods, and leisure), but subject to what may be a large set of constraints, in which a missing market is yet another constraint on the household. At the same time, task of empirical economics has shifted to provide the evidence of market inefficiencies and their impact on (second-best) household production choices.

These theories have some serious shortcomings in explaining farm economies. Similar to profit-maximizing theory, they ignore the effect on the farm household behaviour of uncertainty and risk involved in farm production, and the social context in which farm production takes place. Most of these models are static and assume that prospects are certain or, equivalently, that households are risk-neutral. The empirical testing of farm household models, the research focus, analytical flexibility, and available data result in the significant simplifications of objective function and the constraints (Taylor and Adelman 2003). The criticisms of this theoretical framework are particularly severe when uncertainty and risk aversion are acknowledged to play a central role in farm household production decisions.

2.4.3 Theories Considering Risk-Averse Farmers

Ellis (1992) describes that farms always operate under risk and uncertainty induced by natural hazards (weather, pests, diseases, and natural disasters), market fluctuations and social uncertainty (insecurity associated with control over resources, such as land tenure and state interventions, and war). These conditions pose risks to farm production and make farmers cautious in their decision making (Walker and Jodha 1986). Farmers are generally assumed to exhibit risk aversion in their decision making. Lipton’s (1968) criticism of profit approach shows how the existence of uncertainty and the risk eroded theoretical basis of profit-maximizing model. He argued that small farmers are risk-averse, because they have to secure their household needs from their current production or face starvation.

There are two ways of conceptualizing the farm households’ risk-aversion, the standard expected utility theory and the disaster avoidance approach. According to the former approach, farm households make choices from available risky alternatives, based on what appeals most to their given preferences in relation to outcomes and their beliefs about the probability of their occurrence. This normative approach is based on a set of assumptions and on an implicit hypothesis that farm decision makers are in fact utility maximizers. Both household behaviour and its revealed attitude toward risk (e.g., risk aversion) are reflected in its utility function. Other things being equal, a risk-averse household prefers a smooth consumption stream to a fluctuating one. This, in contexts of incomplete capital markets or underdeveloped institutional arrangements entails a low risk portfolio choice of productive activities (Morduch 1994).

On the other hand the complexity of risks faced by farmers has lead some analysts to develop allocative choice models that do not depend on the ability to calculate expected returns for the large numbers of alternative prospects or knowledge about the complex probability distribution of outcomes. Roumasset (1976)'s early criticism of expected utility theory builds on the application of latter to decision making by subsistence farmers in Southeast Asia. He says that the main limitations of this theory are related to the measurement of risk aversion and the absence of decision costs. Moreover, expected utility maximization can be described as a "full optimality model" since it prescribes the best choice of an individual, given the relevant constraints. However, it fails to specify the decision process that makes the outcomes possible, and thus ignores any important role of decision costs in analyzing decision-making behaviour under uncertainty. As Roumasset emphasizes, where the costs of obtaining and processing the information are substantial it is not necessarily rational for an individual to act consistently with his underlying preferences. A complete preordering only guarantees that an individual can make binary comparisons. But going from the binary comparisons to the most preferred alternatives is not a trivial step" (Roumasset 1976, 24). In the cases of finite information processing devices, it is difficult to generate choices consistent with a preordering.

The full optimality approach appears to be a weak basis for describing the decision process of small-farm operators in developing countries. Many analysts assume that individuals act according to behavioural rules that they choose among a limited number of objectives from their experience by a process of thought that may appropriately be described by "rules of thumb" (Dasgupta 1993). The critics of full optimality approach in farm production modelling formulated the idea of household production behaviour at low income levels in uncertain environments. They assume that, among risky income sources, farm households first opt for safety and from the safe alternatives they choose based on expected utility. These models based on a feasible decision process are known as safety first models of choice under uncertainty. In this case the decision maker wants to ensure survival for him or herself and to avoid the risk of his or her income falling below a certain minimum (subsistence) level. This safety-first criterion can lead to the household favouring either risky income streams or low risk alternatives. This means there are no reasons to expect that individuals behave in conformity with the expected utility theory at very low income levels, which is in stressful circumstances. The disaster avoidance perspective is helpful for describing individual choice under such conditions (Dasgupta 1993).

The attraction of safety-first approach is that it is a positive method to capture some specific behaviour that can be eliminated from the expected utility theory near threshold income levels. The safety-first model does not take actual decision rules as given, as in a “pure behavioural approach”. This model results from the attempt to incorporate the strong points from both the behavioural and full optimality approaches, which is an appropriate descriptive device for a risky choice in low-income farmers. Utility maximization theory cannot highlight such problems as extreme poverty, insecurity, and deprivation that characterize farm life in the most parts of world, the safety first theory explicitly captures these aspects of farm behaviour in rural economies.

Assuming perfect markets, profit maximisation and utility maximising peasant theories take only profit or full income maximisation under one constraint in a competitive economy as a central issue in peasant production analysis. The high risk and uncertainty faced by subsistence producers reduce the prescriptive relevance of these theories. Thus, theory included peasant risk-aversion in its full-optimal utility maximisation framework showing the preferences of farm households towards risk as a key element in explaining uncertain production choices is closer to the reality. However, the analysis of risk preferences based on the assumption that farmers

have to absorb all income risk, without taking into account market imperfections and non-market insurance mechanisms may be misleading (Morduch, 1995).
Theoretical and empirical contributions on farm household production choices under uncertainty have shown that rationed capital markets may contribute in shaping risk-preferences and also behavioural responses to risk. When borrowing constraints are binding and production risks uninsured (whereby credit access may act as an insurance mechanism), households may self protect by exercising caution in making production decisions. Thus, living and operating in risky environments make farm households behaving as to reduce income-risk, i.e. choosing safe or conservative strategies (Mendola 2005).

There is much more to learn about peasant behaviour and current research efforts are directed towards 'behavioural' economics (i.e. including individual psychological traits) through experimental analysis. Many program evaluation experiments and field experiments are currently carried out in developing countries in order to acquire a deeper understanding of determinants of decision making in a poor rural setting, beyond what standard economic theory has taught (Duflo, 2003).

The safety first theory of production choices seem to be better suited for the risky and the subsistent rain-fed agriculture of *Pothwar* area of Pakistan' Punjab (the study area). The severe weather conditions (drought and seasonal rainfall), market imperfections and fluctuation, low farm income, social uncertainty and insecurity, the lack of production insurance and the imperfect capital markets of study area urge farmers to behave as risk averse and make production decisions based on safety first production theory to avoid the farm income below their subsistent level.

2.5 Cobb-Douglas Production Function (CDPF)

The Cobb Douglas production function is an economic mathematics model that describes production input and output under certain assumptions. It indicates functional relationship between a certain combination of whole production factors input and the possible maximum output with same technology. The Cobb-Douglas Production Function is among the best known production functions utilized in applied production analysis (Enaami et al. 2011). In economics, this form of production functions is widely used to represent the relationship of an output to inputs. It was proposed by Knut Wicksell (1851 - 1926), and tested against statistical evidence by Charles Cobb and Paul Douglas in 1928. In 1928 Charles Cobb and Paul Douglas published a study in which they modelled the growth of American economy during the period 1899-1922. They considered a simplified view of economy in which production output is determined by the amount of labor involved and the amount of capital invested. The function they used to model production was of form:

$$P(LK) = bL^{\alpha} K^{\beta} \tag{2.5}$$

Where,

• P = Total production (the monetary value of all goods produced in a year)

• L = Labor input (the total number of person-hours worked in a year)

• K = Capital input (the monetary worth of all machinery, equipment, and buildings)

• b = total factor productivity

• α and β are the output elasticities of labor and capital, respectively. These values are constants determined by available technology.

Common criticism on CDPF include that it cannot handle a large number of inputs and is based on the restrictive assumptions of perfect competition in the factor and product markets. It also assumes constant returns to scale (CRS). Moreover single equation estimates are bound to be inconsistent and it cannot measure technical efficiency levels and growth very effectively.

The advantages of this production function include that it is a simple and equally efficient tool for analysing production process. The estimation process is easy and it has advantages to handle multiple inputs in its generalised form. It does not introduce distortions even in the presence of market imperfections which is the common case in real world. Unconstrained CDPF further increases its potentialities to handle different scales of production. Various econometric estimation problems, such as serial correlation, hetro-scedasticity and multi-collinearity can be handled adequately and easily by using this production function. The common criticism on CDPF is its inflexibility. This can be handled by relaxing most of its assumptions. The problem of simultaneity can be handled through the use of stochastic CDPF (Bhanumurthy 2002).

Linear regression based on Ordinary Least Squares (OLS) is a feasible method to analyze linear relationships but is worthless when relationships are non-linear. However, a non-linear relationship between an independent variable and the dependent variable can be converted into a linear relationship by a Logarithmic transformation of variables (D'Ambra and Sarnacchiaro, 2010). Cobb-Douglas Production Function having exponential relationships which is quite common in the rational theories of economics can be turned into linear relationship by taking the natural logarithm of separate variables (Pennings et al., 2006). In applied work, most researchers in the economics area often commence by estimating the CDPF using OLS, hoping to obtain the estimates of labor and capital output elasticities that look plausible and interpretable from a theoretical point of view (Armagan and Ozden, 2007).

The Cobb-Douglas production function, in its stochastic form may be expressed as

$$Y_i = \beta_1 X_{2_i}^{\beta_2} X_{3_i}^{\beta_3} e^{\mu_i} \quad (2.6)$$

Where,

Y = Total output

X_{2i} = Labor input

X_{3i} = Capital input

μ = Stochastic disturbance term

β_2 and β_3 = Output elasticities of labor and capital

This equation shows the nonlinear relationship between output and two inputs. The following equation can be obtained by the log-transformation of equation 2.6:

$$\text{Ln } Y_i = \ln \beta_1 + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \mu_i$$

$$= \beta_0 + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \mu_i \quad (2.7)$$

The model is linear in the parameters β_0, β_2, and β_3 and is therefore a linear regression model. This model is a ln-ln/double ln or ln-linear model. Following are the properties of Cobb-Douglas production function:

β_2 is the partial elasticity of output with respect to labor input. This shows the percentage change in output with 1 percent change in the labor input, holding the capital input constant.

β_3 is the partial elasticity of output wit respect to capital input. This shows the percentage change in output with 1 percent change in the capital input, holding the labor input constant.

Sum of parameters (β_2 + β_3) shows the returns of scale. That is the response of output to the proportionate change in inputs. If this sum is equal to 1, then there are constant returns to scale; while if sum is less than 1, then there are decreasing returns to scale; and if sum is greater than 1, then there are increasing returns to scale.

Whenever there is ln-linear regression model involving and the number of variables, the coefficient of each of X variables measures the partial elasticity the output with respect to that variable. If there is k number of independent variables, the ln-linear model would be as follows:

$$\text{Ln } Y_i = \ln \beta_0 + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \ldots\ldots + \beta_k \ln X_{ki} + \mu_i \quad (2.8)$$

Each of regression coefficient, β_2 through β_k is the partial elasticity of Y with respect to variables X_2 through X_k (Gujrati 2003)

The current investigation also uses the linear form of Cobb-Douglas Production Function by taking the natural logarithm of dependent and independent variables. The detail functional form of production function is given in Chapter 5.

CHAPTER 3: STATE OF RESEARCH

This chapter shows the current state of research including the empirical research studies on agricultural diversification, off-farm work, agricultural risk sources and management strategies, the determinants of farm income, sustainable agriculture, production variability and the advantages of mixed farming, agricultural growth and crop shifts, research for poverty alleviation in marginal areas, farm size and the inverse relationship of farm productivity, the determinants of wheat production and studies regarding *Pothwar* Region.

3.1 Agricultural Diversification

Diversification of agriculture means developing a larger number of crops or enterprises-mix. It may be the response of subsistence farmers to risks arising from climatic, biotic, economic or seasonal factors. These uncertainties can result in variable returns (farm income) to the decisions farmers make in a particular year. Enterprise diversification is one method of reducing income variability (Robison and Barry, 1987; Newbery and Stiglitz, 1987). A broader point of view put forward that agricultural diversification is a process accompanying economic growth, characterized by a gradual movement of resources out of subsistence food crops such as wheat, rice and maize, to a diversified market oriented production system, triggered by improved rural infrastructure, rapid technological change in agricultural production, particularly staple food production, and diversification in food demand patterns (Rosegrant and Hazell 1999).

Farm-level evidence had demonstrated that diversifying the agricultural production systems had improved the farm sector competitiveness. Agricultural diversification could play a catalyst role in overall socioeconomic development by improving nutritional status, generating incomes and jobs both in the farming and non-farming sectors, enhancing resource use efficiency, boosting growth in the total farm productivity of crop sector (FAO, 2003). There had been a few research studies conducted on the impact of agricultural diversification on farm productivity in Pakistan scenario. Particularly production diversity was not linked to the farm income.

Some studies in Pakistan context had shown that the diversification in crop production can significantly improve total farm profitability. More particularly, an increase in the concentration of cereal area can significantly reduce profitability, while an increase in the commercial crops area like pulses and vegetables can improve profitability. A doubling of diversity in crop production will increase total farm productivity by 56 percent in the Pakistan’s Punjab (Ali 2001). Land fragmentation increased in Pakistan due to increase in the population sharing of land among inheritors.

Kurosaki (1995) empirically investigated how agricultural households in Pakistan control their exposure to risk through enterprise selection and asset accumulation/decumulation. The analysis used three-year household data on production and consumption from the rice-wheat zone of Punjab Province, where most farm households combine livestock keeping and crop cultivation within a farm. The decomposition of per capita income into deterministic and transient portions showed that livestock holding contributed to a reduction in income variability through the negative correlation of livestock income with crop income and through the decumulation of livestock assets. A simulation based on the income decomposition showed that a shift in enterprise composition toward livestock products reduces household income variability. These empirical results suggested that the rise in the share of livestock sub-sector in agricultural value added in Pakistan should have improved the welfare position of households with substantial livestock holding. Since smaller farms had a relatively larger livestock herd in the Pakistan Punjab, the recent phenomenon might have had an equity-improving effect as well. Furthermore, because livestock had an additional welfare value as an effective insurance measure, the farmers might have had a stronger incentive to accumulate livestock than those who maximize expected profit from agriculture. In other words, seemingly the large size of livestock holding from the criterion of profit-maximizing efficiency might be rational and efficient for a poor, risk-averse household. Therefore, a welfare component of on-farm and off-farm diversification should be considered in formulating a policy that attempted to change the agricultural structure of country. The adjustments toward risk were possible because agricultural households decided consumption and production jointly. They could use production adjustments to control their exposure to risk according to their preferences. In this way, agricultural households as an organizational institution had an advantage to overcome the incompleteness in insurance markets.

Kurosaki (1996) analyzed household decisions in producing cereal crops, green fodder, crops and milk for the case of mixed farming in Pakistan's Punjab. In Punjab agriculture the increased yields of major cereal crops and household income resulted in the increased importance of milk in household economy. The study emphasized the constraint that fodder crops represent for further increase in food grain output, by sensitivity analysis based on a household model of crop choices under uncertainty. The results indicated that the welfare cost of production risk is significant and it was higher for the land poor households. Its significant part was attributed to green fodder price risk. The welfare and supply effects of more elastic fodder demand and increased fodder yield were investigated. The technological innovations and improved infrastructure for agricultural marketing contributed to more elastic fodder demand and more efficient marketing of milk and milk products. Fodder crop productivity at the individual farm level could be improved by extension services and research and development activities. These innovations in fodder technology were suggested to have higher potential to improve household welfare and to induce a robust supply response of cereal crops with respect to their prices, than a crop insurance scheme.

The authors applied a model of net profit variability at the individual farm level, to Pakistan's agriculture. They found that the addition of idiosyncratic yield shocks and adjustment for input costs resulted in a much larger variability of net profits than implied by the variability of regional average gross revenues. These adjustments resulted in the unexpected finding of higher profit variability in irrigated Pakistan than in semiarid India. Therefore, an empirical analysis of production risk based on the secondary data of prices and aggregate yields alone would be highly unreliable. Such an analysis might likely underestimate the true production risk faced by farmers. Estimation results showed that the correlation between green fodder profit and milk profit at the farm level was substantially negative because green fodder was the most important input in milk production and its price was the most volatile. This meant that combining fodder production and milk production in one enterprise might be advantageous in terms of risk diversification. This conclusion was further reinforced by higher price differential between selling and the buying prices of fodder. Kurosaki (1995a) suggested that livestock contributed to households' consumption smoothing and that the rise in the share of livestock sub-sector in agricultural value added in Pakistan should have improved the welfare positions of poorer households in rural areas. This paper quantified one of mechanisms whereby the combination of livestock and crop production was a welfare-improving measure for risk-averse farmers. Findings in this paper reinforced the claim that a welfare component of diversification strategies of farmers should be considered in formulating agricultural and rural development policies in Pakistan.

Mac Donald (1998) conducted study on Rationality, Representation, and the Risk Mediating Characteristics of a Karakoram Mountain Farming System. Farming systems are often characterized as irrational and as obstacles to achieving the production goals of 'modernized' agriculture despite the emerging appreciations of contextual knowledge systems and the elements of diversity in mountain. These irrationality and yield gaps as compared to modernized agriculture are in part the result of diseconomies of small-scale agriculture. The case-study of mountain farming system in the Karakoram Mountains of northern Pakistan revealed the farming system rationality in relation to risk minimization. The risk mediating characteristics of practices such as field dispersal, delayed planting, intercropping, and poly-varietals planting were examined. It was the diversity which was the key to minimizing risk and reducing vulnerability in this system. The diversity of crops and livestock and the distribution of land acted to distribute risk and leave something in reserve in the event of calamity. Morren and Hyndmann (1987) noted that a loss of biological variability occurred with the wholesale adoption of one or two modern hybrid varieties which replaced a multitude of long-established or traditional non-hybrid varieties. These new hybrids potentially producing higher yields, often required production inputs not available to most small-scale farmers and were frequently ill-suited to local growing conditions or storage requirements (Chambers, 1983, Redclift, 1984, Hecht, 1987). Indeed, when yields were examined longitudinally, total yields per hectare under poly culture were often higher than sole-crop yields, even when the yields of individual components were reduced (Altieri, 1987, 1991, Liebmann, 1987, Vandermeer, 1989). This is supported with numerous historical examples which reveal a long trend towards the homogeneity of production, usually results to the economic marginalization of rural populations (Poffenberaer and Zurbuchen, 1980, Rambo 1982, Leaf 1983, Regan 1983). This reduction in crop diversity and the disruption of traditional practices had effectively removed food security from local control and increased villagers' dependence on broader market conditions. The characteristic feature of local farming system was a need based diversity to ensure the food security.

Weiss and Briglauer (2002) examined the impact of various farm and household characteristics (such as farm size, the off-farm employment status, the farm operator's age and schooling and the number of family members) on level as well as the dynamics of on-farm diversification. Evidence was provided that smaller farms were more specialized and also tend to increase the degree of specialization over time more quickly than large farms by using linked census data for Upper-Austria from 1980, 1985 and 1990. A significantly lower degree of diversification (higher degree of specialization) as well as a stronger reduction in diversification over time was also reported for businesses operated by older, less educated, part-time farm operators. The analysis of diversification dynamics also suggested that farms adjusted to changes in their environment by steadily approaching their long-run equilibrium level of diversification (β-convergence), and the variance of diversification distribution declined over time (σ-convergence). The path of adjustment towards the new equilibrium level depended on farm characteristics. The farms (managed by full-time a young farm operator) showing smallest increase in specialization (the largest increases in diversification) were considered as the fittest for surviving for the long run. For these farms, the potential gains from realizing the economies of scale were not that important as compared to the returns from risk reduction due to on-farm diversification.

The liberalization of international agricultural markets led to further increase the variability of domestic prices. This might slow down the current trend towards the specializations of production or eventually reverse. Those farms showing rapid diversification reduction have been found to face the highest probability of exiting from the agricultural sector (Weiss, 1999). Investigating the probability of farm exits simultaneously with the dynamics of diversification would be an important extension of present empirical analysis. The results reported from the sample of surviving farms only might be biased due to sample selectivity.

Abdulai and Anna (2001) investigated the determinants of farm households' farm income diversification in Southern Mali. The panel data used was collected from the rural households of representative sample in Southern Mali. The different sources of household income were used to examine the determinants of income diversification. The authors examined the income portfolios of farm households in Southern Mali, focusing on four main activities: food-crop production, cash-crop production, livestock rearing and non-farm work. The results showed that households held the different portfolios of incomes and these in turn were related to the different levels of income and asset holdings. Poorer households were found to have fewer opportunities in cash-crop production as well as non-crop activities, resulting in their less diversified incomes. The deficiency of capital was a major reason for less diversified portfolios of poorer households as almost 42 percent of households indicated that the lack of access to credit was a major constraint to their participation in the non-cropping sector. A conditional fixed effects logit model was employed in the analysis to examine the determinants of participation in various activities. The estimates showed that the wealth of household measured by its land holding had a large positive impact on its participation in both livestock-rearing and non-farm activities. The results also indicated that households closer to local markets were more likely to participate in non-food production activities than their counterparts in remote areas. This supported the notion that households with superior access to markets were in a better position to overcome factor market constraints and develop private marketing initiatives to promote the shift of producer resources into diversification activities. Households with educated heads were more likely to participate in the non-farm sector than those with illiterate heads. Farm households tend to face differential entry barriers into non-cropping activities and taking up lucrative opportunities, due to the shortage of investment capital resources.

Barret et al. (2001) presented evidence on the effects of two different sorts of policy shocks on observed income diversification patterns in rural Africa. Non-farm activities provided opportunities for greater upward farm household income mobility. This increased diversification also lead to skilled employment and self employment.

The benefits of exchange rate devaluation reform accrued disproportionately, to the households which were resourceful before the announcement of policy. The households with poor endowments were less able to respond to attractive emerging on-farm and non-farm opportunities due to entry barriers to superior livelihood strategies. This resulted increase in the inequality among farming community. This revealed the importance of securing all farmers' access to attractive niches within a vibrant rural non-farm economy through improved liquidity, market access and human capital formation.

Block and P. Webb (2001) investigated the livelihood diversification in rural Ethiopia. This paper was based on data for almost 300 households and explored associations among income diversification, the household perceptions of livelihood risks, and changes in consumption outcomes across two points in time in post-famine. The findings of study confirm that households surviving the famine with higher than average income and food consumption levels also had a more diversified income base and more valuable assets in hand (especially livestock). Analysis of the determinants of diversification indicated that greater income diversification (out of cropping) was positively associated with per capita income level, higher dependency ratio, location in the highlands, and the ownership of non-farm assets. No significant association was found between education and changes in well-being over time. It is because opportunities for diversification in the inter-survey period rested little on formal salaried employment with which a link to human capital accumulation would have been expected.

The perception of older household heads and small farm size to be the predictors of household risk was not confirmed empirically. Most households did believe that the income earning outside of cropping (non farm employment and livestock activities combined) was a key to reducing risk, and this was shown to be significant. All households could not reap the benefit of this insight. An inverse association was observed between female-headed households and diversification; despite the fact the female heads were significantly more likely to believe that off-farm income protects a household against famine. It appeared that believing in the inherent superiority of strategy of income diversification could not always be acted upon, especially in the absence of prior wealth and assets.

Nevertheless, the post-famine recovery period was a time of dynamism and change, as highlighted by high inter-deciles income and consumption mobility. The households that most increased their flow of non-crop income between the two surveys were the poorest and least diversified in the initial period. The already well diversified maintained their level of diversification but still increased their income flow and asset wealth. These findings suggest that complex trade-offs exist between the perceptions of risk and diversification practices, trade-offs that vary considerably by household type and location.

Kurosaki and Fafchamps (2002) investigated the efficiency of insurance markets in the Pakistan Punjab by examining how crop choices were affected by the presence of price and yield risk. They estimated reduced-form and the structural models of crop choices using household survey data. The village members efficiently shared risk among themselves and production choices depended on risk. Existing risk sharing and self-insurance mechanisms thus partially protected Punjab farmers against village level shocks. Results also indicated that households responded to consumption price risk, thereby suggesting that yield and output price risk should not be the exclusive consideration for empirical and theoretical work on risk.

The production decisions of Punjabi farmers were affected by the presence of risk despite a large body of evidence suggesting that South Asian farmers self-insure and share risk with others (Townsend, 1994; Morduch, 1991; Foster and Rosenzweig, 2001; Fafchamps and Pender, 1997; Walker and Ryan, 1990; Jacoby and Skoufias, 1995). The reason appeared to be that households find it difficult to protect themselves against collective shocks that affect yields as well as output and input prices. The evidence of risk sharing and precautionary saving by developing countries' households should thus not be interpreted as a sign that existing institutions were efficient. Barriers to the pooling of risk across villages and regions remain. Government intervention is needed to mitigate village-level shocks that these households face, such as famines and floods.

Households adapt production to respond to consumption price risk. This suggested that empirical and theoretical work on risk should avoid putting an exclusive emphasis on yield and output price risk. This result is supported by nicely complement previous work by Antle (1987, 1989), Antle and Crissman (1990), and Walker and Ryan (1990). Households might produce their own food in order to self-insure against price fluctuations even when food markets were present. The same reasoning explains why they might choose to produce inputs, e.g., green fodder, for other farm activities, e.g., milk production.

Kurosaki (2006) studied the role of resource reallocation within agriculture across crops and across regions. The allocation of land was critically important in agriculture due to high transaction costs including transportation costs (Baulch, 1997). Because of this, farmers might optimally choose a crop mix that did not maximize expected profits evaluated at market prices but does maximize expected profits evaluated at farm-gate prices after adjusting for transaction costs (Omamo, 1998a; 1998b). In the growth accounting framework, a similar phenomenon was more often interpreted as disequilibrium. If all producers did not choose activities based on the principle of comparative advantage, there was room for growth by reallocating resources in a way closer to the maximization of profits. In this case, output could increase without technological or price changes, yielding a so-called "disequilibrium" effect in the literature on inter-sectoral factor reallocation (Syrquin, 1984; 1988). Subjective equilibrium models for agricultural households provided other reasons for the divergence of decision prices by farmers from market prices. In the absence of labor markets, households needed to be self-sufficient in farm labor (de Janvry et al., 1991). Also, farmers might consider production and consumption risk or the domestic needs of their families if insurance markets are incomplete (Kurosaki and Fafchamps, 2002). In these cases, their production choices could be expressed as a subjective equilibrium evaluated at household-level shadow prices.

During the initial phase of agricultural transformation, it was likely that the extent of diversification would be similar at the country level and the more micro levels because, given the lack of well-developed agricultural produce markets, farmers had to grow the crops they wanted to consume themselves (Timmer, 1997). As rural markets developed, the discrepancy between the market price of a commodity and the decision price at the farm level was reduced. In other words, the development of rural markets was a process which allowed farmers to adopt production choices that reflect their comparative advantages more closely, and thus contributed to productivity improvement at the aggregate level evaluated at common, market prices. Therefore, the effect of crop shifts on productivity growth was a useful indicator of market development in developing countries.

Based on a production dataset that corresponded to the current borders of India and Pakistan for the period 1900-2000 and a district-level dataset from West Punjab for a similar period, Kurosaki (2006) investigated the performance of agriculture in these regions and associated it with crop shifts. The empirical results showed a discontinuity between the pre and the post independence periods, both in India and in Pakistan, and in West Punjab and its districts. Total output growth rates rose from zero or very low figures to significantly positive levels, which were sustained throughout the post-independence period. The crop mix changed with increasing concentration beginning in the mid 1950s. The study quantified the effects of inter-crop and inter-district crop shifts on the land productivity. It was found that the crop shifts contributed substantially to the productivity growth, especially during the periods with limited technological breakthroughs. Underlying these effects were the responses of farmers to changes in the market conditions and agricultural policies. Agriculture in these regions had experienced a consistent concentration of crops since the mid 1950s, when agricultural transformation in terms of output per agricultural worker was proceeding. These trends continued until the early 1990s in Pakistan's Punjab and until the early 2000s in India. The performance in the latest periods suggested that agriculture in these regions seemed to have entered a new phase of diversified production and consumption at the country level (Timmer, 1997).

Implications for agricultural policies on agricultural production in the 21st century were explored. First, it appeared likely that institutional and policy changes had significant effects on agricultural production in India and Pakistan. Second, farmers in India and Pakistan responded to the changes in market conditions, not only by adopting new technology with high-yield potential but also by adjusting their land allocation toward high value crops. Third, existing evidence suggested that public investment in agriculture and in rural areas had been cut back since the 1980s. It should be emphasized that the sustained growth during the post-independence period was achieved at a time when substantial public investment was being implemented. With reduced public investment and in the absence of simultaneous improvement in investment efficiency, the boom experienced during the 1990s would not be sustained.

Rahman (2009) studied the merit of crop diversification as a strategy for agricultural growth in Bangladesh. Specifically, the existence of diversification economies, scale economies and diversification efficiencies at the farm level were examined using a stochastic input-distance function approach. The results showed the strong evidence of diversification economies amongst most crop enterprises except the combination of modern rice and modern wheat enterprises. The economies of scale and efficiency gains made from diversification were significant among cropping enterprises. The development of rural infrastructure was considered essential as this will not only improve technical efficiency but may also promote crop diversification by opening up opportunities for technology diffusion, marketing, storage and resource supplies.

Mishra et al. (2010) investigated the determinants of farm household income diversification in the United States of America. The goal of study was to identify demographic and economic factors affecting farm household income diversification. Particular attention was given to the role of farm household asset portfolio, farm operator liquidity, attitudes toward risk, and vertical integration in income diversification. The analysis was conducted on a national farm-level basis with the unique feature of larger sample, the comprising farms of different economic sizes and in the different regions of United States. The data used in this analysis were from the 1999, 2003, and 2007 Agricultural Resource Management Survey (ARMS). The characteristics of those households engaging in off-farm work by year, by region, and by farm type were examined. A standard farm household model was used to estimate a censored Tobit regression model.

The results revealed that older operators, full owners, and small farms had the higher intensity of off-farm income in total household income. The dairy farms, vertically coordinated farms and farms located in the Southern and Pacific regions had the lower intensity of off-farm income and thus these farms were less likely to be diversified. These results suggested that the abilities of farm business and farm households to help manage weather, climate and market risks through farm household income diversification vary over space and time, and by the specific demographic and the economic factors of farm households.

3.2 Determinants of Farm Income

Anriquez and Alberto (2006) explored the determinants of rural household and farm-related income in Pakistan. The authors used the PIDE household survey of 2001. The research investigation captured the potential interactions between farm returns and household, farm, and factor market characteristics (schooling, family size, land tenure and operational size, access to water, credit, and capital). Econometric results showed that returns to additional schooling and the revenue elasticity of operated acres increase with farm size. Medium and large farm renters were willing to pay more than observed rents, implying an incentive to increase farm size at the prevailing rental values. In the case of surface water use, medium and small farms showed a higher productivity of water than large farms. This result provided empirical foundations for the proposition that creating a surface water market would improve farm revenues. The results of study favoured farm size increase while off-farm and non-farm income sources were relatively more important for small farmers, contributing to their viability.

The most important result was that land markets were not working efficiently in rural Pakistan. In the short term, land tenure (owned, rented or sharecropped) was fixed, i.e. for the agricultural season so the land decisions were exogenous. Land holdings could be adjusted in the medium term, while variable inputs (labor, fertiliser, capital equipment rental) were adjustable in the short term. The fact that land resources may not be used to their full potential had enormous consequences for rural income, and thus for poverty in Pakistan. Controlling for farm size, education and other variables, land owner-operators, landlords who were also tenants leasing in, and fixed rental tenants earned more revenues than sharecropping tenants, who earned only slightly more than those without operational farmland. The difference between landowner/fix-renter income and sharecropper income varied with family and farm size, as well as water use. Sharecroppers were slightly less efficient as compared to other tenancy-type farmers.

Ibekwe (2010) explored the determinants of income of farm households in the Orlu Agricultural Zone of Imo State, Nigeria. Nigerian rural farm households had decreasing farm production and low farm incomes as compared to rising inflation. This study was designed to partially fill the knowledge gap on nature and the determinants of farm household income within an essentially traditional farming society characterized by high population pressure and a mixture of use of traditional and improved farm inputs. This study determined an average farm household income of N 60,197.81 per annum and a per capita income of N 7,524.73 with a Gini-coefficient of 0.488. The income regression parameter estimates showed that the variables extension services, property income and farm size were positively correlated with farm household income and were also significant at five percent. The variables income from pension, hours spent on farm income from the handicraft education of household head, income transfers and the age of household head were positively correlated with farm household income but not statistically significant at five percent. The hypothesis of no significant difference in the contributions of determinants of farm household income was tested and rejected at five percent level.

3.3 Off-Farm Work and Income Opportunities

Off-farm work by farm household members is a continual and rapidly growing phenomenon in most of the industrialized countries. A number of studies (Mishra and Goodwin 1997, Olfert 1992, Mishra et al. 2002), focused on the reasons of increased off-farm labor supply. Major reasons include a decrease in income risk, the under employment of farm family labor and an increasing attitude towards female participation in paid labor markets. Other studies (Huffman 1991; Lass et al. 1991) investigated the factors (farm size and type, the demographic structure of household) affecting supply of off-farm labor, the demand for farm household labor (education and work experience) and both demand and supply. Relatively less emphasis was given to the impact of off-farm work on farm production methods (Ellis et al. 1999; Goodwin and Mishra 2004; McNally 2002; Nehring and Fernandez–Cornejo 2005; Smith 2002). Some of studies showing the relation of off-farm work and income opportunities and the agricultural production are reviewed here.

McNally (2002) argued that off-farm work may result in less time being devoted to the management of farm business. This might result in neglect to farm operations and an increase in the use of inputs which cause environmental damage. The increase in the input use as a result of more off-farm work, may damage to wildlife and habitats and cause surface and groundwater pollution (McLaughlin and Mineau 1995 and Skinner et al. 1997). The involvement of a farmer in off-farm work affects the intensity of agricultural input use, focusing particularly on inorganic fertilizer and crop protection use intensity, which had well-defined links to environmental damage (Phimister, E. and D. Roberts. 2006). Smith (2002) suggested that the reduction in the time available for farm management inhibits the adoption of time-intensive farming techniques such as integrated pest management, soil testing (to avoid over-fertilization), and precision farming. Goodwin and Mishra (2004) provided support for Smith's hypotheses showing that a greater involvement in off-farm labor markets decreased on-farm efficiency. In contrast, Gasson (1988) suggested that income from off-farm work may help farmers to perform farm operations in more environmental friendly way. Consistent with this, Ellis et al. (1999) found evidence from a field-level survey that off-farm work was associated with less intensive production methods and greater production diversity.

Phimister and Roberts (2006) investigated the effects of off-farm work by farmers on the intensity of fertilizer and crop protection products input use per hectare. A sample selection model based on individual farm level panel data for 2,419 farms in England and Wales was used. The results provided the evidence that input intensity for products could increase as well as decrease as time spent off-farm increases. Results reveal that the use of crop protection per hectare increased at the relatively high levels of off-farm work, in particular when the farmer worked off-farm between 430 and 900 hours annually. In contrast, the evidence that supports the link between fertilizer intensity and off-farm labor suggested that fertilizer intensity declined as off-farm labor increased. Results for other inputs revealed both positive and negative intensity effects. The other inputs intensity increased when a farmer works off-farm between 200 and 430 hours a year, but decreased at the higher levels of off-farm work. The analysis also found the evidence of simultaneity in off-farm work decisions and crop protection use per hectare. In contrast there was no evidence that fertilizer use per hectare or the other input measures used were simultaneously determined with off-farm labor decisions. The lack of consistency was a slight confusing as the basic farm household model would predict either simultaneity or a recursive relationship across all inputs.

Babatunde and Matin (2010) studied the impact of off-farm income on food security and nutrition. The data used was taken from a comprehensive survey of farm households in Kwara State, the north-central region of Nigeria, which was conducted between April and August 2006. The state had a total population of about 2.4 million people, 70 percent of which could be classified as small holder farmers. The farming system was characterized by low quality land and cereal based cropping patterns. Most farm households were the net buyers of food, at least seasonally (KWSG, 2006). Overall 220 farm households were personally interviewed, which were selected by a multi-stage random sampling technique. The effects of off-farm income on household food security and nutrition in the Kwara State of Nigeria were analysed.

Descriptive analyses and econometric approaches showed that off-farm income contributed to improved calorie supply at the household level. Moreover off-farm income had a positive impact on dietary quality and micronutrient supply. Child nutritional status was better in households with access to off-farm income than in households without. Off-farm income had the same marginal effect as farm income, which was true not only for household calorie consumption, but also for dietary quality and micronutrient supply. In the case of Kwara State, where the shortage of capital was a major constraint, off-farm income also contributed to more intensive farming and higher food production and farm income. Overall the results of study revealed that both farm and off-farm activities contributed to better food security and nutrition.

3.4 Sustainability and Agriculture Risk

The importance of sustainability among farmers differs and is influenced by socio-economic characteristics as well as the information-seeking behaviour of farmers. The most commonly used the definition of sustainable development is the development that meets the needs of present generation without compromising the ability of future generations to meet their needs (WCED 1987). To be sustainable, a developmental process should integrate three dimensions, namely environmental, economic, and social. Environmental sustainability is achieved through the protection and the effective management of natural resources. Economic sustainability is attained by a mix of occupations that provide long-term and stable incomes; and social sustainability is ensured by the means of active community participation and a strong civil society (Goodland 1995).

Sustainable agriculture includes a dynamic set of practices and technologies that minimize damage to the environment while providing income to the farmer over a long time (Flora 1992). It is considered that sustainable agriculture is a low-input agriculture, the assumption is unfair because sustainable agricultural systems use ‘‘the best available technology’’ in a balanced, well-managed, and environmentally responsible manner (Hess 1991). The operational goals of sustainable agriculture, as stated by Benbrook (1991), are: (1) more thorough incorporation of natural processes such as nutrient cycling, nitrogen fixation, and beneficial pest–predator relationships into the agricultural production process; (2) reduction in the use of off-farm inputs with the greatest potential to harm the environment or health of farmers and consumers; (3) the productive use of biological and genetic potential of plant and animal species; (4) improvement in the match between cropping patterns, and the productive potential and physical limitations of agricultural lands; and (5) profitable and efficient production with the emphasis on improved farm management, the prevention of animal diseases, the optimal integration of livestock and cropping enterprises, and the conservation of soil, water, energy and biological resources.’’ Farmers and rural people ultimately benefit from the achievement of these goals as most of the goals indicate environmental and the ecological dimensions of sustainable agriculture. Therefore, sustainable agricultural practices must also provide long-term socially attainable economic benefits (Pugliese 2001).

Bard and Peter (2000) conducted study to adopt a methodology formulated in the social sciences for developing a scale to measure an economic agent’s attitude toward risk. The methodology for developing an attitudinal scale was applied to assessing farmers’ attitudes toward the risk in production agriculture. It was hypothesized that attitudes towards tools used for managing risk reflect producer’s underlying the construct of risk attitude. Based on some previous research studies

(Patrick et al., 1985; Patrick and Ullerich, 1996; Patrick and Musser, 1995; Blank and McDonald, 1995), 25 statements addressing different methods for managing risk were formulated. Responses to the statements indicated the degree to which a farmer agrees or disagrees with the tool's utilization. Two comparative methods were used for measuring risk attitudes to farmers, analyzing the responses and refining the scale. The scale assessed risk attitudes by eliciting farmers' opinions towards risk management tools. A Lickert scale was used as the measurement format due to its appropriateness for accessing attitudes (Spector, 1992 and Devellis, 1991). The outcome was recommendations for refined risk attitudes. The implications of resulting scales were limited due to small size and the homogeneous nature of sample. The study did not purpose to a final product in itself but presented an application of methodology for developing a useful tool to agricultural enterprises. The methodology validated the scale with a scientific risk attitude measure and compared the scale to the farmers' self-assessment of their risk attitudes. The study created new analytical tool in agribusiness analysis which will provide opportunities for further scale development and refinement, and application to research, education, industry and policy analysis.

Akcaoz and B. Ozkan (2005) conducted study in the Cukutova region of Turkey. The research objective was to identify the groups of farmers who differ in their risk sources and risk management strategies. The farm households were divided into three risk attitude groups, risk averse, risk seeking and risk neutral by using reference gamble (Lottery) and preference scales. Factor analysis was conducted on information obtained from 112 farmers in 2000. On the basis factor analysis results risk sources were labeled as environmental, price, catastrophe, input costs, production and technological, political, finance, personal, marketing, health and social security. The important risk strategies were named as diversification, off-farm income, marketing, planning, financing and security. The results further showed that for risk averse group government agricultural policy, for risk neutral group input costs and crop prices were determined as the most important risk sources. For both the risk averse and risk seeking groups of farmers, growing more than one crop was the most important risk strategy while spreading sales was the most important risk strategy for the risk neutral groups of farmers.

Madai (2008) gave an overview of risk attitudes of Hungarian sheep producers regarding the changes they had to go through since the political changes of 1989-1990. The objective of this study was to strengthen the empirical basis for risk analysis by identifying the importance of farmers' risk attitudes. The results of a nationwide survey of over 500 sheep farmers revealed risk attitudes, risk sources and applied the risk management techniques of livestock producers. The method was based on a representative national field survey involving 10 percent of sheep farmers and 80 percent of sheep farms in the Hajdú-Bihar Region (consist of 1/3 of Hungarian Sheep Population).

The results of survey showed that sheep farmers tried to apply risk management techniques as was possible under the given conditions. The economies of scales and the lack of capital were major difficulties to carry it out. The most widely applied risk management strategies were the cooperation between farmers and joining to producer groups, which was applied by 74.4 percent of farmers and scored to 3.8. Maintaining feed reserves got a 3.5 score and was applied by 73.6 percent of producers. Gathering market information and monitoring were also highlighted by farmers as useable tools for decreasing risk. Security and safeguarding also obtained the scores of 3.8. These techniques were in correspondence with the main risk sources. The least-used strategies (applied by 16 % of farmers) were debt management and off-farm investment. This showed that most farmers were poor and had no equities and capital to resort debt or make other investments. Irrigation and not producing to full capacity were not widely applied by farmers. Sheep farmers were not so exposed to market regulations, because of subsistent nature of this sector. Overall survey results showed that farmers tried to take measures to protect their businesses against risks coming from the political and economic changes.

Tatlidil et al. (2008) explored the degree of importance that farmers attach to different sustainable agricultural practices and factors that influence it. The primary purpose of this study was to assess in quantitative terms the farmers' perceptions of sustainable agriculture and to determine how those are influenced by different socio-economic characteristics and the information-seeking behaviour of farmers. The study was conducted in the Kahramanmaras province of Turkey and comprised a stratified sample of 208 farmers from the four districts of province. The farmers rated each of 21 selected sustainable agricultural practices regarding their importance on a 5-point scale and the total of these ratings formed the sustainable agriculture perception index. The overall index score measured the farmers' perception of sustainability. However, the score did not predict whether farmers will actually adopt these practices themselves. The index score was calculated for each farmer and was treated as the dependent variable in the stepwise regression analysis procedure. The independent variables were the farming system; the total and irrigated area of farm; the membership of a cooperative society; participation in village administration; age, education and income of farmer and the components of information-seeking behaviour. Information seeking behaviour included the use of mass media (newspapers, radio, and television), the use of internet, travel, and participation in farming events. The results of study showed that the higher the socioeconomic status (more frequent contact with extension services, higher education, the ownership of land) and the greater the access to information, the greater is the perceived importance of sustainable agricultural practices. The results showed that the importance that the farmers attached to the 21 useful sustainable agricultural practices was influenced by their current farming system, their experiences, and their attitudes and beliefs toward change. The farmers' perception of sustainable agriculture was influenced by the personality of farmer and his or her socio-economic and socio-cultural characteristics.

The results suggested that to prevent land division and fragmentation, landowners needed to leave their farms to only one of their heirs who were committed and willing to continue farming. The increasing pressure on land as a sole mean of livelihood for the growing population would threaten the sustainability of agriculture. Off-farm livelihoods activities were considered useful to decrease the population pressure to earn livelihood from agriculture. Of socio-economic characteristics, the ownership of land was the most significant factor. The farmers who own the land take the greater care of it while tenant farmers and share croppers wanted to take the maximum profit out of rented land. They might not be willing to adopt sustainable agricultural practices like the less use of chemicals and fertilizers that might reduce their income. They might exploit publicly owned grazing land beyond its carrying capacity because, not being permanent residents and they had no permanent stake in such a resource. On the contrary, their aim was likely to maximize profits as quickly as possible and shift to other fertile places. The landowners were the permanent residents and their welfare was tied to the long-term sustainability of land. They considered that if they failed to manage the natural resources well, their future generations would have a hard time meeting their own needs. The findings of this study proved that as MARA's extension services reached more farmers in rural areas and as more farmers attended farming events, the farmers' perceptions of importance of sustainability would go up. Consequently, the farmers would more likely to be sensitive to the need to protect and maintain their land as well as publicly owned natural resources.

3.5 Marginal Areas and Poverty Alleviation

Marginal areas are often characterized by a high incidence of 'marginal' people with relatively homogeneous determinants of poverty (TAC, 1999), low agricultural potential, inadequate infrastructure, and neglect by government policy and research (Kuyvenhoven et al., 2004). In such areas responses to poverty include privatization, specialization, intensification, diversification, migration for wages and exiting agriculture (Dixon et al., 2001). Public investments had traditionally concentrated on higher rainfall and irrigated areas, while research, extension, market development, credit provision and infrastructure in the marginal dry areas had often been neglected. As a result there is a shortage of improved agricultural technologies. Many researchers and development planners believe that agricultural research contributes to poverty alleviation, if it can address diverse challenges and the opportunities of rural people and identify development pathways that build on technological innovations. These pathways can be described as the patterns of change in livelihood strategies (Pender, 2004) determined by comparative advantages in agricultural potential, access to markets, population density, local organizations and services and natural resources.

La Rovere and Hassan (2006) analyzed the impact of targeted research on poverty in marginal areas in Syria. The main responses of Khanasser households to challenges of living in marginal areas were the diversification of livelihood strategies, specialization in intensive activities, migration and exiting agriculture. Rural households were heterogeneous as their assets, capabilities, resilience and opportunities were diverse. The presence of the different types of households implied that different technologies were suitable for different endowments. The diversity of options could lead to a variety of impacts. The definition and operative adoption of household typologies was an element of development-oriented research that allowed hypotheses and technologies to be tested vis-à-vis the intended beneficiaries, to design policies that accounted for livelihood diversity and the interdependence of different groups through labor exchanges and people mobility. It also facilitated identification, targeting up, and the out scaling of research solutions. The direct beneficiaries of agricultural research in the Khanasser marginal area were the poor households endowed with enough natural and labor resources that could make a main living from farming. The poorer, virtually landless laborers and more remotely located households with livelihoods only marginally based on farming, representing about a third of total population were not among the direct beneficiaries of agricultural research. These often had to rely on off-farm earnings or exit agriculture, as they had no obvious farming-based opportunities. Agricultural research couldn't directly alleviate their state of poverty, particularly in the short term, but was well placed to identify and advocate alternative policy intervention pathways. Agricultural options that were accessible, profitable, affordable, ecologically sound, and suitable for this marginal area were limited. The experimental results of this study suggested interventions that could positively impact on the livelihoods of poor farmers in Khanasser. The technologies likely to be adopted and successful were those that contribute to:

- A more efficient use of water to preserve ground water mainly during time of drought: water harvesting technologies, water use efficient irrigation, drought-resistant crop varieties.
- Reversing the declines in biomass and pasture degradation, by increasing the reliance on better feeding strategies and the local production of lower cost feed.
- Counteracting the decline in job opportunities by the spread of labor intensive technologies, as viable alternatives to off-farm waged migration.
- Buffering the volatility of farm incomes by yield-stabilizing technologies, access to market information, improved post-harvest technologies and the diffusion of rain-fed cash crops.
- Improving nutrition, food diversity, and health and lowering household food expenditure by the diffusion of dairy, fruit and oil and on-farm vegetables production.

Green revolution for marginal dry areas unlike for irrigated areas did not heavily depend on external inputs. It combined drought tolerant genetic material, nitrogen fixing crops, tillage and water practices for drought resistance, and other context-specific innovations for the boosting portfolio of locally feasible options. Though these investments yielded lower returns compared with other areas, the combination of traditional, alternative, and emerging options might yield higher returns for marginal lands than earlier technology did.

Agricultural research could have only moderate and variable impacts on other paramount challenges (health, education, unemployment and trade) for livelihoods in marginal dry areas. The results showed that all rural population in the marginal dry areas will not necessarily be lifted out of poverty by agricultural research. The poorest households with no agricultural assets would not directly benefit from agricultural research. In addition to the investment in agriculture based innovations for the part of rural people with agricultural assets, long-term social investments for the poorest rural sectors in marginal areas might yield higher returns. Several research organizations, in fact, often ended up working with the better off, educated, endowed, and innovative farmers. This could certainly facilitate testing and the adoption of technologies, but did not always allow reaching those who were in the greater need of new options. This would generally benefit the larger or better off farmers and might contribute to widen inequality gaps.

3.6 Irrigation, Farm Productivity and Poverty

Hussain and Hinjra (2003) extensively reviewed the literature about the impact of irrigation on poverty and found strong direct and indirect linkages between irrigation and poverty. Irrigation caused higher yields, lowered the risk of crop failure and expanded farm as well as non-farm employment. Irrigation helped the poor to adopt more diversified cropping pattern and to grow high value crops. Irrigation reduced both transitional and chronic poverty. Cropping intensity, crop productivity, labor productivity and household incomes were observed higher in irrigated areas than in the rain-fed areas.

Hussain et al (2003 b) analyzed that access to irrigation had significant positive affect on food security and poverty alleviation. Irrigation infrastructure ensured the food security for both farm and non-farm households through increase in agricultural productivity, employment, household income and expenditures.

Hussain et al (2003 c) investigated the linkages between agricultural water availability and rural poverty. The comparison was made for households having access to improved irrigation infrastructure, unimproved and without infrastructure. The survey was conducted three times from 1578 farm and non-farm households in both Sri Lanka and Pakistan. The results revealed that the income and expenditure of households having access to irrigation infrastructure were higher than those having no access. Household expenditures were 24 percent higher in area with irrigation than in area having no access to irrigation infrastructure in Sri Lanka. In Pakistan access to irrigation infrastructure reduced the chronic poverty. Improvement in irrigation infrastructure resulted in 5 to 25 percent increase in crop productivity in Pakistan. The impact of irrigation was higher in the case of equitable land distribution.

3.7 Farm Size and Land Productivity Inverse Relationship (IR)

Several obvious and less obvious reasons and explanations for this IR had been tested and proven. The reason is the failures in different types of production factor markets: land market (Platteau, 1996; Heltberg, 1998), credit market (Assuncao and Ghatak, 2003), insurance market (Dercon and Krishnan, 1996) and labor market (Barrett, 1996; Assuncao and Braido, 2007). Malfunctioning or a complete absence of these markets will lead to suboptimal resource allocation on farm level implying inefficiencies. An important cause of presence of imperfect labor markets in developing countries is claimed to be labor supervision cost (Lipton, 2010). The theory of imperfect labor supervision claims that the labor productivity of family labor forces is higher than that of hired external labor forces. As hired labor is less motivated and effective, it takes more productive family labor to supervise hired labor which decreases overall labor productivity at farm level. This would explain why labor and farm productivity are lower on large farms, which require more hired labor. A second important explanation is related to farm management. Farming practices and production methods might vary according to farm size, leading to differences in yields and productivity (Byiringiro and Reardon, 1996; Assuncao and Braido, 2007; Lipton, 2010).

A third explanation of IR is related to methodological issues. Recent research questions whether the IR between farm size and productivity emerges due to omitted variables. Soil quality is mentioned as an important but often neglected explanatory variable. Differences in soil quality lead to differences in soil productivity which clearly affects output, with small farmers being more productive because of better quality plots. All revised studies on this issue show a decrease in the severity of IR when controlling for soil quality (Lamb, 2003; Assuncao and Braido, 2007; Barrett et al., 2010). Benjamin (1995) finds that the IR disappears when indirectly controlling for soil quality. A second set of missing variables are household specific characteristics such as household size, dependency ratio, and the gender of household head (Assuncao and Braido, 2007; Barrett et al., 2010). However none of the studies cited up to now has proven household characteristics to solely explain the IR. Moreover, Lipton (2010) argues that differentiation in farm management skills as an explanatory variable of farm productivity is not yet sufficiently tested in empirical research. Moreover most empirical studies on the IR are based on cross sectional data. Arguably, the scale range on which the analysis is based is too small to measure scale effects. Analysis usually compares the smaller farmers with the less small farms, and fails to measure a longitudinal effect of scale increase (Collier and Dercon, 2009).

Ahmad and Qureshi (1999) attempted to address the effects of farm size and regional differences on land productivity and the myth of an inverse relationship between farm size and productivity per acre. The study used farm level input and output data from the 'Rural Finance Survey of Punjab (RFS)' conducted by Punjab Economic Research Institute, Lahore. The data comprised 1229 farm family surveys over the cropping year 1997-98.

The existence of inverse relationship between farm size and the total value of output per cultivated acre was established for the overall Punjab province but not for all regions. Main factors for the inverse relationship included the more intensive use of inputs per cultivated acre and a high level of cropping intensity on small farms.

Inverse relationship between the output per acre of crops with the farm size was not found for all crops. In fact, rice and sugarcane had exhibited the opposite relationship, i.e. a strong positive association between the farm size and productivity. Technical efficiency was positively related with the farm size implying that the larger farmers realize greater potential output from the given level of inputs and technology.

Fatma Gül (2006) confirmed the strong inverse relationship between farm size and yield in the case of Turkey. Notably, FAO (1999) and Cakmak (2004) claim that due to small size farm output remained low in comparison to the country's enormous potential. Further, in the most recent OECD (2006) country report on Turkey, it was stated that “stopping land fragmentation and consolidating the highly fragmented land is indispensable for raising agricultural productivity. Fatima Gül (2006) was the first quantitative work on Turkish agriculture which discredited such beliefs, and demonstrated the lack of firm empirical grounds.

This study also suggested that labor input per decare seemed to be driving the IR in Turkey. Additionally, the significance of family labor was consistent with hypotheses regarding the supervision of constraints with respect to labor, according to which hired workers were not perfect substitutes for family labor. The farmer heterogeneity hypothesis being the reason for IR was also not proved. Land heterogeneity explained only part of the inverse size-yield relationship, IR was still very robust and significant despite controlled land heterogeneity. Land fragmentation had positive impact on land productivity for the country in general. The regional analysis of this study did not support OECD (2006) and FAO (1999) claims regarding this relationship. The degree of land ownership inequality and access to credit were important factors in defining the productivity. The findings in this paper pointed not only to economic but also social dimensions might be the crucial determinants of farm productivity. Land ownership inequality had a positive impact on labor input and a negative impact on non-labor (non-land) input. Such a pattern might be suggesting non-economic reasons for why such variation in input usage exists.

Thapa (2007) examined the farm size and productivity relationship using data from the Mardi Watershed Area of Kaski district in the western hills of Nepal. The survey was organized as a part of an MSc dissertation with financial support from the

Norwegian University of Life Science. The random sampling method was applied to select sample households. A cross section random sample of 250 farm households was undertaken during the period June to August 2002.

The analysis used models both allowing for and not allowing for village dummies (as cluster controls), the ratio of irrigated land (as proxy for land quality), and other socio-economic variables such as households, belonging to caste groups, and family size (as proxy for access to resources). The study area represented both the characteristics of subsistence and to some extent of commercial farming. The study area was therefore, regarded as the best area for addressing the farm size-productivity relationship. The survey collected the detailed information of farm and non-farm activities, as well as demographic characteristics. The data set provided the detailed information of tradable and non-tradable inputs and outputs.

The relationship between farm size and output per hectare was analyzed by testing the almost 'stylized fact' of inverse relationship between farm size and productivity. The extended regression equations incorporating village dummies as cluster controls and the ratio of irrigated land (as proxy for land quality) and other socio-economic variables such as household belonging to caste groups and family size (as proxy for access to resources) was performed. The results did not support the hypotheses that the IR is due to the variation of regions as well as access to resources. However, the analysis did not reject completely about the differences in resource accessibility among caste groups as well as family and hired labor. The paper also estimated total cash inputs and labor hours per hectare in order to measure the productivity differentials. The findings supported the stylized fact that small farms were more productive than large farms because of their intensive use of labor and cash inputs than large farms. The coefficients of family size both in output and in labor hours per hectare revealed the importance of family labor on farm productivity in most parts of rural areas.

The paper further applied the Cobb Douglas (CD) production function in order to find returns to scale and the impact of production factors in the Nepalese agriculture. The evidence found constant returns to scale at the 10 percent level of significance in the hilly region of Nepal, rejecting the hypothesis that the IR is due to decreasing returns to scale. Among the different factors of production, labor input seemed more influential than other factors followed by manure. The coefficient of cash input showed that the impact of tradable inputs was still insignificant in the sample farms. The overall result showed that the IR between farm size and output per hectare was perhaps due to more of other inputs used by small farms rather than the diseconomies of scale.

Masterson (2007) assessed the relationship between farm size and productivity in Paraguay. Both parametric and nonparametric methods were used to derive efficiency measures. Smaller farms were found to have higher net farm income per hectare, and to be more technically efficient, than larger farms. This article used more recent data, allowing for comparison between two time periods, and employed both stochastic and nonparametric techniques for generating technical efficiency measurements. The result of inverse relationship between farm size and the productivity per unit of land proved even after taking into account the effect of various other factors (land quality, Green Revolution technology, and supervision costs) on IR between farm size and productivity. Small farms had both higher land productivity and equal or better technical efficiency.

The impact of tenure security was estimated to decrease land productivity and technical efficiency. However, in the smaller models (with just tenure and farm size), tenure appeared to have a significant positive impact on land productivity. This result suggested the owned land instead of rented was not so clearly beneficial and that its supposed benefits might be based on a combination of theory and incomplete empirical analysis. In theory, titling is supposed to improve farm productivity by providing secure collateral for input loans. Better credit terms means more and better inputs and so, better productivity but the results of this paper suggested otherwise.

The rising shares of household labor employed in agriculture resulted in lower productivity and efficiency. This contradicted the theory that household labor required less supervision and was more motivated than hired labor, and so should be more productive and efficient. The share of family labor in total labor was significantly negatively correlated with both the amount of physical capital and land owned by the household. These possible indirect effects were controlled for in the regression analysis (in the form of Assets variable, which had significantly positive impacts on both productivity and efficiency). Another possible explanation is that there was a process of selection happening, with households' "better" farmers opting to hire themselves out, rather than working on the farm. This made sense if the wages they could earn were higher than the returns to working on their own farm. Another important contribution was in terms of gender impact on productivity and efficiency amounts to nothing. Female land rights were never significant in their impact on productivity or efficiency. Both the types of single-headed households were at a disadvantage, both in terms of productivity and efficiency, with single male-headed households being slightly worse off in terms of efficiency. So there is no evidence in this study that there were significant productivity or efficiency differences between men and women.

Ansoms et al. (2008) proved a strong inverse size-productivity relationship for the rural context of post-1994 Rwanda. In addition, this paper found that the other risk-coping mechanisms of small-scale farmers, such as farm fragmentation, and multi-cropping, seem to pay off in terms of productivity. The higher productivity of small-scale farmers was not the necessarily reflection of higher efficiency. It was likely that extreme land scarcity compels small-scale farmers to overexploit their lands in the absence of other income generating opportunities. In addition, land and labor market imperfections, next to the risk of food price fluctuations, might provide valid explanations for the inverse relationship. The rationale of small-scale peasants was based on their heavy investment on their own plots for cultivation.

Verschelde et al. (2011) tried to address a number of important empirical issues. First, mixed output by calculating the market values of all the crops produced while allowing for mixed cropping systems was calculated. Secondly, heterogeneity in the productivity effects of increased access to production factors was investigated by using a non-parametric approach. Thirdly, the several of missing variables were used for controlling heterogeneity in productivity. Household data on farm activities was gathered in 2007 in two densely populated provinces Ngozi and Muyinga in the North of Burundi. In total 640 farm households were interviewed; 360 in the Nogzi Province and 280 in Muyinga Province.

Parametric models (Cobb-Douglass and Translog specifications) were not satisfactory to estimate the determinants of crop productivity. A nonparametric kernel estimation of production function (solved with a local-linear estimator) was used to allow non-linearities and interaction effects. Four different models were estimated controlling for inputs, household, farm and soil characteristics. In each model the effect of cultivated land size, the cost of intermediary inputs and hired labor was consistent. A significant effect of land size and a non-linear effect of hired labor on agricultural output were found. In addition, crops choice and field characteristics were important. Coffee and banana production were found to yield higher returns compared to the other crops. Fragmentation and low perceived soil quality were associated with low agricultural productivity.

The model confirmed that farm size was important for agricultural productivity. The findings of study confirmed both the relatively higher productivity of small farms, but it also showed the economies of scale that larger farms might exploit. This was a confirmation of comments made in Collier and Dercon (2009) on the farming scales that were compared in IR literature, namely that the range of farm sizes studied with parametric econometric models was not large enough to show the true relationship between size and productivity. Results confirmed that the effect of size on production was different over the size spectrum. Hence, the potential contribution of agriculture to the potential improvement of households' livelihoods was different.

3.8 Determinants of Wheat Production

Iqbal et al. (2001) performed an in-depth empirical analysis of various factors responsible for enhanced wheat productivity during 1999-2000 and provided basis for devising a strategy to sustain wheat production in future. The paper is based on primary data collected through a structured questionnaire from 643 wheat growers of the major irrigated cropping zones of country. The study isolated the role of important factors responsible for higher wheat production during 1999-2000.

The results showed that a considerable proportion of wheat area was shifted from late sowing to early planting in the cotton-wheat cropping systems, the rice zone of Punjab and the mixed cropping zone of Sindh. The role of late planting of wheat in determining wheat yield was significantly negative. The significant effect of sowing time on wheat yields points to some extent failure of national agricultural research system to evolve short-duration high-yielding late wheat varieties. Moreover the breeding research lacked the evolvement of early maturing, high yielding, and disease resistant varieties for cotton, rice and other crops preceding wheat to improve the sowing time of wheat. Tested minimal tillage technologies (No/zero tillage technology) for timely and water efficient wheat planting were important for the improvement of water use efficiency and wheat productivity.

The findings of this study emphasized the timely availability of quality inputs such as seed, phosphate fertilizers and weedicides in wheat productivity enhancement. Newly released wheat varieties need rapid promotion through improving the seed multiplication and distribution systems. Improvements in institutional credit disbursement may further enhance farmers' accessibility to production inputs. Increase in the support price of wheat was the main incentive for the farmers to increase area allocation (in certain cropping zone) and higher input use in wheat production. Lower price obtained by the majority of farmers in Punjab than the announced support price for wheat might have adverse effect on future price expectations and thus might result in downward adjustment in acreage and/or the use of other production inputs. There was a dire need to shift emphasis from horizontal (increase in wheat acreage) to vertical expansion (increase in yield) in wheat productivity.

Khan (2002) analyzed the performance of country's agricultural policy in securing a sustainable measure of self-sufficiency in food production. Farmers in Pakistan when exposed to swings in prices had neither sufficient information nor the access and affordability to use future markets and insurance to protect them in the absence of government policy. The study attempted to determine the relationship of both the wheat production and the prices promised to the growers in Pakistan by government's agricultural policy over the period 1966-2001.

The results showed that support price policy, adequate water availability and technology together helped enhance the wheat production of country. The estimated coefficient showing the relationship between support price and wheat productivity was insignificant. The shocks in the economy affected both wheat production and yield. The achievement of the proclaimed objectives of wheat support price policy in Pakistan was constrained because of protection policy to urban consumers by keeping food prices low.

Ahmad et al. (2002) conducted study on “Wheat Productivity, Efficiency, and Sustainability: A Stochastic Production Frontier Analysis”. This study used data from a Fertilizer Use Survey 1997-1998 conducted by the Pakistan Institute of Development Economics. The sample consists of 2368 farmers including 18 sub-districts of three provinces (Punjab, Sindh and Khyber Pakhtoon Khwa) of Pakistan. The farm-level survey data of 1828 wheat farmers who belong to the irrigated areas of three provinces were included in the efficiency analysis of wheat producers. Stochastic frontier production function incorporating inefficiency effects was used to estimate the wheat production efficiency.

According to the results of study the sufficient evidence of positive relationship between wheat productivity and the higher and balanced use of fertilizer nutrients is present. Wheat productivity is significantly higher on farms having access to more reliable irrigation system i.e., canal and tube well both, as compared to the non-irrigated farms and the farms relying only on a single relatively less ensured source of irrigation. The results also indicated that wheat productivity had a strong inverse relationship with the proportionate farm area devoted to rice crop. The reasons for this negative relationship mentioned were the degradation and depletion of land resources caused by practicing the same crop rotations years after years, and the prevalence of higher cropping intensity. The study raised serious concerns about the sustainability of rice-wheat cropping system and the food security goals. On the other hand wheat productivity do not have any association with the proportionate farm area under cotton. Reasons mentioned were the higher doses of chemical fertilizer on both wheat and cotton crops in cotton-wheat system and the absence of competition between wheat and cotton for nutrients use due to shallow and the deep roots of crops respectively.

The results regarding efficiency analysis showed that the average technical efficiency was about 68 percent and thus an average farmer was producing 32 percent less than the achievable potential output. Technical inefficiency was negatively associated with the farm size. Reasons for this relationship included the higher education of larger farmers and their greater access to better irrigation arrangements, the extension services and higher doses of chemical fertilizer with more balanced nutrients. Moreover, they were usually financially better off to use and adopt modern technologies more efficiently and effectively. The farmers who had greater access to credit and were located closer to the markets were more efficient than those having relatively less access to credit and were situated at a grater distance from the markets. Overall the small farmers were not only producing at a lower level but were also operating relatively farther from the production frontier. The results of study indicated considerable scope to expand output and also productivity by increasing production efficiency at the relatively inefficient farms and the sustaining efficiency of those operating at or closer to the frontier. Wheat farmers in Punjab were comparatively more efficient than their counterparts in Sindh and the NWFP.

Hassan (2005) conducted research on the technical efficiency of wheat farmers in the mixed farming system of Punjab, Pakistan. The study focused on the measuring, the technical efficiency, the reasons of inefficiency and return to the scale of wheat farmers in the mixed farming system of Punjab. The efficiency was estimated by using stochastic frontier production function, incorporating technical inefficiency effect model. The Cobb Douglas production function was found to be an adequate representation of data, given the specification of corresponding translog frontier model. Mean predicted that the technical efficiency of wheat farmers was 0.94 ranging between 0.58 and 0.98. The results of frontier model indicated that wheat production could be increased by increasing wheat sown area, weedicides, the number of cultivations for land preparation, fertilizer use and farm location at the head of water channel. The results of inefficiency effect model indicated that the technical inefficiency could be reduced by sowing the crop in time, increasing the education of farmers, by providing credit to the farmers and sowing the crop by drill method. The shortage of canal water on the other hand increased the inefficiency of wheat farmers in the mixed farming system of Punjab. The individual impacts of some of variables in the inefficiency effect model were non-significant, but the combined influence of all the ten variables was significant in reducing the inefficiency of wheat farmers in the mixed farming system of Punjab, Pakistan.

3.9 Studies Regarding *Pothwar* Region

Ahmad and Ahmad (1998) conducted study on the sources of wheat output growth in the *Barani* area of Punjab. Time-series data for the period of 1970-71 to 1996-97 from the four districts (Attock, Rawalpindi, Jehlum, and Chakwal) of *Barani* area of Punjab were used in the study. A time-varying efficiency effects approach was used to disintegrate wheat output growth into different sources. About 7 percent of wheat area in *Pothwar* was under irrigation and, thus, a similar analysis was also conducted to compute irrigated wheat share in the overall growth of region. The overall wheat output in the *Barani* region of Punjab grew at an annual rate of 2.97 percent, 84 percent of which was shared by the *Barani* lands and the remaining 16 percent was contributed by irrigated lands in the region. The results showed that the major driving growth factor was technological change under both conditions, which contributed about the 107 percent of total change in *Barani* output and about 65 percent in irrigated output. The wheat output grew at an annual rate of 2.71 percent under *Barani* conditions, during the period of study. The changing inputs contributed negatively by about 10 percent and the efficiency contribution were 3.7 percent. Irrigated output increased by about 4.7 percent per annum in the region; of which 1.3 percent, and 34 percent were attributable to change in efficiency and increase in inputs.

The common result under both *Barani* and irrigated conditions was that the productivity growth (sum of technological and the efficiency change) showed declining trends exclusively over the period of study due to negative trends in technical efficiency. Annual growth in productivity decreased from almost +8 percent to –2 percent under *Barani* conditions and from 6.3 percent to zero percent under the irrigated system during the study period. The effects of reduction in area under *Barani* wheat were greater than the positive effects of fertilizer and rainfall in *Barani* conditions causing the net output effect attributable to inputs to be negative (i.e., –0.28 percent). While the input effect under irrigated conditions was positive (1.6 percent); of which, 0.77 percent, 0.49 percent, and 0.34 percent were attributable to marginal increase under irrigated area, higher the use of fertilizer, and favorable rains, respectively. Low relative profitability as compared to growing vegetables and raising livestock might be the main cause of this trend in the *Barani* area.

The role of agricultural extension system was of grave importance to improve the management skills of farmers of area to keep the productive efficiency at the same level, with the rapid technological advancements. The reliance of farming performance on seasonal rains revealed the importance of water use efficiency improvement in the rain-fed areas. The ensured supply of other inputs along with reasonable input-output price structure was also essential to control the downward trend in area under wheat.

Ashfaq et al. (2003) examined the land and water resources management in *Pothwar* Plateau. The result of study showed that only 0.61 m hectare (33 %) out of 1.82 m hectare of total area of *Pothwar* plateau was cultivated. There was scope for both the horizontal and vertical expansion of agriculture in the area. There is the need of strategic plan for the management of resources in the area of agricultural development leading to self reliance in food. The dissemination of advanced agricultural production technologies needed the frequent interaction of government departments and farming community.

Kahlown et al. (2004) evaluated the contribution of small dams in the development of water resources in *Pothwar* region. The construction of dug wells had increased due to seepage from these dams the ground water depth reduced from 8-53 meters to 5-20 meters and cropping intensity increased from 67 to 100 percent. Cropping pattern changed from traditional crops (cereals and pulses) to high value crops (fruit and vegetables). Wheat yield increased from 400 to 960 kg per acre and average income increased from PKR 800 to 44000 per acre.

Bhutta et al. (2002) described the utilization of water resources through modern water harvesting techniques and their impact on agriculture. The study was conducted in Cholistan desert and *Pothwar* plateau. The results showed that the rain water harvested could efficiently be used to grow agronomic crops, fruit trees and vegetables and impressively decrease the risk involved in rain-fed agriculture. This also helped in recharging groundwater and reduced floods in down streams.

Hussain et al. (2004) conducted research investigation to estimate land and water productivity in the marginal areas of Punjab. The nine tehsils of *Pothwar* Plateau were selected as study area. Data were collected during 2002-03 and it was found that in rain-fed agriculture, wheat yield was 1451 kg per hectare. Cost of production, gross value product and gross margins for rain-fed wheat were PKR8244 per ha, PKR 12852 per ha and PKR 4607 per ha, respectively. Rain-fed groundnut yield was 864 kg per hectare. Cost of production, gross value product and gross margins for groundnut were PKR 5997 per ha, PKR 17147 per ha and PKR 11149 per ha, respectively. The overall gross margins in rain-fed conditions were PKR 6956 per ha. In irrigated agriculture, wheat yield was 3084 kg per hectare. Cost of production, gross value product and gross margins per ha for wheat were PKR 11510, PKR 26934 and PKR 15414, respectively. Irrigated groundnut yield was 1402 kg per hectare. Cost of production, gross value product and gross margins for groundnut were PKR 7939 per ha, PKR 25771 per ha and PKR 17831 per ha, respectively. The overall gross margin in irrigated agriculture was PKR 8368 per ha. The water productivity was found to be 1.53 kg/m3, 2.47 kg/m3, 0.72 kg/m3, 1.09 kg/m3, and 0.87 kg/m3 for wheat, rabi maize, chickpea, groundnut and kharif maize, respectively. The results of study revealed the difference in major crops yield in irrigated and rain-fed conditions and hence emphasized access to irrigation through small-scale irrigation schemes to increase land productivity. Land consolidation to improve farm size and facilitate the installation of small-scale irrigation was considered important in the study area.

Hussain (2004 a) estimated the determinants of poverty in the farming community of *Pothwar* region (Jand, Attock and Gujar Khan *tehsils*). The share of non-farm income was greater than that of farm income. Logit regression model was estimated to calculate the marginal probabilities of factors accepting poverty. The results of study depicted that the increase in family size and dependency ratio increased the probability of household to become poor. Increase in the education of household head, operational land holding and non crop income decreased the probability of household to become poor.

There has been a lot of empirical research on the different aspects of farm production. Important studies in the past had been reviewed to refresh the current state of knowledge. These empirical research studies include the different aspects of agricultural diversification; the determinants of farm income; off-farm work and income opportunities; sustainability and agricultural risk; marginal areas and poverty alleviation; irrigation, farm productivity and poverty; farm size and land productivity inverse relationship; the determinants of wheat production and studies in *Pothwar* region. The background, methodologies and results of these studies were thoroughly consulted to the construct methodology of current investigation. The results of these studies *will* be compared with the present study in the discussion chapter later on.

CHAPTER 4: AGRICULTURE IN THE STUDY AREA

This chapter describes the agriculture status of *Pothwar* region. This includes the geography of Pakistan, the economic importance of agriculture, the natural and geographic conditions of study area, the overview of Rawalpindi and Chakwal districts, agricultural land utilization status, farm size structure and the production status of major crops of region. Livestock composition and the importance of wheat as staple diet has also been discussed. The data presented in this chapter is collected from secondary sources (published) by the different institutions of federal government and the provincial government of Punjab (Pakistan economic survey, Pakistan agricultural statistics, Pakistan agricultural census 2000, Punjab agricultural census 2000, Punjab development statistics, Pakistan livestock census 2006 and Pakistan Meteorological Department).

4.1 Geography of Pakistan

Pakistan is located at 33° 40′ 0″ north, 73° 10′ 0″ east on the globe and it is positioned in arid and semi arid regions. Its total land area is 796.1 thousand square kilometres of which 50 percent is mountains, valleys and foothills. The Indus plain, where most of the irrigated agriculture is located, covers about 202.02 thousand square kilometres which is almost 25 percent of total area (Government of Pakistan 2002a). Agriculture is utilizing the 95 percent of water resources of Pakistan (Government of Pakistan 2002) and share 80 percent agricultural outputs from irrigated agriculture (Chaturvedi 2000, Lipton et al. 2003). Scant and intermittent rainfall (240 mm per year) plays a complementary role to support agriculture (World Bank 2007a).

4.2 The Economic Importance of Agricultural Sector

Agriculture plays an important role in economic development in the form of food provision, export growth, manpower transfer to non agricultural sectors, contribution to capital formation, and securing markets for industrialization. Improving agricultural productivity is crucial for the realization of these roles. Historical records show that agricultural productivity has increased due to modern technologies, the commercialization process, capital deepening and factor shifts from agriculture to non-agricultural sectors. This overall process can be called "agricultural transformation," and the contribution of factors has been quantified in the existing literature (Timmer, 1988).

Agriculture serves as a back bone of Pakistan's economy. It generates 21 percent of its national income (GDP) and employs the 45 percent of its labor force. Food group accounts for nearly 17.2 percent of country's export earnings (Government of Pakistan 2010). Moreover, this sector provides raw material to domestic agro-based industries such as sugar, ghee (plant oil), leather and textiles. Most notably, 62 percent of country's population living in rural areas depends directly or indirectly on agriculture for its livelihood (Government of Pakistan 2010). Agricultural growth has historically played a major role in Pakistan's development and continues to be crucial for overall growth and poverty reduction. Table 4.1 shows the historical trends of real GDP, real agricultural GDP and population growth since 1961 to 2010. The average annual share of agriculture sector in the GDP of Pakistan decreased from 51 percent in 1950s to 21 percent in 2010. It has historically been the great source of precious foreign exchange in the form of exports of Pakistan since many decades. Despite the decrease in agricultural sector share in GDP, this sector contributes 25 percent to the total export earnings of Pakistan in 2000-05 (Khan 2006).

Table 4.1 GDP, Agriculture GDP and Population Growth in Pakistan 1961-2010 (%)

Year	***1961-70***	***1971-80***	***1981-90***	***1991-00***	***2001-10***
Real GDP Growth	7.19	4.71	6.32	3.75	4.12
Real Ag. GDP Growth	4.89	2.33	4.04	4.42	2.83
Population Growth	2.79	3.18	2.70	2.49	2.10
Rural Population Growth	2.42	2.73	2.34	2.11	1.60
Ag. GDP Growth per Capita	2.04	-0.82	1.31	1.88	1.50

Source: Economic Adviser's Wing, Finance Division (Economic Survey of Pakistan)

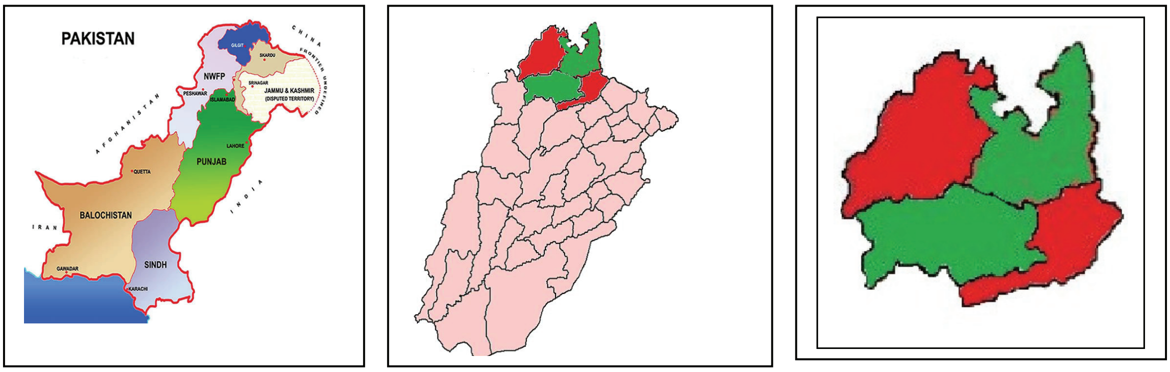
Though, agriculture's share in GDP has fallen yet agriculture remains the largest source of household income for 38 million Pakistanis, including 13 million of the poorest 40 percent of rural households. However, substantial scope exists for increasing productivity and overall economic efficiency in the agriculture sector of Pakistan (World Bank 2007). Despite progress in GDP and better per hectare yield in the agriculture sector, the level of rural poverty is quite higher than urban and the national averages of country. It reduced from 39.1 to 34 percent from 1998-99 to 2004-05 but the figures showed that it had continuous increasing trends i.e. 25.2, 25.4, 33.1 and 33.8 in 1990-91, 1993-94, 1996-97 and 1998-99, respectively (World Bank 2006a, Bhutto and Bazmi 2007). Despite the fluctuations in the poverty in the rural areas of Pakistan, agriculture sector has helped the rural communities to escape from food insecurity and malnutrition.

4.3 Natural and Geographic Conditions of Study Area

Punjab is the largest province of Pakistan having largest irrigated area and major contribution towards the agricultural production. The northern part of province is Barani Punjab Cropping Zone commonly known as Pothwar plateau. The Pothwar area consists of Rawalpindi division including four districts i.e. Rawalpindi, Chakwal, Jehlum and Attock. The area is characterized by rain-fed agriculture. It is about 250 km long and 100 km wide with elevations ranging from 200 metre along River Indus to about 900 metre in the hills north of Islamabad with an average elevation of 457 metre (Khan 2002).

Figure 4.1 Maps of Pakistan, Punjab and *Pothwar*

Pakistan | Punjab | *Pothwar*



The climate of Pothwar comprises of semi-arid in the southwest to the sub-humid in the northeast. The rainfall is erratic. Monsoon rains are usually accompanied by thunderstorms and occur as heavy downpours resulting in considerable surface run-off and soil erosion in the hilly areas and uplands. Most of the annual rainfall in the semi-arid region occurs during June to September period (70 percent) (Ashraf et al., 1999 and Ashraf 2004, Government of Pakistan, 2009). The winter rains occur as the gentle showers of long duration and are more effective for soil moisture absorption than the summer rains. Most of the agricultural soils have developed from wind and water transported material comprising loess, old alluvial deposits, mountain out-wash and recent stream valley deposits. Their texture mostly varies from sandy to silt loam and clay loam comprising from poor to fertile lands. The plateau has a flat to gently undulating surface broken by gullies and low hill ranges (Rehmat Ullah 2009). About the 60 percent of land area has been highly eroded leaving the rest as a flat land which constitutes the main cultivated area. Of total area of 1.8 million hectares, 0.77 million hectares is cultivated, the remaining is mostly grazing land (Khan 2002). Almost the 10 percent of cultivated area is irrigated, while 90 percent is under rain-fed agriculture (Government of Pakistan 2006).

4.4 Economic Structure of Rural Area

4.4.1 Characteristics of Agriculture

The major rain-fed crops grown in Pothwar are wheat, chickpea, groundnut, millets, sorghum, oilseeds and fodders. Maize and sunflower are grown in higher rainfall areas. Vegetables and fruits are grown where access to cities and irrigation water from dams and tube-wells are available. The livestock production is also one of the major economic activities and another main source of livelihood in Pothwar which has over 25 percent of total livestock population of entire Barani tract of Punjab (Khan 2002). This sector has great potential for increasing the farm income and profitability. Sheep and goats are the predominant species followed by cattle, camels and donkeys. Buffaloes are kept mostly in sub-humid areas or areas where water is readily available. Although the various breeds of cattle, sheep and goats are reared in this tract but it is the home of Dhani breed (draught cattle) and Pothwar breed (goat) (Khan 2002). The majority of farms of study area are small and of subsistence type. The lack of improved seed, fertilizer pesticides and credit is one of the major problems of farmers, resulting in lower crop yields.

Repeated drought conditions are the major problems in Pothwar region. There is the great risk of crop failure as agriculture mostly depends on rainfall. In most of the areas of Barani Punjab under ground water is very deep as well as in small quantity so it is uneconomical to irrigate the land on large scale. Government has constructed small dams in some areas where feasible but these dams cover only the small part of whole area. Severe weather conditions particularly frost and weather disasters like hailstorms also destroy crops. Due to economic and the political situation of country, crops' insurance is also not in practice. This leads to further vulnerability in farm income.

4.4.2 Off-farm Income Sources

The agriculture is a part time business of the majority of farm households. Most of them have small landholdings, and livestock helps them to support their daily expenditures by milk sale. Furthermore, it is the cash deposit for resource poor farmers in the time of disaster. The majority of rain-fed Pothwar farm households are involved in off-farm activities to support their daily household expenditures (Ashraf 2004 and Hussain 2004 a). The common off-farm income sources include remittances from abroad (unskilled/semi skilled labor in Middle East) as well as low paid jobs in government and private institutions (district courts, district management offices, oil and gas development corporation, security guards in private companies, cement factories, textile industry and coal mines). Growing more than one crop and livestock rearing may be one possible factor for agriculture risk management. Furthermore off-farm income may also work as coping strategy in the situation of severe drought and complete crop failure. This may help to reduce variability in the farm income and vulnerability of farm households. Linking the agriculture of area with alternative production activities such as high value crops and livestock, the farm households can be brought out of the subsistence nature of agriculture and food security can be ensured.

4.4.3 Research Institutes

There are two agriculture research institutes established particularly for this area. First the Barani Agricultural Research Institute, Chakwal (BARI), is conducting research for crop sector. The research efforts of BARI are mostly confined to major crops such as wheat, groundnut and chickpea while high value cash crops such as fruits and vegetables are neglected in their research efforts. Furthermore there is no special focus of research regarding evolving the drought resistant varieties. Second research institute is Soil and Water Conservation Research Institute (SAWCRI), which is focusing on soil and water resources conservation. The research funding for these institutes are limited and the major portion of budget of these institutes is spent on salaries leaving small amount for the operational cost of research activities. Agriculture education and extension services are week in the area as compared to irrigated/plane areas (other cropping systems of Punjab). Financing/agricultural credit opportunities are limited due to the risky nature of agriculture of area.

4.5 Districts Rawalpindi and Chakwal

District Rawalpindi and Chakwal were selected as study sites from Pothwar region. These districts having pure rain-fed agriculture were found very suitable to achieve the set targets of study. This section elaborates the overview of districts Rawalpindi and Chakwal including the demographic characteristics and climate (temperature and rainfall).

4.5.1 Population Growth

District Rawalpindi is situated in the northern part of Punjab province. Administratively it has been divided into 7 *tehsils* (sub-districts) i.e. Rawalpindi, Gujar Khan, Murree, Kahuta, Taxila, Kotli Sattian and Kallar Syedan. According to 1951 Census, its population was only 873 thousand which rose up to 4247 thousand people according to the estimate of 2009 (Government of Punjab 2009). The overall increase in the population of Rawalpindi district was 386.5 percent during 58 years (1951 to 2009). The increase over first decade (1951 to 1961) remained 2.4 percent per annum. The increase for next 11 year (1961-72) was relatively higher (5.5 % per annum). This may be due to rapid urbanization and the construction of new city of Islamabad. Due to the shift of Pakistan capital from Karachi to Islamabad in 1961 the population from the different areas of Pakistan shifted to Islamabad and Rawalpindi city (twin cities). The increase in the population from 1972 to 1981 was 2.4 percent while from 1981 to 1998 and 1998 to 2009 remained 3.4 and 2.4 percent respectively.

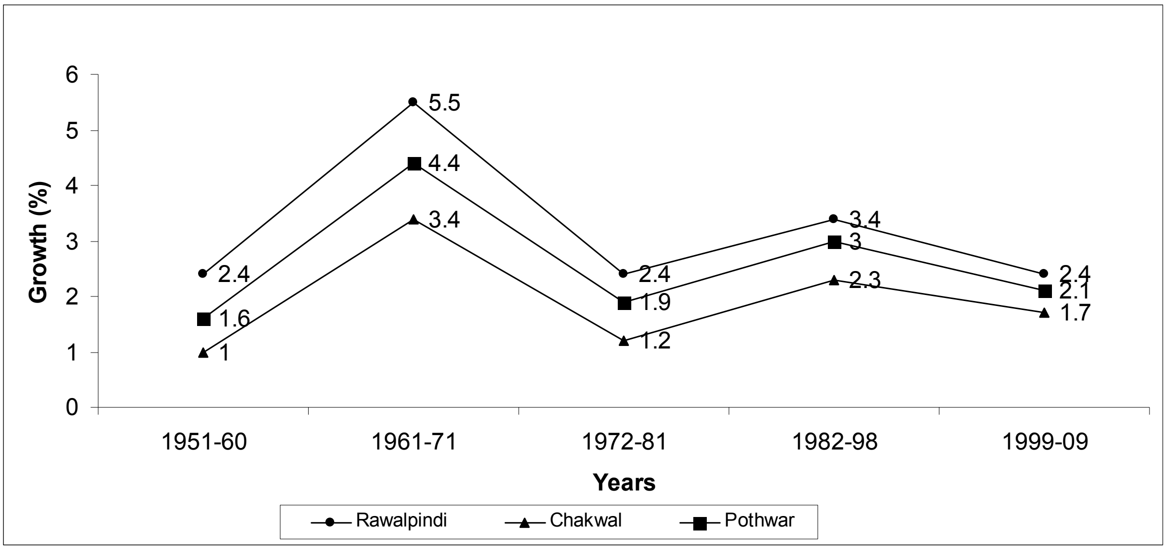
Table 4.2 Population Growths of Rawalpindi and Chakwal Districts

Year	***1951***	***1961***	***1972***	***1981***	***1998***	***2009****
Rawalpindi						
Population 000	873	1086	1745	2121	3364	4247
Incremental difference (%)	--	24.4	60.7	21.5	58.6	26.2
Chakwal						
Population 000	460	508	700	776	1084	1283
Incremental difference (%)	--	10.4	37.8	10.9	39.7	18.4
Pothwar						
Population 000	2182	2537	3778	4433	6660	8189
Incremental difference (%)	--	16.3	48.9	17.3	50.2	23.0

Source: Punjab Development Statistics 2009 * Estimated

District Chakwal is situated towards the south of Rawalpindi district. Administratively it has been divided into 4 *tehsils* (sub-districts) i.e. Chakwal, Talagang, Choa Saiden Shah, and Kallar Kahar. According to 1951 Census, its population was only 460 thousand which rose up to 1283 thousand people according to the estimate of 2009 (Government of Punjab 2009). The increase in the overall population of Chakwal district remained 178.9 percent during 58 years (1951 to 2009). The increase over first decade between 1951 and 1961 was 1.0 percent per annum. The increase for next 11 year (1961-72) was relatively higher (3.4% per annum). The increase in the population from 1972 to 1981 was 1.2 percent while from 1981 to 1998 and 1998 to 2009 remained 2.3 and 1.7 percent respectively. The population growth rate in the overall *Pothwar* region followed almost the same pattern as of Rawalpindi and Chakwal districts.

Figure 4.2 Annual Population Growth Rate in the Study Area (%)



Source: Punjab Development Statistics 2009

4.5.2 Demographic Characteristics

According to the government of Punjab (2009), Rawalpindi is more populated (i.e. 3.36 million) than Chakwal (i.e. 1.08 million) with higher population density (479 person/square Km) as compared to that in Chakwal (186 person/square Km). The population density of Rawalpindi district is high due to the mega urban centre of Rawalpindi city. The population density of Chakwal is well below as compared to the *Pothwar* region and the Punjab average. Overall the population density of *Pothwar* region is lower as compared to that of Punjab. The reason may be the less productive rain-fed agriculture and comparatively less off-farm income opportunities (particularly industry) in *Pothwar* region than in the rest of irrigated Punjab. Table 4.3 expresses details regarding the demographic characteristics of both districts population.

Table 4.3 Demographic Characteristics of Study Area (Population Census 1998)

Population	*Rawalpindi*	*Chakwal*	*Pothwar*	*Punjab*
Total Population '000'	3364	1084	6660	73621
Population density (Person/Km^2)	479.0	186.0	299.0	359.0
Male (%)	51.2	47.8	50.2	51.7
Female (%)	48.8	52.2	49.8	48.3
Urban (%)	53.2	12.2	36.8	31.7
Rural (%)	46.8	87.8	63.2	68.3

Source: Punjab Development Statistics 2009

The population of Rawalpindi rose from 3.36 million in the 1998 population census to 4.25 million in 2009 (according to the estimate of 2009). In Rawalpindi district the gender ratio is in the favour of male with 51.2 percent males and 48.8 percent females. Moreover more than half population lives in urban centres (56 percent) while only 44.1 percent live in rural areas. The population of Chakwal rose from 1.08 million in the 1998 population census to 1.28 million in 2009 (according to the estimate of 2009). In Chakwal district the gender head count ratio is in the favour of women with 47.8 percent males and 52.2 percent females. The vast majority (87.9 %) of population in Chakwal district lives in rural areas while a small number (12.1%) live in three small urban centres of Chakwal, Talagang and Choa Saiden Shah. Rawalpindi is more urbanized with 55.9 percent urban population as compared to Chakwal (12.1 %), due to the mega urban centre of Rawalpindi. Moreover Rawalpindi district has also more urban population percentage (53.2%) than that of *Pothwar* region (36.8 %) and Punjab province (31.7 %). In *Pothwar* region as well as Punjab the population gender is slightly in the favour of males (50.2 and 51.7 %). Different employment sectors in both districts have absorbed the various proportions of their labor force. Agriculture, construction sector and public service sector including civil and military forces provide livelihood opportunities to the maximum rural inhabitants of both the districts.

4.5.3 Climate of Study Area

Average annual temperatures in both districts is almost same i.e. 21.7 ^{0}C and 22.3 ^{0}C but average rainfall in district Rawalpindi is far high (1206.4 mm) than that of Chakwal (607 mm) due to its upland areas (Government of Pakistan 2009). For all months of the year except June the rain fall in Rawalpindi district is higher as compared to that in Chakwal. The hottest months are May, June, July and August and coldest ones are December and January in both districts. The majority of areas of district Rawalpindi are uplands and have sub-humid climate. The climate of district Chakwal varies from arid to semi arid.

Table 4.4 Monthly Mean Temperature (^{0}C) and Rainfall (mm) (2008)

Months	***Chakwal***		***Rawalpindi***	
	M. Temp (^{0}c)	**Rainfall (mm)**	**M. Temp (^{0}c)**	**Rainfall (mm)**
JAN	8.2	44.4	9.3	110.1
FAB	11.5	36.2	12.1	41.8
MAR	21.5	0.0	20.7	19.1
APR	22.6	66.3	22.7	92.9
MAY	29.6	55.2	28.8	10.1
JUN	29.3	215.8	30.3	99.6
JULY	29.7	76.5	28.9	432.5
AUG	29.3	42.6	28.2	221.0
SEP	27.4	12.6	26.4	65.8
OCT	26.1	8.0	23.2	24.0
NOV	18.3	0.0	16.7	18.0
DEC	13.8	49.4	13.2	71.5
2008	22.3	607.0	21.7	1206.4

Source: Pakistan Meteorological Department

4.6 Agricultural Land Utilization Status of *Pothwar* Region

The reported area of district Rawalpindi is 525 thousand hectares, As far as district Rawalpindi is concerned, farming is being carried out on the 44 percent of total reported area (231 thousand ha). Rawalpindi district has comparatively higher area under forest (13.0 %) due to more upland/mountainous areas. More than one forth area (26.2) is culturable waste while 23.1 percent area is not available for cultivation which include 7 urban centers and extensive roads network. Land utilization statistics shows net sown area as 79.6 percent and the area left fallow as 20.3 percent in the whole district. Moreover, 22.5 percent area was cultivated more than once in a year. Total cropped area of district is 236 thousand hectares with 102.2 percent cropping intensity (Government of Punjab 2009).

Total reported area of district Chakwal is 669 thousand hectares, 47.7 percent of which is cultivated (319 thousand ha). Overall 8.7 percent area is covered by forests, 9.7 percent is culturable waste and 16.6 percent is not available for cultivation in the district. The land utilization shows net sown area as 79.3 percent, current fallow as 20.7 percent and area sown more than once as 4.7 percent. The cropped area of district is 267 thousand hectares with the cropping intensity of 83.7 percent (Government of Punjab 2009). Due to the uneven topography a large area (90.1 percent) of *Pothwar* region lacks irrigation infrastructure (Government of Punjab 2009). Only the percent of the area of Rawalpindi district and 6.4 percent of that of Chakwal is irrigated.

Table 4.5 Land Utilization of *Pothwar* Region ('000' ha-2008)

Districts	***Punjab***	***Pothwar***	***Rawalpindi***	***Chakwal***	***Attock***	***Jehlum***
Reported Area	17680	2246	525	669	693	359
Forest area	498	244	68	58	73	45
Culturable waste	1614	202	77	34	34	57
Unavailable for cultivation	2966	804	149	258	267	132
Cultivated area	12602	994	231	319	319	125
Net Sown	11043	750	184	253	224	89
Area sown twice	6051	99	52	15	18	14
Current Fallow	1559	244	47	66	95	36
Cropped area	17094	847	236	267	241	103
Cropping intensity (%)	135.6	85.2	102.2	83.7	75.5	82.4
Total area sown	16459	819	227	250	240	102
Irrigated	14219	81	9	16	29	27
Un-irrigated	2240	738	218	234	211	75
Irrigated (%)	86.4	9.9	4.0	6.4	12.1	26.5

Source: Punjab Development Statistics 2009

4.7 Farm Size Structure in *Pothwar* Region

Table 4.6 depicts the farm size structure of Rawalpindi and Chakwal districts, *Pothwar* region and overall Punjab province. The farm size of Rawalpindi district is considerably small as compared to that of Chakwal. In Rawalpindi 81 percent farms are less than 5 acres with the farm area of 39 percent while in Chakwal 48 percent farms are below the 5 acres of land with only 12 percent area. Average farm size in Chakwal (8.8 ac) is almost three times as compared to that in Rawalpindi (3.1 ac). Due to small farm size the cultivated area as percent of farm area is higher in Rawalpindi (83 %) as compared to that in Chakwal (77 %). The cultivated area as percent farm area decrease with the increase in farm size in both districts from 90.3 percent to 59.2 percent and 92.3 percent to 59.6 percent in Rawalpindi and Chakwal districts respectively.

Table 4.6 Farm Size of *Pothwar* Region

Farm Size Category (ac)	*No of farms (%)*	*Farm area (%)*	*Cultivated area (%)*	*Cultivated area (% farm area)*	*Av. Farm size (ac)*	
					Farm area	**Cultivated area**
Rawalpindi						
<5.0	81	39	43	90.3	1.8	1.6
5.0 to < 12.5	15	34	35	86	7.55	6.45
≥12.50	3	27	22	59.2	88.9	48.4
All farms	**100**	**100**	**100**	**83**	**3.1**	**2.6**
Chakwal						
<5.0	48	12	14	92.3	1.8	1.7
5.0 to < 12.5	34	29	33	89.5	7.65	6.8
≥12.50	17	59	52	59.6	80.9	40.5
All farms	**100**	**100**	**100**	**77**	**8.8**	**6.8**
Pothwar						
<5.0	64	19	22	91.3	1.8	1.6
5.0 to < 12.5	25	30	33	86.5	7.6	6.5
≥12.50	12	51	44	61.2	94.1	53.0
All farms	**100**	**100**	**100**	**78**	**6.2**	**4.8**
Punjab						
<5.0	56	16	18	95	1.8	1.7
5.0 to < 12.5	29	31	32	95	7.7	7.2
≥12.5	15	53	52	85.6	91.6	74.7
All farms	**100**	**100**	**100**	**92**	**7.2**	**6.6**

Source: Punjab agricultural census report 2000 *Value less than 0.5

The farm size of *Pothwar* region is smaller as compared to that of Punjab province. In *Pothwar* region 64 percent farms are less than 5 acres with only 19 percent farm area while in Punjab province 56 percent farms are below the 5 acres of land with only 16 percent area. This shows that the number of small farms and percent area (under 5 acres) is higher in *Pothwar* region as compared to that of Punjab. Average farm size in Punjab (7.2 ac) is relatively higher as compared to that in *Pothwar* (6.2). The cultivated area as the percent of farm area is higher in Punjab province (92 %) as compared to that in *Pothwar* (78 %). The cultivated area as percent farm area decrease with the increase in farm size from 95 percent to 85.6 percent and 91.3 percent to 61.2 percent in overall Punjab province and *Pothwar* region, respectively.

4.8 Production Status of Major Crops of *Pothwar* Region

Wheat, chickpea, lentil and mustard are the major winter crops of study area while groundnut is the sole major cash crop in summer followed by summer fodder crops sorghum and millet, grown for feeding livestock. During winter Mustard is the major fodder crop which in most cases is intercropped with Wheat. Wheat yield in *Pothwar* region is almost half (55.7) as compared to that of overall Punjab (Government of Pakistan 2008). Rawalpindi and Jehlum are better districts in this regard having almost two third of wheat yield at Punjab level. The major reasons are the higher rainfall in Rawalpindi and more area under irrigation in Jehlum.

Table 4.7 Major Crops Area, Production and Yield in *Pothwar* Region (2007-08)

Districts	*Punjab*	*Pothwar*	*Rawalpindi*	*Chakwal*	*Attock*	*Jehlum*
Wheat						
Area (000 ha)	6402	440	109	122	157	52
Production (000 tones)	15607	597	175	137	200	85
Yield (kg/ha)	2437.8	1356.8	1605.5	1123.0	1273.9	1634.6
Yield (%of Punjab)	--	55.7	65.9	46.1	52.3	67.1
Chickpea						
Area (000 ha)	989.0	14	0.6	9.3	3.9	0.2
Production (000 tones)	387.5	6.7	0.3	4.8	1.4	0.2
Yield (kg/ha)	391.8	478.6	500	516.1	359	1000
Yield (%of Punjab)	--	122.2	127.6	131.7	91.6	255.2
Lentil						
Area (000 ha)	18.0	10.3	3.9	4.1	0.5	1.8
Production (000 mt)	7.0	3.7	1.5	1.4	0.2	0.6
Yield (kg/ha)	388.8	357.5	395.4	334.4	372	324.1
Yield (%of Punjab)	--	91.9	101.7	86.0	95.7	83.4
Mustard						
Area (000 ha)	127.0	24.5	2.8	13.2	4.5	3.8
Production (000 mt)	103.3	13.2	1.5	6.8	3.2	1.6
Yield (kg/ha)	811.0	538.8	535.7	515.2	711.1	421.1
Yield (%of Punjab)	--	66.4	66.1	63.5	87.7	51.9
Groundnut						
Area (000 ha)	85.2	78.9	10	41.2	27.3	0.4
Production (000 mt)	67.4	59.3	11.1	26.8	21.1	0.3
Yield (kg/ha)	791.1	751.3	1108	650.4	772.5	790.1
Yield (%of Punjab)	--	95.0	140.1	82.2	97.6	99.9

Source: District wise Agricultural Statistics of Pakistan 2008 and Punjab Development Statistics 2009

Chickpea crop yield in the study area has higher yield as compared to Punjab average. The main reason is that chickpea is cultivated only in rain-fed areas in the whole Punjab province. The weather conditions of area better suits to chickpea as compared to Mung Bean wheat cropping zone (the major chickpea crop producing area of Punjab). Lentil yield is a little lower (91.9%) than that of Punjab average. The lentil yield of Rawalpindi and Attock is almost at par with the average of Punjab while that of Chakwal and Jehlum is on lower side. The mustard yield of overall *Pothwar* region, Rawalpindi and Chakwal districts is almost two third of Punjab yield. Overall the 92.6 percent of groundnut area of Punjab is cultivated in *Pothwar* region with 88 percent of total production of Punjab. The groundnut yield of region is a little lower as compared to the average yield of Punjab. The yield of Rawalpindi district is higher than Punjab average while that of Chakwal is lower. The groundnut yield of Attock and Jehlum is almost equal to the Punjab average. The area and production of major crops is higher in Chakwal as compared to the other districts of *Pothwar* region except for wheat crop. As chickpea, groundnut and lentil crops are only grown in rain-fed conditions, their yields in *Pothwar* region are at par (122.2, 95.0 and 91.9 percent of Punjab average respectively) with the average yield at Punjab province level. The yields of wheat and mustard are considerably lower (55.7 and 66.4 % of Punjab average respectively) in *Pothwar* region as compared to that of Punjab province average.

4.9 Livestock Composition of Study Area

Livestock plays an important role in the farm income stability of rural households of study area. Livestock contributes towards household income in the form of daily milk sale and the sale of the newly added off springs of small and large ruminants every year. The cultivated area of *Pothwar* region is 7.9 percent of cultivated area of overall Punjab province. The important species of livestock large ruminants in *Pothwar* include the cattle and buffaloes while of small ruminants include sheep and goats.

The Cattle, buffaloes, sheep and goats of *Pothwar* region are 9.2, 4.6, 6.5 and 10.1 percent of the total number of these species at province level (Government of Pakistan 2006 and Government of Punjab 2009). The percentage of cattle and goats is higher while the percentage of buffaloes and sheep is lower as compared to the percent cultivated area of *Pothwar* region. Main reason may be the scarcity of green fodder in the area as buffaloes consume more fodder as compared to cows.

Table 4.8 Livestock Composition in the *Pothwar* Region

Districts	*Punjab*	*Pothwar*	*Rawalpindi*	*Chakwal*	*Attock*	*Jehlum*
Cultivated Area (ha)	12602	994	231	319	319	125
Cultivated area (%)	--	7.9	1.8	2.5	2.5	1.0
Cattle	14412	1332	344	435	386	167
Cattle (%)	--	9.2	2.4	3.0	2.7	1.2
Buffaloes	17747	660	248	145	121	146
Buffalo (%)	--	4.6	1.7	1.0	0.8	1.0
Sheep	6362	415	17	158	181	59
Sheep (%)	--	6.5	0.3	2.5	2.8	0.9
Goats	19831	2001	489	580	629	303
Goats (%)	--	10.1	2.5	2.9	3.2	1.5

Source: Punjab Development Statistics 2009 and Punjab Livestock census report 2006

4.10 Importance of Wheat as Staple Diet of Area

Wheat is the major crop of area gown on almost half of cultivated area. It is the major staple food of population of region. Farmers' first preference is to grow wheat to ensure food security for their household members. A higher share of area (47.2%) is under wheat in Rawalpindi as compared to that of district Chakwal (38.2%). The major portion of the small irrigated area of region is devoted to wheat crop. The overall wheat yield of region is almost half of the average wheat yield at Punjab level. The main reason is that almost the 90 percent wheat sown area of *Pothwar* region is un-irrigated and only 10 percent of area is irrigated while vice versa is the case for overall Punjab province level (almost 90 % wheat sown area is irrigated). When we compare wheat grown on irrigated area in *Pothwar* region and at Punjab province level wheat yield at *Pothwar* is a little higher (103 %) as compared to that at Punjab level. When rain-fed wheat yield is compared the yield in *Pothwar* region and at Punjab level is almost same. There is more than 50 percent yield gap between rain-fed and irrigated wheat yields at Punjab as well as *Pothwar* region level (Government of Pakistan 2008 and Government of Punjab 2009). Table 4.9 shows that the major limiting factor responsible for the low yield of wheat in *Pothwar* region as compared to Punjab average is the scarcity of water and the lack of supplementary artificial irrigation system. The yield gap of irrigated and rain-fed area of wheat is lower (34.7%) for Rawalpindi as compared to that of Chakwal (58.4%).

The reason is the higher (1206 mm per annum) rainfall in Rawalpindi than in Chakwal (607 mm per annum) (Government of Pakistan 2009).

Table 4.9 Wheat Area, Production and Yield in *Pothwar* Region

Districts	***Punjab***	***Pothwar***	***Rawalpindi***	***Chakwal***	***Attock***	***Jehlum***
Cultivated area (000 ha)	12602	994	231	319	319	125
Overall Area						
Area (000 ha)	6402	440	109	122	157	52
Area (%)	50.8	44.3	47.2	38.2	49.2	41.6
Production (000 tones)	15607	597	175	137	200	85
Yield (kg/ha)	2437.8	1356.8	1605.5	1123.0	1273.9	1634.6
Yield (%)	--	55.7	65.9	46.1	52.3	67.1
Irrigated Area						
Area (000 ha)	5742	44	5	9	15	15
Area (%)	89.7	10	4.6	7.4	9.6	28.8
Production (000 tones)	14812	117	12	22	41	42
Yield (kg/ha)	2579.6	2659.1	2400.0	2444.4	2733.3	2800.0
Yield (%)	--	103.1	93.0	94.8	106.0	108.5
Rain-fed						
Area (000 ha)	660	396	104	113	142	37
Area (%)	10.3	90	95.4	92.6	90.4	71.2
Production (000 tones)	795	480	163	115	159	43
Yield (kg/ha)	1204.5	1212.1	1567.3	1017.7	1119.7	1162.2
Yield (%)	--	100.6	130.1	84.5	93.0	96.5
Yield Gap	**53.3**	**54.4**	**34.7**	**58.4**	**59.0**	**58.5**

Source: District wise Agricultural Statistics of Pakistan and Punjab Development Statistics 2009

Punjab is the largest province of Pakistan having largest irrigated area and major contribution towards the agricultural production of Pakistan. The northern part of province is *Barani* Punjab Cropping Zone (*Pothwar* region). The area is characterized by rain-fed agriculture. The major rain-fed crops grown in *Pothwar* are wheat, chickpea, groundnut, lentil, millets, sorghum, oilseeds and fodders. Livestock production is also one of the major economic activities and another main source of livelihood in *Pothwar*. Agriculture is the part time business of majority farm households and they have also some off-farm income sources.

District Rawalpindi and Chakwal were selected as study sites from *Pothwar* area. Rawalpindi is more populated with 3.36 million people than Chakwal with 1.08 million. Average annual temperatures in both districts is almost same i.e. 21.7 ^{0}C and 22.3 ^{0}C but average rainfall in district Rawalpindi is almost double (1206.4 mm) than that of Chakwal (607 mm) due to its upland areas. District Chakwal has higher reported area (669 thousand hectares with 47.7 percent cultivated area) as compared to that of district Rawalpindi (525 thousand hectares with 44 percent cultivated area). Due to the uneven topography a large area of *Pothwar* region lacks irrigation infrastructure and, consequently, the 90.1 percent of lands are un-irrigated and only 9.9 percent area is irrigated. The total irrigated area of Rawalpindi district is lower (4.0%) than that of Chakwal district (6.4%). Farm size of Rawalpindi district is considerably small as compared to that of Chakwal. The farm size of *Pothwar* region is smaller as compared to that of Punjab province. The number of small farms and percent area in the *Pothwar* region is higher as compared to that of Punjab.

As chickpea, groundnut and lentil crops are only grown in rain-fed conditions, their yields in *Pothwar* region are at par with the overall average yield at Punjab province level. The yields of wheat and mustard are considerably lower in the *Pothwar* region as compared to that of Punjab province average. The wheat grown on irrigated area in *Pothwar* region is a little higher than that of Punjab province level while rain-fed wheat yield of *Pothwar* is almost same as compared to the rain-fed wheat of Punjab level. There is more than 50 percent yield gap between rain-fed and irrigated wheat yields at Punjab as well as *Pothwar* region level. The yield gap of irrigated and rain-fed area of wheat is lower for Rawalpindi as compared to that of Chakwal.

CHAPTER 5: MATERIALS AND METHODS

The investigation has been devised to analyze the determinants of farm income and the yields of major crops, important agricultural risk sources and risk management strategies by the farm households of study area. Various approaches were employed in order to examine land allocation, tenancy structure, cropping patterns, cropping intensity and the crop diversity of farmers by disintegrating the total numbers of farming households in three distinct size groups. This chapter is organized into two major portions i.e. data sources and data analysis. The data sources section is further divided into sub-parts data types; site selection and sampling methods; data collection techniques; the limitations of data, sample size and data cleaning. Data analysis section is further divided into sub-parts cropping pattern; cropping intensity; crop diversity; the cost of production; factor productivities; research hypotheses; production function and factor analysis.

5.1 Data Sources

5.1.1 Data Types

Primary as well as secondary data were used to fulfill the objectives of study. A huge amount of farm level primary data was collected from the study area comprising districts Rawalpindi and Chakwal. A well-defined structured questionnaire with close ended questions was used as a tool for the primary data collection. The secondary data on farm size and crops area production and yield was collected from Pakistan Agricultural Research Council through different publications like Pakistan Agricultural Census and Agricultural Statistics of Pakistan. The weather related data was collected from Pakistan Metrological Department, *Barani* Agricultural Research Institute and Soil and Water Conservation Research Institute Chakwal. On the basis of consultations and discussions with experts further secondary data were extracted from various published and internet sources such as the Agriculture Census Reports of Pakistan of various years (1960, 1972, 1980, 1990 and 2000), Agriculture Census Reports of Punjab 2000, Punjab Development Statistics 2009, Statistical Year Book of Pakistan 2008, Economic Survey of Pakistan 2009 and 2010, Household Income and Expenditure Survey 2006, Livestock census Report 2006, various reports of Food and Agriculture Organization and different World Bank publications.

Agricultural Census Organization conducted the fourth nationwide Livestock Census (2006) covering the four provinces (Punjab, Sindh, Khaiber Pakhtoon Khwa and Balochistan) of Pakistan, Azad Jammu & Kashmir, Federally Administrative Tribal Areas (FATA) and Northern Areas (Gilgit Baltistan). Three previous censuses were conducted in 1976, 1986 and 1996 respectively. This organization conducts such censuses to fulfil the legal obligations entrusted vide Agricultural Census Act 1958. Previously the need for data pertaining to livestock sector was catered by quinquennial livestock censuses conducted by Provincial Land Revenue Departments. After establishment of this organization in 1958 statistics pertaining to livestock sector were the part of reports of Agricultural Censuses which were conducted in 1960 and 1972. Afterwards it was felt that because of rapidly changing livestock scenario an exclusive full-fledged Census of Livestock may be conducted between the intervening periods of decennially conducted Agricultural Censuses.

The census was carried out with main objectives to provide the current estimates of commercially important livestock and poultry by age, sex, and breed to provide basic information on livestock consumption and to ascertain the number of livestock holders reporting animals and poultry birds to provide the estimates of animals vaccinated, fallen sick treated, purchased, sold and died. Furthermore, to ascertain the number of work animals by work type, by estimated milk production and by slaughtered animals.

5.1.2 Site Selection and Sampling Methods

Considering the vulnerability of rain-fed agriculture to weather risks, *Barani* Punjab (*Pothwar*) was selected for survey data collection. This is Rawalpindi division including the districts Attock, Rawalpindi, Jehlum and Chakwal. The purposive and stratified random sampling technique was applied to select the sample farmers. At the first stage out of four districts, Rawalpindi and Chakwal were selected for the study purposes. It is because these districts represent the pure rain-fed conditions of *Barani* Punjab. The further reason for selecting these districts was that they cover a range of climate from sub humid to semi arid and arid conditions. The amount of annual rainfall decreases from north east to south west. The area of other two districts i.e. Jehlum and Attock is relatively more supplemented by artificial irrigation and also stretches to hilly patches. At the second stage one sub district Gujar Khan from Rawalpindi (high rainfall) and two sub districts i.e. Chakwal (medium rainfall) and Talagang (low rainfall) were selected from District Chakwal. Most of the other sub districts consist of hilly and forest area, leaving less area for commercial agricultural production. At v the third stage 10 villages were randomly selected from each of 3 sub districts. Finally, at the fourth stage within these three sub districts, 7 farm households from each village were selected randomly (convenience sampling) for interview by chance meeting with them at the time of field survey.

5.1.3 Data Collection Techniques

The primary data was collected through personal interview with individual farmers using structured questionnaire. The author himself collected the whole data. Only logistic and transportation support from friends and relatives in the sample villages was taken for finding and reaching the sample farmers. Formal and informal techniques were carried out to collect the data. The respondents were probed in different manners to attain reliable data. It was preferred to interview only household head. Household head in the study area is mostly the eldest male of household. Most of the farm households in the study area consist of nucleus family (male with his wife and children). Only in case of the absence of household head the adult family member actively involved in agricultural production activities is interviewed to attain required information.

5.1.4 Limitations of Data

The data collected mostly relied on the memory status of sample respondents as record keeping is not a usual practice among the farming communities in Pakistan. In some cases the respondents were reluctant to give the accurate data. The main reason was the fear of government taxation on agriculture income. This difficulty was handled by ensuring them that their personal farm level data will only be used for the research study purposes and it will be kept confidential. Moreover, the personal local references were also used to take the sample respondents in confidence about the purpose of data collection. It is because the majority of farm household heads are not well educated and they don’t trust the intensions of government officials coming from out of village. When a local educated person of same village introduces the purpose of survey, they trust him. These personal references helped a lot in getting a better response of respondents and collecting reliable data. Totally alien village's data may have some dubious response but this approximates below one forth the total sample size. Cost on transport and mobility limited data collection as the study lacked financial support for data collection. Personal as well as rented conveyance was used for reaching the sample respondents.

5.1.5 Sample Size and Data Cleaning

According to the area specification 70 respondents from each of three sub-districts for the year 2008-09 were selected for final survey sample. Overall 210 farmers were interviewed to collect the farm level primary data. Farmers were divided into three farm size groups for the initial data analysis i.e.:

Small holders owning < 2 hectares

Medium holders owning 2-5 hectares

Large holders owning > 5 hectares

Farms size with less than 2 hectares was categorized as small while those with 2-5 hectares and greater than 5 hectares were nominated as medium and large farms respectively. Farm size groups were constructed by carefully observing the average farm size of all sample farm households in the study area. Moreover, the farm size of each individual farmer was determined by subtracting rented/shared out and adding rented/shared in land in the ownership holdings. The renting in or renting out of land is the process in which land rent (per year) is fixed in monitory term for using the land for crops production during the whole year. The duration of contact varies from farm to farm (mostly it is up to 5 years). Shared in/out is the agreement between the land owners and tenants about the sharing of production cost and output. They have mutual contract for growing the crops and sharing percentage of inputs and output.

5.2 Data Analysis

The various types of analytical methods were used to attain the set objectives. This section has been meant to explain methods to calculate the cropping patterns, cropping intensity, crop diversity index, the cost of production and factor productivity. Moreover, research hypotheses, production function (to find out the determinants of farm income and the yields of major crops) and factor analysis (to identify the factor responsible for important agricultural risk sources and risk management strategies) is also discussed in this section.

5.2.1 Cropping Pattern

Cropping pattern is the percentage acreage distribution of different crops in any one year in a given farm area such as a county, water agency, or farm (American Psychological Association (APA), Chicago Manual of Style (CMS) and Modern Language Association (MLA) 2011). Thus, a change in a cropping pattern from one year to the next can occur by changing the relative acreage of existing crops, and/or by introducing new crops/eliminating the old crops. Cropping pattern is calculated when farm households prefer to plant two or more species on the same farm in the same year. To maintain biological, economic, and nutritional diversity, multiple-species systems are used by the majority of world's farmers, particularly in developing countries. This is more common where the farm size is small and the lack of capital has made it difficult to mechanize and expand. Farm families that need a low-risk source of food and income often use multiple cropping. The cropping pattern in the study area was computed by using the following formula:

$$PA_i = \frac{AR_i}{\sum_{i=1}^{n} AR_i} \cdot 100 \qquad (5.1)$$

Where,

PA_i= Percentage of total cropped area under *ith* crop in a cropping season.

ARi= Total area under ith crop in a cropping season.

ΣARi= Total cropped area (total area under various crops) in a cropping season.

5.2.2 Cropping Intensity

Cropping Intensity is defined as the ratio of total cropped area (total sown area including the area sown twice in the year) in both cropping seasons i.e. summer and winter to the total cultivated area expressed in percentage. This also indicates the extent to which the cultivated area is used for cropping. This is an informative measure to determine the intensiveness of agriculture per annum in the form of crop production in a specified area. Formula utilized to determine cropping intensity in the study area for different farm size categories is as follows:

$$CI = \frac{\sum_{i=1}^{n} AR_i}{CA} . 100 \qquad (5.2)$$

Where,

CI = Cropping intensity.

AR_i = Area under *ith* crop.

CA = Total cultivated area.

5.2.3 Crop Diversity

Crop diversity means growing the higher number of crops-mix to ensure food security and to avoid the risk of crop failure. In other words, it is the response of subsistence farmers to reduce risks arising from climatic, biotic, or seasonal factors and ensures farm household food security. In the dry (arid and semi arid) areas of world where crop production is risky and opportunities are limited for insuring against it through working off-farm, many farm families still depend directly on the crop diversity for food security. It can also be explained as a number of various kinds of crops grown in the study area based on their species and cultivars. For calculating cropping diversity index, the following inverse Herfindahl Index (Patil and Tailllie, 1982) is used:

$$CDI = \frac{1}{\sum_{i-1}^{n} S_i^2} \qquad (5.3)$$

Where,

CDI = crop diversity index

S_i = Share of individual crop in total cropped area

5.2.4 Cost of Production

The farmers of study area produce major cereal grain crops and rear livestock. The major crops include wheat, pulses (chickpea and lentil), cash crop (groundnut), fodder crops (mustard, sorghum, and millet). A few of them also produce labor and capital intensive horticultural crops (vegetables and fruits). This study focuses on the cost of production of key products (wheat, groundnut, chickpea, mustard, lentil and livestock), which have a major contribution to farm household's income.

Production cost of farm products vary considerably, from farm to farm and season to season. The variations are based on the unique character of each operation and the uncertainty of factors beyond the control of farm households. The source with little differences can be found in several key input categories: (1) machinery costs that may vary because of difference in age, size, the usage of equipment and the price variation of fuel; (2) irrigation costs which are subject to variations in rainfall, temperature and irrigation systems (water use efficiency); (3) fertilizer, seed, and chemical costs which vary depending on used quantities and paid prices ; (4) labor costs which are dependent on prevailing wage rates, working conditions, and the efficiency of individual workers. The prevailing market prices of major inputs have been used in the production cost estimation. The cost of production is based on the average use of input quantity of farm households of study area. Crop production costs include:

- Land preparation cost (rental cost or fuel and the maintenance cost of farm machinery),
- Input costs (expenses for materials used in production such as seeds, fertilizers, farm yard manure and pesticides)
- Labor cost (the monetary valuation of family and hired labor at prevailing market rate).
- Land rent

Livestock production costs include:

- Feed expense (green & dry fodder and concentrate feeding),
- Health costs (medicines and veterinary consultancy fees) and
- Labor and management cost.

In addition, interest on operating capital was charged on variable costs in all cases. Detailed production estimation methodology is presented below:

i) Farm Revenue per Hectare

The farm revenue is total value of output by all enterprises of the farm household measured in terms of the farm gate prices per unit of area (PKR/ha). Farm's total revenue per hectare is determined by summing up all the revenues calculated for all the individual crops and livestock enterprises and then dividing by the operational land holding. The revenue for the individual crops was calculated by multiplying the farm household production of each crop by its market price. Then these revenues from each crop were added to reach at the revenue from crop's sub sectors. The revenue from livestock sub sector was calculated by multiplying the milk production in liters with the market price of milk and adding the income from the sale of livestock. The farm revenue was then calculated by adding the revenue from crop and livestock sub sectors and dividing by operational farm households' land holdings. The formula for calculating per hectare revenue for each crop is as follows:

$$TR_C = \sum_{i=1}^{n} {}_iY_i * P_i \qquad (5.4)$$

Where,

TRc = Total Revenue from crop sector (PKR/ha)

Yi = Production of ith crop (kgs/ha)

Pi = Price of ith crop (PKR/kg)

The formula for calculating the revenue from livestock used is as follows:

$$TR_L = (Y * P) + ILS \qquad (5.5)$$

Where,

TR_L = Revenue from Livestock (PKR/ha)

Y = Total milk production at farm (Liters/ha)

P = Price of milk (PKR/Liter)

ILS = Income from livestock sale (PKR/ha)

The formula used for calculating the per hectare farm revenue is as follows:

$$FR = \frac{TR_C + TR_L}{A_i} \qquad (5.6)$$

Where,

FR = Farm Revenue (PKR/ha)

TR_C = Total Revenue from crop sector (PKR/ha)

TR_L = Revenue from Livestock (PKR/ha)

A_i = Operational land holding (ha)

ii) Gross margins

Gross margin, gross profit margin or gross profit rate is the difference between the sales revenue and production costs (excluding overhead, land rent, taxation, and interest payments). The gross margin is the money value of crop after the direct costs (costs which can be attributed directly to that crop) have been deducted. In first step the gross margin of each crop and livestock were calculated separately by deducting direct costs from the total revenue of each crop. Secondly, after these calculations have been done for all the crops and livestock of farm, the gross margins of all crops and livestock were added. It can be expressed in absolute terms:

$$GM = FR - VC \quad (5.7)$$

It can also be expressed as ratio of gross profit to cost of production, usually in form of percentage:

$$GM\% = \frac{FR - VC}{VC} * 100 \quad (5.8)$$

Where,

GM % = Gross margins (%)

FR = Farm Revenue (PKR/ha)

VC = Variable Costs (PKR/ha)

iii) Net Profit

Gross margin's value does not yet represent what the household has earned in cash and in kind. To obtain this figure, we must calculate net profit. Net profit is calculated by subtracting a farm's total expenses from total revenue, thus showing what the farm has earned (or lost) in a given period of time (usually in one year). It is also called net income or net earnings. Net profit is the measure of profitability of a venture after accounting for all costs. Net profit was calculated by deducting all the indirect or fixed costs (land rent and interest payable) from gross profit. This gives net profit from crop cultivation. It can be expressed as:

$$NP = FR - TC \text{ or}$$
$$NP = GM - FC \quad (5.9)$$

Where,

NP = Net Profit (PKR/ha)

FR = Farm Revenue (PKR/ha)

TC = Total Costs (PKR/ha)

GM = Gross margins (PKR/ha)

FC = Fixed Cost (PKR/ha)

Net profit can also be expressed as the ratio of net profit to the cost of production, usually in terms of percentage:

$$NP\,\% = \frac{FR - TC}{TC} * 100 \qquad (5.10)$$

Where,

NP % = Percentage net profit rate (%)

FR = Farm Revenue (PKR/ha)

TC = Total cost (PKR/ha)

iv) Variable Costs of Production

The variable costs of a crop included in the analysis are land preparation costs, input costs (include cost on seeds, fertilizers and pesticides), labor costs (the value of total labor used for performing all farm operations related to each enterprise) and farm machinery costs (for harvesting and threshing). The cost of production for five important livestock enterprises namely, buffaloes, cows, sheep, goats, and draught animals are included in this study. They include feeding cost (green fodder, dry fodder and concentrates), health cost and labor costs.

Land Preparation Costs

The general trend for renting the tractor is on per hour basis. Land preparation cost is calculated by multiplying the whole time of farm operations for a particular crop in the whole season with the prevailing market price of farm machinery, again on per hour basis. For the farm household owning tractor, the actual cost of used fuel and maintenance cost was included to reach the land preparation costs.

Costs for External Inputs

Cost of inputs make up a major component of variable costs involved in farming operation. This includes seed costs, chemical inputs (fertilizer, herbicides, fungicides, and insecticides).

Seeds: If seeds are bought, the cost is the market price paid for them. If seeds are taken from the stock left from the previous harvest, the cost used is the price one would have to pay for seeds at the local market.

Fertilizers: If chemical fertilizer is used, the cost is the price paid for it. If manure is used, no cost can be allocated because manure is not sold and therefore has no price. Overall very little manure is used as natural fertilizers[2].

Pesticides/Weedicides: This cost is the market price of quantity used for each crop.

Labor Costs

The labor cost is money paid to hired workers or the money value of that part of crop given to them in return for their work. The labor was divided into three categories for the accurate estimation of labor costs i.e. operator labor, regular hired labor, and seasonal hired labor. Operator labor is used primarily for operating machines and for other tasks which require a high level of skill. This type of labor is generally provided by the owner or farm family members. Regular hired labor is somewhat less skilled and used primarily for general farm operations such as livestock keeping. Seasonal hired labor is used primarily for planting, weeding, seed, fertilizers and pesticides/weedicides application and harvesting. The amount of operator, regular hired, and seasonal hired labor required for each crop depends on the number and frequency of tasks, the overall size of operation, and whether harvesting is accomplished by hand or machine. This cost is calculated by multiplying the amount of labor in days with market labor wage rates. The prevailing market labor wages are used for the household family labor incase of its usage for farm operations.

Harvesting and Threshing Costs

The machinery was used only for land preparation and threshing by the majority of farm households. A few households used machinery for crop harvesting as the majority of them manually harvested their crops by using family as well as hired labor. The operating costs include repair and maintenance costs, as well as the fuel and oil costs of self propelled machinery. The operating costs of machinery are a component of variable costs. The cost of owned and rented machinery for land preparation is already discussed. The same procedure was adopted to estimate the machinery cost for harvesting and threshing of crop produce.

[2] Mostly cow/buffalo dung is used for fuel in cooking after making cow dung cakes and drying it. These cakes are just used for household cooking and not sold in the market. So this was used neither on the revenue side nor on the cost side.

Interest on Operating Capital

The interest on operating capital is included in production cost. Interest on variable costs incurred for crop production (duration six months) is charged at the rate of 12 percent[3] per annum (the prevailing interest rate in the study area during the time of data collection i.e. the year 2009). Interest on the operational cost of land preparation, inputs and labor costs is included in variable costs while for harvesting and threshing was not included as these costs were incurred just before the marketing of crops produce. For livestock, interest on operating capital was not included in the cost of production as the revenue obtained from the livestock was the regular flow of revenue from milk sales during the whole year (in most of the cases farmers get revenue from milk sales just after one week).

v) Fixed Costs of Production

The fixed costs of a crop included in the analysis are land rent costs and farm overhead costs.

Land Rents

Land rent per hectare prevailing at the village level is included as the cost of land for owned and rented land used for each field crop production.

Farm Machinery Costs

The machinery and equipment costs consist of overhead costs and operating costs. The estimates of overhead or fixed costs of machinery and equipment were based on the replacement values of machines and include depreciation, interest and insurance. These costs were calculated on the basis of time of their use on farm and their workable life.

5.2.5 Factor Productivities

i) Total Factor Productivity (TFP)

Output of any crop attained by land unit or farm level expressed in the monetary or physical terms of their weights (e.g. tons, mounds, kilo grams, grams) divided by the cost or quantity of all the factors of production is termed as total factor productivity. In the present study as the total factor productivity was calculated at farm level so this was calculated in the monetary terms. TFP in physical term is not meaningful at the

[3] Interest rate is quite high due the high inflation rate in Pakistan's economy.

farm level as the units of different commodities differ. To reach uniformity for calculating TFP at farm level all the factors and products are monetized by multiplying with their respective market prices. For this purpose the revenues and costs used were calculated by using the formulas mentioned in the previous section (cost of production). TFP was calculated by using the following formula:

$$TFP_m = \sum_{i=1}^{n} \frac{FR_i}{TC_i} \tag{5.11}$$

Where,

TFP = Total Factor Productivity

FR_i = Farm Revenue of all major enterprises of farm

TC_i = Total Cost of Production of all the factors involved in production

ii) Labor Productivity

To determine labor productivity family labor man days were converted in to monetary terms by multiplying the number of family labor days involved in the farm operations with the prevailing market labor wage rate per day (PKR 250/day) of study area. Furthermore, the hired labor and family labor man days in monetary form were added together to attain labor productivity of study area. Labor productivity was calculated by using the following formula:

$$LP_m = \sum_{i=1}^{n} \frac{TR_i}{LC_i} \tag{5.12}$$

Where,

LP = Labor productivity

TR_i = Total revenue of ith crop (PKR)

LC_i = Labor cost of production for the ith crop (PKR)

iii) Land Productivity

Land is the limiting factor of production as majority of farm households have small land holdings and can't increase it in the short run. Partial land productivity was calculated by dividing the total revenue of all crops by the total land rent of area sown of all crop. Land productivity was calculated by using the following formula:

$$LdP_m = \sum_{i=1}^{n} \frac{TR_i}{LR_i} \tag{5.13}$$

Where,

LdP = Land productivity

TR_i Farm revenue of ith crop (PKR)

LR_i = Land Rent for the ith crop production (PKR)

5.2.6 Research Hypotheses

i) Research Hypotheses about Determinants of Farm Income

To fulfill the different research objectives several hypotheses regarding the determinants of farm income (PKR/ac), determinants of major crops yield (kg/ac) and risk sources and risk management strategies have been formulated. The hypotheses related to the determinants of farm income with detail relationship between the dependent variable (net farm income per acre) and various independent variables have been presented in Table 5.1.

Table 5.1 Research Hypothesis about Determinants of Farm Income

Dependent Variable: Net Farm income (PKR/Acre)

Hypothesis	Indicator (Independent Variables)	Units	No of question	Hypothesized Relationship
H1.1	Size of Operational Holding	Acres	Q 2	Negative
H1.2	Irrigated area	Acres	Q 2	Positive
H1.3	Production diversity	Crop diversity index and no of animal units	Q 4	Positive
H1.4	Cropping Intensity	%	Q 2,4	Negative
H1.5	Off-farm income	Pak Rupees	Q 20	Positive
H1.6	Number of livestock	Number	Q 9	Positive
H1.7	Direct costs incurred on crops	Pak Rupees	Q 5	Positive
H1.8	Cost incurred on livestock	Pak Rupees	Q 10	Positive
H1.9	Tractor ownership	Dummy (1=owned 0=rented)	Q 3	Positive
	Hired labor cost	Pak Rupees	Q 13	Positive
	Family labor cost	Pak Rupees	Q 19	Positive
	Farmers' age	Years	Q 1	Positive
	Farmers' education	Years	Q 1	Positive
	Contact with extension department	Dummy (1=yes 0=no)	Q 7	Positive

ii) Research Hypotheses about Determinants of Major Crops Production

Several hypotheses have been formulated regarding the determinants of major crops yield according to research objectives. The details of hypothesis related to the determinants of major crop yields with detailed relationship between the major crops yield (kg per acre) and various independent variables have been presented in Table 5.2.

Table 5.2 Research Hypotheses about Determinants of Major Crops Yield

Dependent Variable: Yield of Major crops (Wheat, Groundnut, Chickpea and Mustard)

Hypothesis	Independent Variable	Indicator	No of question in questionnaire	Hypothesied Relationship
H2.1	Operational Holding	Hectares	Q 2	Positive
H2.2	Irrigated area Crop area Crop price	Hectares Hectares Hectares	Q 2 Q 4 Q 4	Positive Positive Positive
H2.3	Crop diversity index Cropping intensity Off-farm income	index % Pak Rupees	Q 4 Q 2,4 Q 20	Positive
H2.4	Number of plowing Seed rate Fertilizer	Number Kg/ha Kg/ha	Q 5 (Table) Q 5 (Table) Q 5 (Table)	Positive Positive Positive
H2.5	Crop costs	Pak Rupees	Q 5 (Table)	Positive
H2.6	Hired labor Family labor	Hrs/ha Hrs/ha	Q 13 Q 19	Positive Positive
H2.7	Tractor ownership Farmers' age Farmers' education Contact with extension department	Dummy (1=owned 0=rented) Years Years Dummy (1=yes 0=no)	Q 3 Q 1 Q 1 Q 7	Positive Positive Positive Positive

iii) Research Hypotheses about Risk Sources and Risk Management Strategies

Following hypotheses are formulated regarding risk sources and risk management strategies to fulfil the research objectives related to risk:

H 3.1: Lack of information and rainfall shortage are the major risk sources for farm income of rain-fed households and

H 3.2: The crop diversification and participation of farm household members in off-farm income activities are the major risk management strategies for rain-fed farm households' income

5.2.7 The Production Function

Econometric tools were employed to find out the determinants of farm income of rain-fed farmers in the study area. A double natural log function was used by employing Ordinary Least Square (OLS) method to investigate the relationships between different explanatory variables and farm income (dependent variable). The following general farm model equation was used to test the hypothesis regarding determinants of farm income:

$$LnY = \alpha + \beta_i \sum_{j=1}^{n} LnX_i + \gamma_i \sum_{k=1}^{n} D_i + e_i \qquad (5.14)$$

Ln Y = Farm income (Dependent Variable)

Xi = List of independent continuous variables

Di = List of independent dummy variables

α, $ß_i$ and γ_i = Production function parameters to be estimated

ei = Disturbance term

To avoid multi-collinearity problems and to reduce the number of variables, the different kinds of input costs were added together and overall variable cost at farm level was calculated. The production function was run by using Statistical Package for Social Scientists (SPSS) software.

i) Farm Income Ln-In Production Function

The details of relationship between farm income (dependent variable) and the independent variables are presented as follows:

Ln FARMINC = β_0 + β_1 LN OPHOLD + β_2 LN ARIRRIG + β_3 LN PRODDIV + β_4 LN CROPINT+ β_5 LN OFFARMINC+ β_6 LN LSTKNO + β_7 LN CROPCOST + β_8 LSTKCOST + β_9 LN FAMLABCO + β_{10} LN HRLABCO + β_{11} SMLFARMS (D) + β_{12} MEDGFARMS (D) + β_{13} TRACTOWN (D) + β_{14} VISITEXT (D) + β_{15} DISCHAK (D) + β_{16} DISTALAG (D) + β_{17} LN AGHH + β_{18} LN EDUHH + e_i (5.15)

Where,

Dependent Variable:

- FARMINC = Farm Income (PKR/acre)

Independent Variables:

- OPHOLD = Operational Land Holding (ac)
- ARIRRIG = Area Irrigated (ac)
- PRODDIV = Production diversity

- CROPINT = Cropping intensity (%)
- OFFARMINC = Off farm income (PKR/annum)
- LSTKNO = Livestock (No)
- CROPCOST = Cost on crops (PKR/ac)
- LSTKCOST = Cost on livestock (PKR/ac)
- FAMLABCO = Family labor (Hrs/ac)
- HRLABCO = Hired labor (Hrs/ac)
- SMLFARMS (D) = Small farms (Dummy)
- MEDFARMS (D) = Medium farms (Dummy)
- TRACTOWN (D) = Ownership of tractor (Dummy)
- VISITEXT (D) = Contact with extension (Dummy)
- DISCHAK = Dummy for Chakwal Sub-district
- DISTALAG = Dummy for Talagang Sub-district
- LN AGHH = Age of household head (Yrs)
- LN EDUHH = Education of household head (Yrs)

ii) Major Crops Ln-Ln Production Function

Ln YLD = β_0 + β_1 LN AROWN + β_2 LN ARIRRIG + β_3 LN ARSOWN + β_4 LN PRODPR + β_5 LN CROPDIV + β_6 LN CROPINT + β_7 LN OFFARMINC + β_8 LN NOPLOW + β_9 LN SEDRAT + β_{10} FERT + β_{11} LN VARCO + β_{12} LN FAMLAB + β_{13} LN HRLAB + β_{14} MEDFARMS (D) + β_{15} LARGFARMS (D) + β_{16} DISCHAK (D) + β_{17} DISTALAG (D) + β_{18} TRACTOWN (D) + β_{19} VISITEXT (D) + β_{20} LN AGHH + β_{21} LN EDUHH + e_i (5.16)

Where,

Dependent Variable:

- YLD = Crops yield (kg/ac)

Independent Variables:

- AROWN = Land holding (ac)
- ARIRRIG = Area irrigated (ac)
- ARSOWN = Area sown (ac)
- PRODPR = Product price (PKR)
- CROPDIV = Crop diversity index
- CROPINT = Cropping intensity (%)
- OFFARMINC = Off farm income (PKR/annum)
- NOPLOW = Frequency of plowing (No)
- SEDRAT = Seed rate (Kg/ac)
- FERT = Quantity of fertilizer applied (Kg/ac)
- VARCO = Variable cost (PKR/ac)
- FAMLAB = Family labor (Hrs/ac)
- HRLAB = Hired labor (Hrs/ac)
- MEDFARMS (D) = Medium farms (Dummy)
- LARGFARMS (D) = Large farms (Dummy)
- DISCHAK = Dummy for Chakwal Sub-district

- DISTALAG = Dummy for Talagang Sub-district
- TRACTOWN (D) = Ownership of tractor (Dummy)
- VISITEXT (D) = Contact with extension (Dummy)
- LN AGHH = Age of household head (Yrs)
- LN EDUHH = Education of household head (Yrs)

5.2.8 Factor Analysis

Exploratory factor analysis (EFA) was used for the present study. EFA is the collection of methods used to examine how underlying constructs influence the responses on a number of measured variables. Factor analyses are performed by examining the pattern of correlations (or covariance) between the observed variables. Variables that are highly correlated (high factor loadings either positively or negatively) are likely influenced by the same factors, while those that are relatively uncorrelated are likely influenced by some different factors. The general purpose of factor analytic techniques is to find a way of condensing the information contained in a number of original variables into a smaller set of new composite dimensions (factors) with a minimum loss of information (Hair et al., 1987). The primary objectives of an EFA are to determine the number of common factors influencing a set of different variables and the strength of relationship between each factor and the each observed measure of variables.

A Likert-type scale was used to determine risk sources and strategies preferred by farm households in agricultural production in the study area. The scale varied from 1 (strongly disagree) to 5 (strongly agree) which showing their view about the agreement with the particular risk source and risk management strategy. Factor analysis was conducted by using SPSS software. Considering the research area conditions and agricultural practices, risk sources and strategies were gathered under 19 and 13 variables, respectively. Factors were named on the basis of the strength of their factor loadings with the Likert scale measures of these variables.

CHAPTER 6: FARM CHARACTERISTICS AND CROPPING PATTERN

This chapter presents results about the composition of sample farmers, the education and experience of farm household members, farm characteristics, cropping pattern, cropping intensity, crop diversity, and livestock composition. Some basic information regarding farm mechanization, irrigation sources, sources and the extent of agricultural production and marketing information, agricultural credit, and farm household labor is also provided in the chapter.

6.1 Composition of Sample Farmers

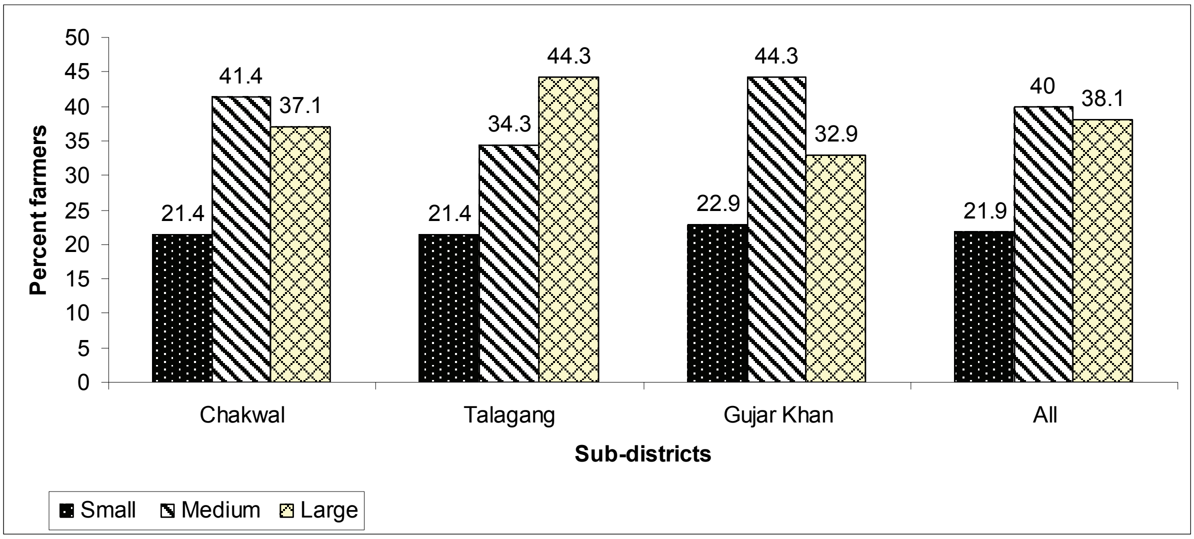
For initial descriptive data analysis, based on farm operational holding, the sample farms were classified into three distinct size categories on the basis of operational land holdings: small farms having less than 2 hectares of land, medium farms with 2 to 5 hectares and large farms with more than 5 hectares. The gathered information pertained to farm level crop and livestock production during two cropping seasons i.e. Rabi 2008-09 (October 2008-April 2009) and *Kharif* 2009 (May-September 2009). Table 6.1 shows sample composition across sample sub districts. Overall 22 percent of farms belong to the small farm size category while 40 percent were included in the medium and 38 percent are included in large farm size category. Average farm size for small farms category is 1.19 ha, for medium 3.27 ha and for large farm size category it is above 9 ha. Talagang sub-district (44.3 %) has the higher percentage of large farms followed by Chakwal (37.1 %) while Gujar Khan sub-districts has the least number of large farms (32.9 %). The farm size structure in Chakwal and Gujar Khan Sub-districts follows almost similar pattern.

Table 6.1 Composition of Sample Farms by Farm Size and Study Sites (% Farms)

Farm size	Chakwal	Talagang	Gujar Khan	All	Farm size (Ha.)
Small	21.4	21.4	22.9	21.9	1.19
	(15)	(15)	(16)	(46)	(0.54)
Medium	41.4	34.3	44.3	40.0	3.27
	(29)	(24)	(31)	(84)	(0.89)
Large	37.1	44.3	32.9	38.1	9.44
	(26)	(31)	(23)	(80)	(6.61)
All	100.0	100.0	100.0	100.0	5.16
	(70)	(70)	(70)	(70)	(5.37)

Note: Figures in parentheses are number Source: Author's Survey data 2009

Figure 6.1 Composition of Sample Farmers



Source: Author's Survey data 2009

6.2 Education and Experience of Farm Household Members

To gauge the distinction amongst the three farm size categories regarding their family and farm character's descriptive statistics is run with SPPS. Tables 6.2 and 6.3 show the descriptive results exhibiting differences and similarities in demographic factors across the farm size categories.

Table 6.2 shows the average age, farming experience, education of household head and education status of members of farm household. The average age of household head is above 50 years and their education level is 7.5 years of schooling. The age of household head of medium farms is higher than that of small and large farms while the education of farm household head is almost same. The average farming experience of household head is almost 30 years with the owners of large farms having higher experience than the owners of small and medium farms. This shows that farmers practicing agriculture are mostly aged with vast farming experience and lesser education. According to the author's observation most farmers prefer their children to get education at least to certain minimum level and get off-farm jobs.

Overall there are on average almost 6 adult (>15 years of age) members in farm households. The large farms have bigger family size (6.6) as compared to small (5.3) and medium (5.6) farms. In the sample farm households, the percentage of adult males and females is almost equal. In large and small farm size categories the percentage of male is more than half (52 %) while in medium farm category the percentage is less than half (47 %). More than 10 percent of males are illiterate while almost 12 percent of them have the primary level of education. The majority (almost two third) of male members have eight (almost 30 %) and ten (almost 33 %) grade education. Only a small percentage has 12 years of schooling (9 percent) and graduate or above (almost 6 percent). Education level in the male members of study area is far better as compared to female members. The table 6.2 shows that slightly less than half (43 percent) female members of sample household are illiterate and almost one forth have only up to the primary level of education. The females having 8 and 10 grade education are 13 and 10 percent only. A small percentage (6% and 4%) of females have intermediate (12 grades) and graduate or above education.

Table 6.2 Education Status of Farm Household Head and Other Members

Farm Size	Small	Medium	Large	All	F
Household head					
Age (yrs)	51.2	54.4	52.4	52.9	0.855
Education (yrs)	7.4	7.4	7.8	7.5	0.335
Experience (yrs)	26.6	29.3	32.8	30.0	2.475*
Family Size (> 15 years)	5.3	5.6	6.6	5.9	3.868**
Male (%)	52.0	47.2	52.0	50.1	3.662**
Education Male members					
Illiterate	13.1	11.9	9.2	11.2	0.470
Primary	12.2	13.9	10.4	12.2	0.420
Middle	33.1	30.1	27.8	29.9	0.355
Matric	27.5	30.2	38.5	32.8	2.080
Intermediate	6.7	9.5	9.4	8.9	0.331
Graduate and above	7.4	4.4	6.3	5.8	0.571
Education Female members					
Illiterate	39.4	46.7	41.1	42.97	0.722
Primary	20.1	21.9	27.1	23.52	0.979
Middle	12.3	13.2	13.6	13.15	0.044
Matric	13.4	11.5	6.6	10.05	1.973
Intermediate	8.7	4.1	6.4	5.97	1.163
Graduate and above	6.1	2.7	5.0	4.34	1.039

Source: Author's Survey data 2009

6.3 Farm Characteristics

Table 6.3 reveals the farm characteristics concerning average owned area, operational holding, wasteland, rented/shared in, rented/shared out and percent irrigated area. The average area owned and operation land holding of study area is 6.73 and 5.16 hectares respectively. The smaller operation holding relative to the area owned shows that the wasteland, rented/shared out land is higher as compared to rented/shared in land in the study area. The average farm size of large farms category (9.44 ha) is almost three-fold as compared to medium (3.27 ha) and small (1.19 ha) farm categories. Overall almost 10 percent area is irrigated. The irrigated area of small and large farms is higher than medium farms.

Table 6.3 Farm Characteristics by Farm Size Categories in the Study Area (ha)

Farm Size	Small	Medium	Large	Total	F
Area owned	2.10	4.45	11.79	6.73	24.087***
Wasteland	0.41	1.12	2.03	1.31	2.529*
Rented in	0.06	0.27	1.28	.61	5.405***
Rented out	0.15	0.42	0.14	.25	0.672
Shared in	0.10	0.28	0.24	.22	0.652
Shared out	0.53	0.20	1.70	.84	2.479*
Operational holding	1.19	3.27	9.44	5.16	73.156***
Area irrigated	0.13	0.21	0.96	.48	5.233***
Area rain-fed	1.05	3.05	8.47	4.68	68.782***
% Irrigated area	11.20	6.50	10.20	9.3	5.117***

Source: Author’s Survey data 2009

6.4 Cropping Pattern

The cropping pattern indicates the relative share of each crop in the total cropped area in a cropping season. In the study area due to water shortage and occurrence of cyclic severe drought attacks, farmers usually prefer to grow only one crop per year. The common trend is to keep almost half the land fallow during summer and *monsoon* season. During this period the farmers used to prepare their land by frequent tillage practice. The planking is applied to conserve the soil moisture for coming *rabi* (winter) season crops. More area is under crops during winter season as compared to summer. Wheat, chickpea, lentil and mustard are major *rabi* crops occupying 65.58 percent of total farm area during the winter season. Almost the one third (31.8 %) operational holding remained fallow during the winter season 2008-09. In *kharif* season (summer), groundnut sorghum and millet account for almost the half (49.6%) of total farm area. The major cash crop during summer is groundnut for all the three farm size categories. Almost half (48.4%) of the operational holding remained fallow during the summer.

Table 6.4 Cropping Patterns by Farm Size (% Area)

Farm Size	Small	Medium	Large	Total	F
Winter Season					
Wheat	65.08	51.30	46.24	52.39	12.848***
Chickpea	3.75	4.54	7.00	5.30	2.081
Lentil	4.59	4.46	3.08	3.97	0.626
Mustard	2.73	3.85	4.68	3.92	1.068
Oat	0.71	1.01	0.94	0.92	0.216
Berseem	0.04	0.11	0.12	0.10	0.322
Barley	0.72	0.15	0.16	0.28	1.743
Taramera	0.00	0.68	1.28	0.76	1.558
Winter vegetables	2.17	0.03	0.31	0.61	1.473
Area fallow *rabi*	**20.2**	**33.8**	**36.19**	**31.75**	**10.442*** **
Summer Season					
Groundnut	20.70	27.99	34.22	28.77	5.156***
Sorghum	21.51	13.23	7.22	12.76	26.293***
Millet	11.59	9.17	4.98	8.10	11.456***
Maize	1.78	0.58	0.79	0.92	1.622
Guar seed	0.00	0.00	0.06	0.02	0.811
Mung	0.00	0.05	0.96	0.39	3.346**
Summer vegetables	1.70	0.07	0.66	0.65	1.426
Area fallow *kharif*	**42.71**	**48.8**	**51.16**	**48.40**	**2.080**

Source: Author's Survey data 2009

6.5 Cropping Intensity

Cropping Intensity is defined as "the ratio of total cropped area in the whole year to the total cultivated area expressed in percentage" (Government of Pakistan 2000). It indicates the extent to which the cultivated area is used for repeated cropping in a particular year (Mahmood 2000). Cropping intensity is a useful measure to gauge the farm use with respect to the number of crops grown on a particular farm area per year or per season. Table 6.5 expresses the detail results about the cropping intensity of different sub-districts by farm size categories.

The cropping intensity is estimated as 120 percent on an average. Fluctuation in the rainfall, no canal irrigation system and the limited opportunities of tube-well irrigation in the area are the main reasons for low cropping intensity. Obviously Talagang and Gujar Khan Sub-districts with 124.5 and 123.2 percent, are more intensively cropped as compared to Chakwal sub-district with 111.8 percent. Cropping intensity is inversely related to farm size (Table 6.5). The cropping intensity on small farms (137.1 %) is higher than that on medium (117.2 %) and large farms (112.69 %).

Furthermore, in all the sub-districts there is a similar trend that the rate of cropping intensity tends to decrease with increasing farm size.

Table 6.5 Cropping intensity (%) and Crop Diversity by Study Sites and Farm Size

Farm Size	Small	Medium	Large	Total	F
Chakwal					
Cropping intensity	125.27	108.70	107.50	111.81	2.353
Crop diversity index	3.23	3.28	3.55	3.37	0.425
Talagang					
Cropping intensity	147.11	122.51	115.12	124.51	8.209***
Crop diversity index	2.87	2.80	2.65	2.75	0.557
Gujar Khan					
Cropping intensity	138.77	121.14	115.29	123.25	3.181**
Crop diversity index	3.02	3.15	2.98	3.06	0.265
Overall Study Area					
Cropping intensity	137.09	117.24	112.69	119.85	12.038***
Crop diversity index	3.04	3.09	3.04	3.06	0.078

Source: Author's Survey data 2009

6.6 Crop Diversity

Crop diversity is a measure which is normally used in biological sciences to distinguish the various kinds of species. This measure is used to observe the numbers and kinds of plants in a given area on the basis of their physical as well as genetic make up. Afterwards it is adopted not only in agriculture but also in agriculture production economics to make various crop production decisions on the basis of their physical as well as monetary gains. It is also called crop rotation diversity. Decisions about crop rotational diversification are, mainly taken to cultivate disease resistant, land fertility enhancing, high yielding varieties, reduction in the cost of production, easily marketable crops and reduced agricultural production risk.

Table 6.5 shows the crop diversity in different study locations by farm size categories. It is observed that Chakwal (3.37) is the highest crop diverse sub-district followed by Gujar Khan (3.06) while Talagang (2.75) has the least crop diversity. Crop diversity is almost the same on small, medium and large farms. In Chakwal sub-district crop diversity showed an increasing trend with increasing farm size categories. In Talagang sub-district this slightly decreased along with the increase in the farm size categories. In Gujar Khan the crop diversity is highest on medium farms (3.15) while that for small (3.02) and large (2.98) farmers is almost same.

6.7 Livestock Composition

The livestock production of area is basically of subsistence nature. The farmers of study area kept large ruminants particularly for milk purpose while small ruminants mostly for selling and earning livelihood (meat purpose). The majority of farmers have small number of animals (1 to 2). The main purpose is to produce milk just for the home consumption needs. In the case of small marketable surplus, it is sold locally to the milk carriers, retailers or directly to consumers at the spot. The young male cow or buffalo stock are fed for 1 to 2 years and then sold to balance the vulnerability/variability of crop income due to severe weather conditions. Farmers preferred to keep the young female cow and buffalo to have addition to their adult milking cow and buffalo stock. Livestock played the role of cash deposit for the farming community of area. Resource poor farmers raised livestock to sell it at the time of dire need for money.

Table 6.6 Livestock Composition by Farm Size

Farm Size	Small	Medium	Large	All	F
Buffalo milk	0.39	0.70	1.14	0.80	10.467***
Buffalo dry	0.13	0.12	0.34	0.20	3.693**
Buffalo young stock	0.33	0.71	1.05	0.76	8.258***
Cow milk	0.78	1.21	1.78	1.33	9.253***
Cow dry	0.35	0.82	0.96	0.77	3.040**
Cow young stock	0.91	1.38	2.06	1.54	7.553***
Adult sheep/goat	1.04	2.64	3.59	2.65	2.875*
Young sheep/goat	0.09	0.51	1.24	0.70	2.184
Draft animal	0.48	0.45	0.38	0.43	0.417
All Animals	4.50	8.54	12.54	9.18	7.301***

Source: Author's Survey data 2009

Table 6.6 shows that overall households keep on an average 09.18 animals per farm. Farmers having large farms kept significantly more animals than farmers having small and medium farms. The total number of large ruminants is higher as compared to small ruminants. The main reason for this is the household milk consumption needs and higher milk demand in the rural and urban markets. Small ruminants couldn't produce enough milk to fulfill the home consumption needs.

These animals are mostly kept for earning livelihood by selling them for meet purposes. Among large ruminants the number of cows is slightly higher than buffaloes. The possible reason maybe that the cows consumed less fodder than buffaloes while their lactation period is higher. In the situation of fodder shortage in rain-fed area cows are more economical to rear than buffaloes. The number of draft animals is lower as tractor replaced the draft animals for land preparation, threshing, and the transportation of inputs and produce.

6.8 Farm Mechanization and Irrigation Sources

Table 6.7 shows farm traction power, tractor ownership, irrigation sources, water lifting device, soil type, soil quality and rainfall during winter season 2008-09 and summer season 2009. Tractor is the main source of farm traction power as almost 99 percent of farmers used this for farm operations. Overall 62 percent farmers used rented tractor while 38 percent have their own. Only 2 percent farmers relied to some extent on bullocks for land preparation and seed sowing. The majority of farmers (61 %) having large farms owned tractor while a majority (84.8 %) of farmers having small farms relied on the services of rented tractor for farm operations. Those who possessed their own tractor used it for their farm operations as well as provided tractor rental services to the fellow farmers and earn livelihood for their household members. Almost 30 percent of medium farmers have their own tractor.

The majority (81.9 %) of farmers have no external source of irrigation while 8.6 percent farmers have dug wells, 8.1 percent tube-wells and 4.3 percent small dams for irrigating their land. More than half (57 %) of farmers used electric motor as water lifting device while almost 46 percent used diesel engine for the same purpose. Small and large farms depended on both water lifting devices like diesel engine as well as electric motor while the majority of medium farms used electric motor as water lifting device.

Almost 80 percent farmers have clay loam soils while 59 percent respondents have loamy soils (total percentage exceeds 100 % as some of farm households have both type of soils). Clay loam soils have more capacity to preserve moisture in the root zone as compared to loamy and sandy soils. The results showed that more than three forth of the land in study area has good moisture preservation capacity which is ideal for agriculture in rain-fed conditions. Due to this reason more than 90 percent of farmers expressed that their land is good for agricultural production. According to the view of more than 95 percent farmers, rainfall during winter season 2008-09 is in medium quantity. The rainfall during the summer season 2009 is below their expectations. This hampered the summer season crops particularly main summer fodder crops (sorghum and millet) and cash crop (groundnut).

Table 6.7 Farm Traction Power, and Irrigation Sources by Farm Size (% Farms)

Farm Size	Small	Medium	Large	All
Farm traction power				
Tractor	97.8	100	98.8	99.0
Bullock	4.3	1.2	1.3	1.9
Tractor ownership				
Rented	84.8	71.4	38.8	61.9
Own	15.2	28.6	61.3	38.1
Irrigation source				
Rain-fed	78.3	85.7	80.0	81.9
Dug wells	10.9	10.7	5.0	8.6
Tube-well	17.4	0	11.2	8.1
Small dams	0	7.1	3.8	4.3
Water lifting device				
Electric motor	41.7	90.0	46.2	57.1
Diesel Engine	50.0	20.0	61.5	45.7
Tractor	8.3	0.0	0.0	2.9
Soil Type				
Clay loam	84.8	79.8	77.5	80.0
Loamy	52.2	56.0	66.3	59.0
Soil quality				
Good	93.5	90.5	97.5	93.8
Average	6.5	10.7	3.8	7.1
Rainfall during rabi				
Medium	84.8	98.8	100.0	96.2
Low	15.2	1.2	0.0	3.8

Source: Author's Survey data 2009

6.9 Sources of Agricultural Information

According to the author's observation television is a strong electronic medium in the dissemination of agricultural information in Punjab in particular for the younger generation. The majority of farm household heads who are responsible for decision making process for agricultural operations is aged and less educated. They mostly are not interested in watching the television and getting agricultural information for improving their farm production and profitability. Altogether less than half farmers watched television program to get agricultural production and marketing information.

According to the farm level data gathered from the study area, 95 percent of farmers are not visited by the extension agents. The extension department workers visited mostly the large farms of study area while the small and medium farms are neglected. Farmers have the impression that department officials only visited villages nearby the urban centers and developed some relationship with the influential farmers. The department officials used these farmers as show case for their performance to their higher officials.

Table 6.8 Agricultural Information Sources by Farm Size (% Farms)

Farm Size	Small	Medium	Large	All
TV for Agriculture Information				
Don't watch	63.0	51.2	48.8	52.9
Watch	37.0	48.8	51.3	47.1
Extension agents' farm visit				
No visit	100.0	96.4	90.0	94.8
Once per season	0.0	3.6	8.8	4.8
Monthly	0.0	0.0	1.3	.5
Farmers visit to extension office				
No visit	100.0	97.6	90.0	95.2
Once per season	0.0	2.4	7.5	3.8
Monthly	0.0	0.0	2.5	1.0
Farmers' visit to research institute				
No visit	100.0	97.6	97.5	98.1
Once per season	0.0	2.4	2.5	1.9

Source: Author's Survey data 2009

The majority (95 %) of farmers don't visit local extension office to get first hand knowledge about production technology. Only 4 percent visited the office once in season and 1 percent visited monthly. Only 2 percent farmers visited local agricultural research institutes to get improved variety seed and production technology knowledge. The majority of sample farmers used the seed of major crops from their previous year produce for at least 3 to 5 years. Alternatively, they exchanged seed with their fellow farmers.

6.10 Extent of Agricultural Information

According to the farmers view the level of information regarding agricultural production and marketing is quite low in the study area. The majority of farmers mentioned that rain-fed Punjab is neglected by the Punjab extension department. This department concentrated on the irrigated areas where commercial agriculture with sufficient canal and tube well irrigation water existed. Moreover the extension department mostly concentrated on major crops (wheat and groundnut) production while high value crops (fruits and vegetables), livestock production and agricultural marketing information are given less consideration. Overall 98 percent farmers are unsatisfied with the information they received. The owners of small farms are more unsatisfied with the agricultural information received than that of medium and large farms.

Table 6.9 Extent of Agricultural Information by Farm Size (Percent Farmers)

Farm Size	Small	Medium	Large	All
Agriculture Information				
Unsatisfied	100.0	98.8	95.0	97.6
Satisfied	0.0	1.2	5.0	2.4
Production technology				
Incomplete information	100.0	98.8	97.5	98.6
Complete information	0.0	1.2	2.5	1.4
Pesticide spray				
Incomplete information	6.5	10.7	13.8	11.0
No information at all	93.5	88.1	83.8	87.6
Complete information	0.0	1.2	2.5	1.4
Time of input operation				
Incomplete information	8.7	7.1	10.0	8.6
No information at all	91.5	86.8	87.5	90.0
Complete information	0.0	1.2	2.5	1.4
New varieties				
Incomplete information	78.3	88.1	90.0	86.7
No information at all	21.7	10.7	6.3	11.4
Complete information	.0	1.2	3.8	1.9
Support price				
Incomplete information	100.0	90.5	93.8	93.8
No information at all	0.0	8.3	2.5	4.3
Complete information	0.0	1.2	3.8	1.9
Credit facility				
Incomplete information	89.1	84.5	88.8	87.1
No information at all	10.9	11.9	8.8	10.5
Complete information	0.0	3.6	2.5	2.4
Market price				
Incomplete information	76.1	78.6	80.0	78.6
No information at all	23.9	21.4	18.8	21.0
Complete information	0.0	0.0	1.3	.5
Government purchasing points				
No information at all	100.0	97.6	96.3	97.6
Incomplete information	0.0	1.2	3.8	1.9
Complete information	0.0	1.2	0.0	0.5

Source: Author's Survey data 2009

Overall more than 90 percent farmers received incomplete information regarding agriculture production technology, new varieties, support price, credit facility and market price. More than 90 percent farmers do not receive any type of information regarding pesticide spray, the time of input operation and government purchasing points.

6.11 Marketing and agricultural credit

The majority of farmers (96.2 %) sold their agricultural produce in wholesale market and almost 9.5 percent farmers sold their produce at farm gate. The combined percentage becomes more than 100 percent as almost 6 percent farmers sold half of their produce in the wholesale market and the remaining sold at the farm gate to village level consumers. The 96.2 percent farmers, who bring their produce to wholesale market, sold their agriculture produce through commission agent. There is great trend of price fluctuation during the whole year. Prices are low at the time of harvest and started rising after the farmers have sold their produce. Farmers don't have any storage facility for their produce so they have to sell their produce right after harvesting. Furthermore the majority of farmers are small and they couldn't afford to store their produce. They don't have storage facilities as well as they have to sell their produce immediately to right off their liabilities and purchase the inputs for the coming season crops. At the time of sowing, when farmers have to purchase the seed, prices are at peak. In this way they got substandard seed from commission agents at high prices. Overall 77 percent of farmers sold milk produced at their farm, directly to the consumers while more than 40 percent sold to milk collectors (almost 20 percent farmers sold to both the consumers as well as milk collectors).

Overall 98 percent do not take agricultural credit from any source. For the majority of farmers main reasons for not getting the agricultural credit are high interest rates and the farmers' aversion to be indebted. The risk of complete crop failure due to unpredictable weather prevents farmers from taking agricultural credit. They fear that they might not be able to repay the loan in the case of crop failure, as there is no system of crop insurance in the study area. The other reasons for not recieving credit include are no credit need, the fear of rejection, lack of information about credit sources, difficult procedure, the demand of bribery and past defaults. Only 8 farmers out of 210 sample respondents took credit from institutional sources (commercial banks). As the agriculture in the area is of subsistence and risky nature, farmers who took credit are unable to completely right off their loan on time and hence they came under debt trap. General discussion with the respondents revealed that most of them used this credit on the consumption needs instead of their production investments. In this way they came under more and more debt burden due to increase in the interest rate on the loan.

Table 6.10 Agricultural Commodities Marketing and Credit (% Farms)

Farm Size	Small	Medium	Large	All
Crops sale place				
Wholesale market	95.7	86.9	91.3	90.5
Farm Gate	2.2	7.1	1.3	3.8
Both places	2.2	6.0	7.5	5.7
Market channels for crops				
Commission agents	97.8	94.0	98.8	96.7
Consumers	2.2	8.3	5.0	5.7
Local dealers	2.2	1.2	1.3	1.4
Price fluctuation				
Yes	93.5	96.4	96.3	95.7
No	6.5	3.6	3.8	4.3
Market channels for milk				
Consumers	89.7	64.3	34.8	56.5
Milk collectors	10.3	14.3	37.7	23.2
Both	0.0	21.4	27.5	20.2
Agricultural credit				
No	100.0	98.8	95.0	97.6
Yes	0.0	1.2	5.0	2.4
Reasons for taking no agriculture credit				
High Interest Rate	91.3	95.2	92.1	93.2
Do not like to be in debt	91.3	89.2	88.2	89.3
No need	4.3	12.0	10.5	9.8
Believed would be refused	6.5	3.6	2.6	3.9
No information about credit sources	6.5	3.6	1.3	3.4
Difficult procedure	4.3	3.6	2.6	3.4
Bribery	0.0	2.4	1.3	1.5
Default in past	0.0	1.2	1.3	1.0

Source: Author's Survey data 2009

6.12 Farm Household Labor

At least one person of 82.4 % of farm households is doing full time agriculture while 18 percent farm household heads are only part time involved in agriculture. For almost 90 percent farm household at least one or more persons are involved in some off-farm income activity. The common off-farm income activities are employment in defense forces, private jobs as labor on others farms or off-farm, government jobs in civil departments and some private business (commercial poultry farms, property dealers, commission shops in agricultural markets and shop keeping). About 40 percent members in the farm household did job in other districts.

Table 6.11 Farm Household Labor by Farm Size (% Farms)

Farm Size	**Small**	**Medium**	**Large**	**All**
Family Farm Labor				
Full time	69.6	83.3	88.8	82.4
Part time	30.4	16.7	11.3	17.6
Off-farm work place				
Other district	30.6	50.0	33.9	39.6
Same district	38.9	21.2	43.5	33.5
Same union council	11.1	18.2	14.5	15.2
Abroad	13.9	10.6	6.5	9.8
Other province	5.6	.0	1.6	1.8
Off-farm work type				
Defense Forces	27.8	25.8	29.0	27.4
Private job	33.3	30.3	11.3	23.8
Government civil job	16.7	21.2	21.0	20.1
Private business	8.3	12.1	32.3	18.9

Source: Author's Survey data 2009

Almost half of the members of farm households did off-farm work in the same district and out of which 15 percent worked in the same union council. About 10 percent farm household members worked abroad and sent foreign remittances to their families for investment in agriculture and consumption purposes. The majority of these members worked as semi skilled and unskilled labor in Gulf States (United Arab Emirates, Oman, Bahrain, Kuwait and Saudi Arabia). More than one forth farm household members did job in defense forces while more than one third did private jobs or off-farm labor work inside country or abroad. Almost one fifth of farm household members did jobs in civil government departments and the remaining one fifth has their own small private business.

In this chapter, overall farm and household head characteristics, the education status of farm household members, cropping pattern, cropping intensity, crop diversity index, the livestock composition of sample farm households have been described in detail. Some basic information regarding farm mechanization, the source of water supply, agricultural production and marketing information, agricultural credit and on farm and off-farm labor have also been provided.

The majority of sample respondents have small land holding with the average farm size of 5.16 hectares. Only 9 percent of operational land holding on each farm is irrigated. Wheat and groundnut are the major crops with 52.39 percent and 28.77 percent area in winter and summer season, respectively. The cropping intensity of area is almost 120 percent and the crop diversity index is 3.06. Overall farm households have 9.18 animals. Almost 62 percent of the farmers used rented tractors for their farm operations. The average age of household heads is above fifty years. More than half (52 %) of the household male members are having below 10 grade education or are illiterate while the situation for the females is worst with 79.6 percent. Almost 82 percent sample household heads are full time farmers and 90 percent households have some off-farm income source. According to farmer's view the level of information regarding agricultural production and marketing is low. The majority of farmers sold their crops in the wholesale markets of urban centers in the area while they sold milk in the village to the local consumers and milk collectors.

CHAPTER 7: PRODUCTIVITY AND COST OF PRODUCTION

This Chapter presents results about the cost of production of major crops and factor productivity analysis. The major crops include wheat, groundnut, chickpea, lentil and mustard. Farm household overall income composition; wheat, groundnut, chickpea, lentil, mustard and livestock production cost; total factor productivity; and partial factor productivities (labor and land productivity) are discussed in detail.

7.1 Farm Household Income Composition

Table 7.1 depicts farm household income composition consist of off-farm income, farm revenue, net profit, crops and livestock revenue and production cost. Total labor including males, females, family and hired are also shown in table 7.1. Overall 1600 family labor hours per hectare are involved in farming and livestock keeping activities annually. Large farms have only about one fifth family labours per hectare (671 hrs) as compared to that of small farms (3554 hrs). Female family labor involved in the agriculture is almost one third of male family members. Females have mostly supportive role e.g. cooking, crop harvesting and looking after livestock. Family labor involved in farming is high in small farm households as compared to that of medium and large farm households. This means that more family members, including females, are involved in farming in a small farm household. Per hectare hired labor constitutes, small portion compare to total labor involved in farming. This labor is mostly involved in the harvesting of major crops. The other farming operations are mostly mechanized such as plowing, seed sowing and threshing. The labor involved in livestock keeping in most cases is family labor (particularly female family labor). The main reason for higher family labor involved in farming is keeping higher livestock by small farm households. The majority of small farm households depend on livestock grazing in wild range areas as they have small area left for fodder crops cultivation.

Livestock kept per hectare in study area is almost 2.6 animals. The owners of small farms keep more than three times per hectare animals as compared to that of large farms. Net income from livestock is PKR 29014 per hectare. This income from livestock is considerably higher (PKR. 36367/ha) in small farms than in large farms

(PKR 20767/ha). Net income from crops is almost PKR 19521 per hectare. Per hectare net crop income is highest (PKR. 25752) for small farm size category while it is lowest for medium farm size category (PKR 14268). The overall share of crop income in the total farm income is 40 percent. This share is higher (51 %) in large farms as compared to small and medium farms (41 and 30 %). This shows that large farms are more dependent on income from crop sub-sector while small and medium farms are more dependent on income from livestock sub-sector.

Table 7.1 Cost of Production, and Farm Household Income Composition

Farm Size	Small	Medium	Large	Total	F
Family labor (hrs/ha)	3554.40	1421.98	671.06	1603.02	67.838***
Male labor (hrs/ha)	2593.87	964.34	487.29	1139.55	47.603***
Female labor (hrs/ha)	960.53	457.64	183.76	463.46	48.847***
Hired labor (hrs/ha)	5.21	4.46	4.56	4.66	0.085
Total labor (hrs/ha)	3559.61	1426.44	675.62	1607.68	67.845***
Livestock (No/ha)	4.52	2.70	1.37	2.59	21.449***
Livestock cost (PKR/ha)	75798.30	30065.51	14455.44	34136.47	37.008***
Livestock revenue (PKR/ha)	112165.69	62907.15	35222.81	63150.70	31.051***
Livestock net profit (PKR/ha)	36367.39	32841.64	20767.38	29014.23	3.541**
Crop cost (PKR/ha)	38950.82	33606.57	29603.14	33252.10	23.067***
Crop revenue (PKR/ha)	64703.21	47874.33	51057.93	52773.46	8.183***
Crop net profit (PKR/ha)	25752.38	14267.76	21454.78	19521.35	5.094***
Farm cost (PKR/ha)	114749.1	63672.08	44058.58	67388.58	42.068***
Farm revenue (PKR/ha)	176868.9	110781.5	86280.7	115924.2	30.495***
Farm net profit (PKR/ha)	62119.78	47109.40	42222.16	48535.58	3.082**
Crop income share (%)	41.46	30.29	50.81	40.22	--
Net Farm Income	85103.0	153174.6	369074.0	220511.1	34.390***
Off-farm income (PKR/anm.)	249104.4	221128.6	275220.0	247862.9	1.269
Total Income (PKR/anm.)	334207.4	374303.2	644294.0	468374.0	20.500***
Farm net profit (%)	72.28	73.51	94.50	81.24	2.889*

Source: Author's Survey data 2009 1 PKR = 123 Euro, 1 PKR = 85 US Dollar

Profit obtained by subtracting the costs of all the production factors from the gross output value of grown crops per hectare is designated as "net profit" or "net income." The net profit variability of different farm size categories is illustrated in the table 7.1 showing that net profit per hectare is highest for small farms while the large farms of study area have minimum profit. Overall farm cost, revenue and net profit per hectare decrease with the increase in farm size. The farm cost (PKR 113385/ha), revenue (PKR 175094/ha) and net profit (PKR 61709/ha) is highest for the small farm size category and lowest (PKR 42015/ha, PKR 81328/ha, PKR 39312/ha) for the large farm size category. The comparison of small, medium and large farms of each farming system highlights the fact that small farmers are the most efficient with highest profit margins.

Annual off-farm income is highest (PKR 275220.00/annum) among large farms and lowest among medium farms (PKR 221128.57/annum). Overall farm household income increases from almost 0.33 million Pakistani Rupees per annum in small farm size category to almost 0.64 million in large farm size category.

7.2 Cost of Production of Major Crop-livestock Enterprises

7.2.1 Wheat Cost of Production

Wheat constitutes the most important crop that contributed 13.1 percent towards value added in agriculture and accounted for 38.0 percent of total cropped area in the country during 2008-09 (Government of Pakistan 2009a). This crop occupies more cropped area (40.3%) in the Punjab province. The performance of wheat crop affects the overall growth rate, import bill, and the nutritional standard of our people, especially the urban poor. It has a pivotal role for attaining national food-security goals.

Wheat is cultivated on more than half (52.4%) of the cultivated land in the study area. The importance of food self sufficiency compels small land holders to grow wheat on more area (65.1%) as compare to medium (51.3%) and large farms (46.2%). The overall wheat yield of study area is 1704 kgs per ha which is below national average. The wheat yield of small farms is the highest (2011 kg/ha) followed by large farms (1684 kg/ha) while medium farms (1556 kg/ha) have the lowest wheat yield. The seed used for sowing wheat decreases with the increase in the farm size category. Small land holders use highest per hectare seed (113 kg) as compare to medium (106 kg) and large farms (102 kg). Overall 1087 kg wheat is consumed at home as wheat is the staple food in the study area. The result for the household wheat consumption shows that farmers have to at least sow two third hectare of land to wheat to ensure their household member's food security. Land preparation cost at small farms is significantly higher (PKR 10069 per hectare) than that at medium

(PKR 8592 per hectare) and large (PKR 7114 per hectare) farms. The wheat cultivation needs extensive land preparation to conserve moisture in soil for good seed germination. The main reason for high land preparation cost for small farms is that the majority of small land holders use rented tractors while that of medium and large farms have their own tractor. Moreover the economies of scale also play important role in reducing the cost for land preparation. Plowing in the small fields with heavy machinery requires higher costs as compared to larger fields. The input cost also decreases with the increase in the farm size category. The input cost at small farms is significantly higher (PKR 11332 per hectare) than that at medium (PKR 8676 per hectare) and large (PKR 7598 per hectare) farms.

Table 7.2 Wheat Cost of Production by Farm Size

Farm category	Small	Medium	Large	All	F
Area (Ha)	.71	1.67	4.20	2.44	48.843***
Area (%)	65.08	51.30	46.24	52.39	15.776***
Yield (Kg/ha)	2011.11	1555.87	1684.87	1703.97	3.807**
Seed rate (kg/ha)	112.97	105.71	101.97	105.84	2.438*
Home consumption (kg)	898.00	1055.38	1231.43	1087.45	13.842***
Value of byproduct (PKR)	19068.95	14459.85	15163.62	15727.69	4.249**
Land preparation cost (PKR/ha)	10068.78	8592.24	7114.18	8343.20	9.549***
Input cost (PKR/ha)	11332.17	8675.5 50	7598.02	8835.87	9.829***
Labor cost (PKR/ha)	7193.51	7125.92	6718.48	6983.83	2.439*
Threshing cost (PKR/ha)	2377.74	1809.50	1622.59	1860.55	21.151***
Interest Cost	1715.67	1463.62	1285.84	1449.77	18.219***
Variable cost (PKR/ha)	32687.88	27666.85	24339.10	27473.23	21.676***
Total cost (PKR/ha)	42925.65	37904.61	34576.87	37710.99	21.676***
Total revenue (PKR/ha)	68868.04	52572.32	56320.35	57539.39	4.309**
Gross margins (PKR/ha)	36180.16	24905.48	31981.25	30066.16	2.578*
Net Profit (PKR/ha)	25942.39	14667.71	21743.48	19828.40	2.578*
Gross Margins %	112.34	94.85	132.41	113.08	2.608*

Source: Author's Survey data 2009 1 PKR = 123 Euro, 1 PKR = 85 US Dollar

The labor cost also decreases with increase in the farm size categories but difference is small as compared to other cost categories. The labor cost at small farms is higher (PKR 7194 per hectare) than that at medium (PKR 7126 per hectare) and large (PKR 6718 per ha) farms. Same situation exists with the threshing cost.

The overall variable costs of production decrease with increase in the farm size categories. The variable costs of small farms are significantly higher (PKR 32688 per hectare) as compared to that of medium (PKR 27667 per hectare) and large (PKR 24339 per hectare) farms. Total revenue and gross margins per hectare for small farms are highest (PKR 68868 and 36180 per hectare) followed by large farms (PKR 56320 and 31981 per hectare) while for medium farms are lowest (PKR 52572 and 24905 per hectare). Same trend is seen for the net profit along the farm size categories, as is observed for total revenue and gross margins. Overall the gross margins for this crop are 113 percent. This means that 100 PKR investment in the wheat production gives gross margins amounting 113 PKR. Percent gross margins in large farms are highest (132%), followed by small farms (112.3 %) while for the medium farms they are lowest (95%).

7.2.2 Groundnut Cost of Production

Groundnut crop is grown on more than one forth (29 %) of cultivated area during summer season. This is the main cash crop of summer season. The other major crops during summer season are fodder crops like sorghum and millet. The overall groundnut yield of study area is 609 kilograms per hectare. This yield of study area is lower than the national average. The main reason for lower yield of groundnut is the low rainfall during summer season in 2009 as compared to the same duration of previous years. The groundnut yield of small farms is highest (676 kg/ha) followed by large farms (603 kg/ha) while medium farms (589 kg/ha) have lowest yield. The seed used for sowing groundnut decreases with the increase in the farm size category. Small farms use highest per hectare seed (44 kg/ha) than medium (39 kg/ha) and large farms (35 kg/ha). Overall farm households incur less land preparation and input costs on this crop. The main reasons for this are less number of plowings and very small fertilizer use as compared to wheat, lentil and mustard crops. Overall land preparation cost is PKR 5448 per hectare. Land preparation cost decreases with increase in the farm size. The land preparation cost of small farms is significantly higher (PKR 6702 per hectare) as compared to that of medium (PKR 5961 per hectare) and large (PKR 4432 per hectare) farms. The main reason for high land preparation cost for small farms is that the majority of small land holders use rented tractors while medium and large land holders have their own tractor. Moreover the economies of scale also play important role in reducing the cost for land preparation. Plowing in the small fields with heavy machinery requires higher costs as compared to larger fields.

Table 7.3 Groundnut Cost of Production by Farm Size

Farm category	Small	Medium	Large	All	F
Area (Ha)	.46	1.10	3.99	2.19	20.420***
Area (%)	20.70	27.99	34.22	28.77	2.048
Yield (Kg/ha)	676.15	589.40	603.16	609.02	1.059
Seed rate (kg/ha)	44.29	39.06	35.14	38.28	2.219
Land preparation cost (PKR/ha)	6702.43	5961.48	4432.27	5447.95	5.269***
Input cost (PKR/ha)	4449.56	4076.09	3747.19	4000.00	1.146
Labor cost (PKR/ha)	4305.52	3868.53	3110.79	3625.27	3.525**
Threshing cost (PKR/ha)	2067.59	1750.54	1287.83	1610.06	7.697***
Interest cost (PKR/ha)	927.45	834.37	677.42	784.39	4.411**
Variable cost (PKR/ha)	18452.56	16491.01	13255.49	15467.68	5.082***
Total cost (PKR/ha)	28690.33	26728.78	23493.26	25705.45	5.082***
Total revenue (PKR/ha)	54998.87	48769.19	48904.44	49824.95	1.025
Gross margins (PKR/ha)	36546.31	32278.18	35648.94	34357.27	0.633
Net profit (PKR/ha)	26308.54	22040.41	25411.17	24119.50	0.633
Gross margins (%)	165.17	186.72	285.93	225.03	5.219***

Source: Author's Survey data 2009 1 PKR = 123 Euro, 1 PKR = 85 US Dollar

A few farmers use chemical fertilizers because this crop is leguminous and it fixes the atmospheric nitrogen. They use more phosphate fertilizers for winter crops which are not fully utilized for these crops due to limited moisture availability. The phosphate fertilizers remain in the soil for longer period than nitrate fertilizers. So these fertilizers remain available in the soil to coming crops. The part of these fertilizers is utilized by this crop as it immediately follows winter crops. Overall input cost is PKR 4000 per hectare. The input cost also decreases with the increase in farm size category. The iput cost of small farms is significantly higher (PKR 4450 per hectare) as compared to that of medium (PKR 4076 per hectare) and large (PKR 3747 per hectare) farms. Overall labor cost is PKR 3625 per hectare. The labor cost also decreases with increase along the farm size categories. The labor cost of small farms is significantly higher (PKR 4306 per hectare) as compared to that of medium (PKR 3869 per hectare) and large (PKR 3111 per hectare) farms. The threshing cost also decreased with increasing the economies of scale.

The variable cost for this crop remains PKR 15468. The variable costs of production decrease with the increase in farm size categories. These costs for small farms are significantly higher (PKR 18453 per hectare) than medium (PKR 16491 per hectare) and large (PKR 13255 per hectare) farms. Total revenue per hectare for small farms is highest (PKR 54999 per hectare) while for medium and large farms is almost same (PKR 48769 and 48904 per hectare). Gross margins and net profit for small (PKR 36546 and 26309 per hectare) and large (PKR 35649 and 25411 per hectare) farms are higher as compared to medium farms (PKR 32278 and 22040 per hectare). Overall the gross margins as the percentage of production costs are 225 percent. Percent gross margins for large farms (286 %) are very high as compared to medium (186 %) and small (165 %) farms. The main reason for higher gross margins percentage is the lower costs of production for large farms.

7.2.3 Chickpea Cost of Production

Chickpea is grown on relatively smaller area during winter cropping season. It is grown on almost 5 percent of cultivated area. The grown crop area increases from almost 4 percent to 7 percent with the increase in the farm size category. The overall chickpea yield of study area is 1110 kilograms per hectare. The chickpea yield of small farms is highest (1465 kg/ha) followed by large farms (1133 kg/ha) while that of medium (958 kg/ha) farmers is the lowest.

The seed used for sowing chickpea is highest (65 kg/ha) for medium farms followed by small farms (62 kg/ha) while large farms use lowest (58 kg/ha) seed. Overall land preparation cost is PKR 10562 per hectare. The land preparation cost of medium and large farms is significantly higher (PKR 11710 and 10158 per hectare) as compared to that of small farms (PKR 8590 per hectare). The main reason for less land preparation cost for small farms is the less plowing than that of medium and large farms. Most of the small farmers usually grow chickpea just for home consumption. So they prefer to incur less cost on land preparation (a few numbers of plowings).

Overall this crop requires less input costs. A few farmers use chemical fertilizers because this is a leguminous crop and it fixes the atmospheric nitrogen. Mostly this crop is grown on marginal areas receiving small rainfall and hence farmers don't prefer to apply chemical fertilizers to this crop. Overall input cost is lowest (PKR 2516/ha) as compared to the other major crops of study area. The input cost also sharply decreases with the increase in the farm size category. The input cost of small farms is significantly higher (PKR 4532 per hectare) as compared to that of medium (PKR 2399 per hectare) and large (PKR 1984 per hectare) farms. Overall labor cost is PKR 3549 per hectare. The labor cost also decreases with increase in the farm size categories. The labor cost of small farms is significantly higher (PKR 4209 per hectare) as compared to that of medium (PKR 3605 per hectare) and large (PKR 3292 per hectare) farms. The threshing cost also decreased with the increasing economies of scale.

Table 7.4 Chickpea Cost of Production by Farm Size

Farm category	Small	Medium	Large	All	F
Area (Ha)	0.21	0.40	1.33	0.79	8.405***
Area (%)	3.75	4.54	7.00	5.30	.906
Yield (Kg/ha)	1464.54	958.01	1133.04	1109.55	1.093
Seed rate (kg/ha)	61.78	65.40	57.70	61.40	.323
Land preparation cost (PKR/ha)	8590.21	11710.29	10158.00	10562.34	.341
Input cost (PKR/ha)	4532.27	2398.52	1984.19	2515.91	3.244**
Labor cost (PKR/ha)	4209.11	3604.90	3291.52	3549.45	0.881
Threshing cost (PKR/ha)	2214.38	1756.82	1440.38	1679.03	2.140
Interest Cost (PKR/ha)	1039.90	1062.82	926.02	997.66	0.262
Variable cost (PKR/ha)	20585.86	20533.35	17800.12	19304.39	0.331
Total cost (PKR/ha)	30823.63	30771.12	28037.89	29542.16	0.331
Total revenue (PKR/ha)	44949.31	29745.99	34749.27	34181.28	1.017
Gross margins (PKR/ha)	24363.45	9212.64	16949.15	14876.89	1.125
Net profit (PKR/ha)	14125.68	-1025.13	6711.38	4639.12	1.125
Gross margins (%)	34.06	31.16	121.22	71.88	2.356

Source: Author's Survey data 2009 1 PKR = 123 Euro, 1 PKR = 85 US Dollar

The variable cost for this crop remains PKR 19304. The overall variable costs of production decrease with increase in the farm size categories. The variable costs of small and medium farms are significantly higher (PKR 20586 and 20533 per hectare) as compared to that of large farms (PKR 17800 per hectare). Overall total revenue is PKR 34181 per hectare. Total revenue per hectare for small farms is highest (PKR 44949 per hectare) followed by large farms (PKR 34749 per hectare) while for medium farms it is lowest (PKR 29746 per hectare). Gross margin and net profit is highest for small (PKR 24363 and 14126 per hectare) followed by large farms (PKR 16949 and 6711 per hectare) while medium farms have lowest gross margins and net profit (PKR 9213 and -1025 per hectare). Overall the gross margins are 72 percent on the cost of production of chickpea crop. The percent gross margins are highest (121 %) for large farms than small (34 %) and medium (31 %) farms.

7.2.4 Lentil Cost of Production

Lentil is grown on the relatively smaller area (4 percent of cultivated area) during the winter cropping season. The crop area grown decreases from almost 4.6 percent to almost 3 percent with the increase in the farm size category. The overall lentil yield of study area is 788 kilograms per hectare. The lentil yield of small farms is higher (979 kg/ha) followed by medium (783 kg/ha) while large farms (697 kg/ha) have the lowest lentil yield.

Seed rate applied for lentil sowing is almost 17 kg/ha in the study area. The seed used for sowing lentil is highest (24 kg/ha) for large farms followed by small farms (16 kg/ha) while for medium farms is lowest (12 kg/ha). Overall land preparation cost is PKR 12351 per hectare. This crop is grown on well prepared land with the higher number of plowings. Land preparation cost decreases with the increase in the farm size. This cost is significantly higher for the small farms (PKR 17046 per hectare) than that of medium (PKR 11664 per hectare) and large farms (PKR 10724 per hectare). Main reason for the high land preparation cost for the small farms is that the majority of small land holders use rented tractors while medium and large holders have their own tractor. Moreover the economies of scale also play important role in reducing the cost for land preparation. Plowing in the small fields with heavy machinery requires higher costs as compared to plowing in larger fields.

Few farmers applied nitrogenous fertilizers because this is a leguminous crop which fixes the atmospheric nitrogen. The majority of farmers use phosphate fertilizers for this crop because this is one of the important cash crops in the winter season. Farmers purchase the inputs costs of following summer season crops by selling the produce of this crop. Overall input cost is PKR 5996 per hectare. The input cost increases along with increase in farm size categories. The input cost on large farms is highest (PKR 6651 per hectare) followed by medium farms (PKR 5923 per hectare) while the small farms incurred the least amount (PKR 4839 per hectare) of money on input application. Overall labor cost is PKR 4046 per hectare. The labor cost also increase with the increase in the farm size categories. The labor cost of small farms is significantly lower (PKR 3870 per hectare) as compared to that of medium (PKR 4055 per hectare) and large (PKR 4124 per hectare) farms. The threshing cost slightly decreases with the increasing economies of scale.

Table 7.5 Lentil Cost of Production by Farm Size

Farm category	Small	Medium	Large	All	F
Area (Ha)	0.31	0.54	1.34	0.81	6.922***
Area (%)	4.59	4.46	3.08	3.97	2.410
Yield (Kg/ha)	978.56	783.22	696.66	787.58	1.730
Seed rate (kg/ha)	16.31	12.00	23.72	17.44	1.963
Land preparation cost (PKR/ha)	17045.80	11664.33	10723.60	12350.61	2.473*
Input cost (PKR/ha)	4838.90	5923.11	6651.16	5996.03	1.164
Labor cost (PKR/ha)	3870.20	4055.24	4124.45	4046.10	0.351
Threshing cost (PKR/ha)	2721.80	2036.24	1859.30	2101.27	3.644**
Interest Cost (PKR/ha)	1545.29	1298.56	1289.95	1343.56	0.838
Variable cost (PKR/ha)	30021.99	24977.48	24648.46	25837.58	1.121
Total cost (PKR/ha)	40259.76	35215.25	34886.23	36075.35	1.121
Total revenue (PKR/ha)	84561.04	65171.54	59489.73	66745.24	2.039
Gross margins (PKR/ha)	54539.05	40194.05	34841.27	40907.67	1.443
Net profit (PKR/ha)	44301.28	29956.28	24603.50	30669.90	1.443
Gross margins (%)	228.11	176.43	143.21	173.53	1.052

Source: Author's Survey data 2009 1 PKR = 123 Euro, 1 PKR = 85 US Dollar

The variable cost for this crop remains PKR 25838 per hectare. These costs are considerably higher for small farms (PKR 30022 per hectare) as compared to that of medium and large farms (PKR 24977 and 24648 per hectare). Overall total revenue is PKR 66745 per hectare. The revenue decreased with the increase in the farm size. Total revenue per hectare for small farms is highest (PKR 84561 per hectare) followed by medium farms (PKR 65172 per hectare) while for large farms it is lowest (PKR 59490 per hectare). Gross margins and net profit are highest for small (PKR 54539 and 44301 per hectare) followed by medium farms (PKR 40194 and 29956 per hectare) while large farms have lowest gross margins and net profit (PKR 34881 and 24604 per hectare). Overall the percent gross margins are 174 percent on the chickpea cost of production. The percent gross margins are highest (228 %) for small farms than medium (176 %) and large (143 %) farms.

7.2.5 Mustard Cost of Production

Mustard is grown on relatively smaller area during the winter cropping season. It is grown on almost 4 percent of cultivated area. The crop area grown increases from almost 2.7 percent to almost 4.7 percent with the increase in the farm size category. The overall mustard yield of study area is 813 kilograms per hectare. The mustard yield of medium farms is highest (879 kg/ha) followed by large farms (825 kg/ha) while small farms have least mustard yield (562 kg/ha). The reason of low yield for the small farms is that the major portion of this crop on small farms is fed as green fodder to livestock.

Seed rate applied for mustard sowing is almost 6 kg/ha in the study area. The seed used for sowing mustard is highest (7.7 kg/ha) for medium farms followed by small farms (5.2 kg/ha) while large farms used lowest seed (4.7 kg/ha). Overall land preparation cost is PKR 12911 per hectare. This crop is grown on well prepared land with the higher number of plowings. The land preparation cost is significantly higher for medium farms (PKR 16462 per hectare) than that of small (PKR 13701 per hectare) and large farms (PKR 10029 per hectare). The main reason for high land preparation cost for small farms is that the majority of small land holders use rented tractors while medium and large land holders have their own tractor. The reason of the high land preparation cost of medium farms is high number of plowing for seed bed preparation as compared to small and large farms. The economies of scale, self tractor use and the less number of plowing favor large land holders to reduce their land preparation cost.

Overall input cost is PKR 3080 per hectare in the study area. The input cost decreases along with increase in farm size categories. The input cost of small farms is highest (PKR 3648 per hectare) followed by medium farms (PKR 3268 per hectare) while the large farms incurred the least cost (PKR 2801 per hectare) on input application. Overall labor cost is PKR 3298 per hectare. The labor cost also decreases with the increase in the farm size categories. The labor cost of small and medium farms is significantly higher (PKR 3560 and 3508 per hectare) as compared to that of large (PKR 3075 per hectare). The threshing cost decrease with the increasing economies of scale.

Table 7.6 Mustard Cost of Production by Farm Size

Farm category	Small	Medium	Large	All	F
Area (Ha)	0.25	0.44	1.20	0.80	4.208**
Area (%)	2.73	3.85	4.68	3.92	1.094
Yield (Kg/ha)	561.76	878.92	824.69	813.36	0.390
Seed rate (kg/ha)	5.22	7.71	4.74	5.92	1.452
Land prep. cost (PKR/ha)	13700.89	16461.67	10029.40	12910.90	2.507*
Input cost (PKR/ha)	3648.21	3267.85	2800.84	3080.45	0.257
Labor cost (PKR/ha)	3560.44	3507.86	3075.38	3297.99	0.531
Threshing cost (PKR/ha)	1843.03	1771.72	1229.24	1509.13	2.644*
Interest Cost (PKR/ha)	1254.57	1394.24	954.34	1157.36	2.237
Variable cost (PKR/ha)	24007.14	26403.36	18089.20	21955.83	2.369
Total cost (PKR/ha)	34244.91	35822.10	28326.97	31883.36	1.802
Total revenue (PKR/ha)	24682.17	38091.84	28390.59	31615.80	1.126
Gross margins (PKR/ha)	675.03	11688.49	10301.40	9659.98	0.534
Net profit (PKR/ha)	-9562.74	2269.74	63.63	-267.56	0.603
Gross margins (%)	2.81	68.27	56.45	53.13	1.019

Source: Author's Survey data 2009 1 PKR = 123 Euro, 1 PKR = 85 US Dollar

The variable cost for this crop remains PKR 21956 per hectare. The overall variable costs of medium farms are highest (PKR 26403 per hectare) followed by small farms (PKR 24007) while large farms incur least variable costs (PKR 18089 per hectare). Overall total revenue is PKR 31616 per hectare. Total revenue per hectare of medium farms is the highest (PKR 38092 per hectare) followed by large farms (PKR 28391 per hectare) while that of small farms is lowest (PKR 24682 per hectare). Gross margin and net profit is highest for medium farms (PKR 11688 and 2270 per hectare) followed by large farms (PKR 10301 and 64 per hectare) while small farms have lowest gross margins (PKR 675 per hectare). If the fixed costs are deducted from their gross margins then their net profit is in negative (-9563) which means they are operating in loss. Overall the percent gross margins are 53 percent on the chickpea cost of production. The percent gross margins are highest (68 %) for medium farms followed by large farms (56 %) while small farms (3 %) have least percent gross margins.

7.2.6 Major Crops' Comparative Cost of Production

Wheat, chickpea, lentil and mustard are major crops in winter season while groundnut is the major cash crop of summer season in the study area. Wheat is the major crop grown in the area with more than half of cultivated area in winter season. The groundnut is cultivated on more than quarter of cultivated area even though almost half of the area remained fallow during the summer season. Major area in summer season is left fallow for continuous tillage and moisture conservation for the better land preparation and higher production of coming winter season crops. The variable cost of wheat is the highest (PKR 27473/ha) followed by lentil (PKR 25838/ha) and mustard (PKR 21956/ha). The variable cost of chickpea (PKR 19304/ha) is on lower side while that for groundnut is lowest (PKR 15468/ha). The farmers perform more number of plowing for land preparation for the sowing of winter crops to conserve the soil moisture for good seed germination. The excessive land tillage and use of more chemical fertilizers are the major reason for the higher cost of production of these crops. Comparatively the less cost of production for chickpea is due to almost no chemical fertilizer application. The reasons for small variable costs in groundnut production are the small use of fertilizers and less tillage for land preparation. This crop doesn't need excessive tillage for moisture conservation as this is summer crop and it receives enough rainfall during monsoon season.

The gross margins of lentil crop are highest (PKR 40907/ha) as compared to all other major crops of area followed by groundnut (PKR 34357/ha). The main reason for the high gross margins for the lentil crop is the high price of this crop as compared to the other crops of area. The higher margins of groundnut crop owe to the lesser cost of production of this crop as compared to other crops. Wheat has relatively higher gross margins (PKR 30066/ha) as compared to chickpea and mustard due to its higher per hectare yield. Mustard has the least gross margins (PKR 9660/ha) due to the fact that some part this crop is used as green fodder for animals without the consideration of its economic value. Groundnut crop has highest percentage gross margins (225 %) as compared to all the other crops of area as this crop has the lowest cost of production (PKR 15468/ha).

Table 7.7 Comparative Cost of Production of Major Crops

Crops	Wheat	Groundnut	Chickpea	Lentil	Mustard
Area (Ha)	2.44	2.19	0.79	0.81	0.80
Area (%)	52.39	28.77	5.30	3.97	3.92
Yield (Kg/ha)	1703.97	609.02	1109.55	787.58	813.36
Seed rate (kg/ha)	105.84	38.28	61.40	17.44	5.92
Land preparation cost (PKR/ha)	8343.20	5447.95	10562.34	12350.61	12910.90
Input cost (PKR/ha)	8835.87	4000.00	2515.91	5996.03	3080.45
Labor cost (PKR/ha)	6983.83	3625.27	3549.45	4046.10	3297.99
Threshing cost (PKR/ha)	1860.55	1610.06	1679.03	2101.27	1509.13
Interest Cost (PKR/ha)	1449.77	784.39	997.66	1343.56	1157.36
Variable cost (PKR/ha)	27473.23	15467.68	19304.39	25837.58	21955.83
Total cost (PKR/ha)	37710.99	25705.45	29542.16	36075.35	31883.36
Total revenue (PKR/ha)	57539.39	49824.95	34181.28	66745.24	31615.80
Gross margins (PKR/ha)	30066.16	34357.27	14876.89	40907.67	9659.98
Net profit (PKR/ha)	19828.40	24119.50	4639.12	30669.90	-267.56
Gross margins (%)	113.08	225.03	71.88	173.53	53.13

Source: Author's Survey data 2009 1 PKR = 123 Euro, 1 PKR = 85 US Dollar

7.2.7 Livestock Cost of Production

Livestock play important role in stabilizing the farm income in the study area. They provide daily income through the milk sale for daily household consumption. Moreover they act as cash deposit for the sudden financial needs of farm households. Farmers usually rear the female off springs of cows and buffalos. When these become adult and are at milking stage then sell at good competitive market price. In this way livestock play important role in fulfilling some of huge expenses of farm households like the house construction or marriage of son/daughter of household head.

Farmers usually use green fodder (Mustard, Berseem, Sorghum and Millet) and dry fodder (wheat straw) from the product of crops grown on their farms. Moreover they supplement the milking livestock feed with the use of different concentrates like the most common are cotton seed cakes. Farm households keep overall 10.1 animals on their farms in the study area. The number of livestock kept increase with the increase in the farm size. Large land holders keep the highest number of livestock (14.1), followed by medium farms (8.8) while small holders have the lowest no of animals (5.4) on their farms. Overall cost incurred on livestock fodder feeding is PKR 80406/annum, concentrate feeding is PKR 26161/annum, while cost incurred on livestock health maintenance is PKR 2167/annum. Costs on these categories increase as the farm size and number of livestock increased. Overall variable costs incurred on livestock are PKR 108735. These costs for large farms are highest (PKR 138888) followed by medium farms (PKR 94701) while for small farms are lowest (PKR 82677). Overall revenue and gross margins per farm obtained from livestock are PKR 245089 and 136354. Revenue and gross margins for large farms

Table 7.8 Livestock Cost of Production (Pak Rupees)

Farm category	Small	Medium	Large	All	F
No of animals	5.45	8.77	14.11	10.09	7.784***
Fodder cost (PKR)	62559.31	73549.33	97877.51	80406.29	10.986***
Concentrate cost (PKR)	18528.63	19175.90	38313.70	26161.18	16.742***
Health cost (PKR)	1589.47	1976.22	2697.18	2167.28	14.591***
Total Variable costs (PKR)	82677.42	94701.45	138888.40	108734.75	19.520***
Income from milk sale (PKR)	114658.03	151835.55	260553.45	184852.43	20.582***
Income from livestock sale (PKR)	32134.21	48276.83	89088.73	60236.13	10.847***
Total Revenue (PKR)	146792.24	200112.38	349642.18	245088.56	22.574***
Gross margins (PKR)	64114.82	105410.93	210753.79	136353.81	16.400***
Gross margins (%)	78.51	117.83	164.45	127.34	6.404***
Revenue per Hectare (PKR/ha)	136020.94	64429.10	39684.62	69474.29	50.087***
Variable cost per Hectare (PKR/ha)	92042.79	30795.24	16093.67	37515.64	53.966***
Gross Margins per Hectare (PKR/ha)	43978.15	33633.85	23590.95	31958.66	4.056**
Revenue per milking animal (PKR)	93583.64	101151.42	113306.34	104164.11	2.002
Cost per milking animal (PKR)	63426.09	53545.98	49630.80	53914.60	3.481**
Gross margins per milking animal (PKR)	38179.01	52792.69	63675.54	54212.27	3.871**

Source: Author's Survey data 2009 1 PKR = 123 Euro, 1 PKR = 85 US Dollar

(PKR 349642 and 210754) are highest followed by medium farms (PKR 200112 and 105411) while those for small farms are lowest (PKR 146792 and 64115).

When the cost of production, the revenue and gross margins of livestock are calculated on per hectare basis of farm, these variables decrease with the increase in the farm size. Variable costs for the livestock production of small farms are highest (PKR 92043/ha), followed by medium farms (PKR 30795/ha) while for large farms are lowest (PKR 16094/ha). Per hectare gross margins of livestock production for small farms are also the highest (PKR 43978/ha), followed by medium farms (PKR 33634/ha) while that of large farms are the lowest (PKR 23591/ha). Cost of production per milking animal decreases with increase in the farm size. Cost of production per milking animal for small farms is the highest (PKR 63426) followed by medium farms (PKR 53546) while that of large farms is lowest (PKR 49631). Total revenue and Gross margins per milking animals increase with the increase in the farm size. Large farms get highest revenue and gross margins per animal (PKR 113306 and 63676), followed by medium farms (PKR 101151 and 52793) while small farms obtain the least revenue and gross margins per milking animal (PKR 93584 and 38179).

7.3 Productivity Analysis

This section of the chapter critically analyzes and describes the total factor productivity and partial productivities scenarios in the study area. Productivity examination on the basis of farm size categories follows the assessment of crop productivity in the three sub districts of study area. The land and labor are very important variables for the partial productivity analysis of farming community. This section compares total factor productivity, land and labor productivities based on different study locations as well as different farm size categories.

7.3.1 Total Factor Productivity (TFP)

Total factor productivity is the ratio of outputs to the aggregate of inputs. These ratios are calculated dividing the monetary values of outputs and inputs. Table 7.9 depicts the facts about total factor productivity in the study area. The overall total factor productivity in the study area is 2.47. This means for the every one PKR invested in purchasing all inputs generates the revenue of almost two and half PKR. The overall total factor productivity is highest in large farm size category (2.81), followed by small farms (2.36) while medium farms have the lowest (2.19). Almost same trend is seen for Talagang and Gujar Khan sub-districts. In Chakwal sub-district the TFP increases with increase in farm size category. Large farms have highest TFP (2.99) followed by medium (2.59) farms while small farms have least (1.96) TFP. Total factor productivity in Chakwal sub-district and Talagang is higher (2.61 and 2.58) as compared to Gujar Khan sub-district (2.20). The results of comparative areas show that TFP is considerably higher in Chakwal and Talagang sub-districts as compared to Gujar Khan sub-district.

Table 7.9 Total Factor Productivity by Farm Size and Study Sites

Farm Size	Small	Medium	Large	Total	F
Chakwal	1.96	2.59	2.99	2.61	5.581***
Talagang	2.69	2.07	2.93	2.58	2.991*
Gujar Khan	2.42	1.91	2.45	2.20	1.618
All	2.36	2.19	2.81	2.47	5.894***

Source: Author's Survey data 2009

7.3.2 Partial Productivity

Partial productivity can be defined as the ratio of output to the ratio of some specific input, the productivity of which is to be determined. Following section presents the partial productivities of land and labor costs which are presented to elaborate farm size and inter study locations differences.

i) Labor Productivity

Labor is one of the most important factors of crop production. The current part of this section provides a view of labor productivity by comparing different sub-districts including different farm size categories. Table 7.10 depicts that labor productivity in Chakwal sub-district is higher (11.77) than Talagang (10.07) and Gujar Khan 8.46) sub-districts. Table 7.10 displays the rhythmic increasing relationship of labor productivity amongst small, medium and large farms in the Chakwal sub-district of study area. The labor productivity for Talagang, Gujar Khan and overall study area show the trend that small farms have highest (11.69, 10.69 and 10.90) labor productivity followed by large farms (10.29, 8.77 and 10.84) while medium farms have lowest (8.77, 7.08, and 8.95) labor productivity. Overall small and large farms have almost same labor productivity (10.90 and 10.84) while medium farms have considerable low (8.95) labor productivity. The medium farms are least labor productive as compared to small and large farms in the whole study area. The farmers of Chakwal districts have highest (11.77) labor productivity followed by Talagang (10.07) while Gujar Khan farmers have lowest (8.46) labor productivity. It is concluded that the farmers of Chakwal are more labor productive in comparison with Talagang and Gujar Khan sub-districts.

Table 7.10 Labor Productivity by Farm Size and Study Sites

Farm Size	Small	Medium	Large	Total	F
Chakwal	10.30	11.10	13.32	11.77	2.740*
Talagang	11.69	8.77	10.29	10.07	1.944
Gujar khan	10.69	7.08	8.77	8.46	4.801**
All	10.90	8.95	10.84	10.09	4.516**

Source: Author's Survey data 2009

ii) Land Productivity

Table 7.11 shows that the farmers of Chakwal sub-district have comparatively higher land productivity than Talagang and Gujar Khan sub-districts. It also displays that land productivity on small farms (6.46) is higher than that on medium (4.68) and large (4.99) farms. In Chakwal sub-district the large farms (6.14) have highest land productivity while small (5.59) and medium (5.49) farmers have almost same land productivity. The land productivity in Talagang decreases with the increase in the farm size. It is far high in small farms (7.83) as compared to that in medium (4.34) and large (3.96) farms. Talagang sub-district has overall more percentage of large farms as compared to other sub-districts. The rainfall is lower in this area as compared to other study locations while irrigated area is comparatively higher in this study location. The farmers having small land holding may irrigate the higher proportion of their operation land holding from the limited irrigation opportunities of small dams. This may be the reason for highest land productivity for small farms as compared to medium and large farms in Talagang sub-district. In Gujar Khan sub-district small farms (5.93) have highest land productivity followed by large farms (4.99) while medium farms (4.68) have least land productivity.

It is concluded that Chakwal (5.76) sub-district has higher land productivity than Talagang (4.92) and Gujar Khan (4.87) sub-districts. The small farms are highest land productive while medium farms are least land productive in the whole study area.

Table 7.11 Land Productivity by Farm Size and Study Sites

Farm Size	Small	Medium	Large	Total	F
Chakwal	5.59	5.49	6.14	5.76	0.827
Talagang	7.83	4.34	3.96	4.92	13.362***
Gujar khan	5.93	4.17	5.07	4.87	5.255***
All	6.46	4.68	4.99	5.18	9.895***

Source: Author's Survey data 2009

In this chapter the results about economic and productivity analysis with the different study locations and farm size categories are presented. According to the results of economic analysis at farm level the farm percent net profit is highest for large farms as compared to small and medium farms. Among the major crops grown in the study area groundnut is the most profitable with highest percent gross margins due to their low production cost. The farmers of Chakwal sub-district are more productive in terms of total factor, labor and land than those of Talagang and Gujar Khan sub districts. In the overall study area small farms have higher labor and land productivities while large land holders are more productive in terms of total factor productivity.

CHAPTER 8: FARM INCOME AND RISK

This Chapter presents the results of determinants of farm income and major crops production as well as factor analysis for agricultural risk sources and risk management strategies. Risk sources and risk management strategies playing important role in overall farm income are discussed in detail. The results of Ln-Ln production model about farm income and major crops' yields are also elaborated.

8.1 Determinants of Farm Income

Multiple linear regression function (The Linear form of Cobb Douglas Production Function) is used to find out the determinants of farm income. For this purpose the natural logarithm of dependent variable and all independent variables is taken. The usual problem in the cross sectional farm level data is multi-collinearity. Many methods are used to detect multi-collinearity in econometric models. Examples include the computation of correlation matrix of predictor variables and result analysis. A very high correlation coefficient between any two variables may indicate that they are collinear. This method is easy but it cannot produce a clear estimate of the degree of multi-collinearity. The variance inflation factor (VIF) is another approach to testing for multi-collinearity. Generally, when VIF>10, it is assumed that high multi-collinearity exists between the exogenous variables (Adnan et al., 2006).

Overall 18 independent variables are used in production function. They explain 54 percent of variation independent variable (R^2 0.54). Nine of 18 independent variables show a statistically significant relationship with the farm income. The model is overall highly significant with F value 12.205. The mean value of VIF 2.455 shows that the model does not have serious problem of multi-collinearity.

Table 8.1 displays the results of farm income Ln-Ln production model. There is an inverse relationship between the size of land holdings and farm income which is statistically highly significant with strong coefficient (-0.363). This elasticity shows that with 1 percent increase in operational land holding in the study area, on average per acre farm income would reduce by 0.36 percent. Though the irrigated area is small, it has significant effect on farm income (highly significant at 5 %) with the coefficient of 0.14. Farmers' annual off-farm income has significant positive effect on farm income with the coefficient of 0.02. This shows that with increase in the off-farm income opportunities the farm income increases as a certain part of income from off-farm activities is invested in farm production activities.

Table 8.1 Results of Farm Income Ln-Ln Production Model

Dependent Variable: Net farm income (PKR per ha)

R^2 0.54 F 12.205*** Mean VIF 2.455

Variables	Coefficient	Std. error	t	Hypothesis
Constant	7.291	1.625	4.485***	--
Operational holding (ac)	-.363	.126	-2.884***	Support H 1.1
Irrigated area (ac)	.141	.069	2.037**	Support H 1.2
Production diversity	.170	.193	0.882	Reject H 1.3
Cropping intensity (%)	.171	.197	0.865	Reject H 1.4
Off-farm income (PKR/anm)	.020	.011	1.895*	Support H 1.5
Livestock (No/ac)	.222	.076	2.916***	Support H 1.6
Cost on crops (PKR/ac)	.025	.062	0.399	Reject H 1.7
Cost on livestock (PKR/ac)	.122	.024	5.087***	Support H 1.8
Family labor cost (Hrs/ac)	.079	.098	0.801	Reject H 1.9
Hired labor cost (Hrs/ac)	.051	.021	2.480**	Support H 1.9
Ownership of tractor (D)	.235	.103	2.275**	Support H 1.9
Contact with ext. dept. (D)	-.085	.190	-0.449	Reject H 1.9
Age (yrs)	.047	.167	0.281	Reject H 1.9
Education (yrs)	.083	.062	1.339	Reject H 1.9
Small farms (D)	-.199	.233	-0.855	--
Medium farms (D)	-.185	.133	-1.387	--
Chakwal sub-district (D)	.322	.116	2.768***	--
Talagang sub-district (D)	.004	.116	0.038	--

*Significant at 10 % level, ** Significant at 5 % level, ***Significant at 1 % level (No hypothesis is formulated for last four variables) Source: Based on Author's Survey data 2009

The livestock number on farm and cost incurred on livestock has strong positive relationship with per acre farm income. Both are significant at 1 percent level of significance with the coefficient of 0.22 and 0.12 respectively. Opportunity cost on family labor has no significant affect while cost incurred on hired labor has positive relation with farm income with the elasticity of 0.05 percent.

Variable about the ownership of tractor is included in the model as dummy variable. It contributes positively towards farm income (significant at 05 percent significance level) with strong coefficient (0.24). The main problem of area is the limitation of moisture availability for crop germination and growth as rainfall is not evenly distributed in the whole year. The major portion of annual rainfall is concentrated in the monsoon season i.e. the months of July and August. Farmers have to conserve the soil moisture of heavy rainfall of summer monsoon season to obtain the good germination of winter crops as these crops are more important for their farm income (Almost 70 % of the operational land holding of farm households is occupied by winter crops). For this purpose almost half of the area during summer season is kept fallow. One deep plowing with furrow turning plow is applied before the start of monsoon season so that maximum water may absorb in the soil and it may not runoff due to the sloppy nature of area. This follows the frequent tillage by simple cultivator along with planking to conserve the soil moisture absorbed during monsoon season's frequent rainfalls. This all increases the land preparation costs for winter crops. Farmers who own their tractor have clear advantage in better and cheap land preparation as compared to farmers who rent the tractor at market price for extensive land preparation. This scenario makes the tractor ownership beneficial for increased farm income.

The farmers in Chakwal sub district have considerably higher per acre farm income as compared to Gujar Khan and Talagang sub-district farmers. Talagang sub-district is disadvantaged of all the sub-districts having received the smallest amount of annual rainfall. Moreover this sub-district has relatively more percentage of large and less crop diverse farmers. Due to these reasons this sub-district has lower farm income as compared to sub-districts Chakwal and Gujar Khan. Chakwal having more crop diversity, less cropping intensity and relatively more area under irrigation as compared to Gujar Khan, has higher farm income as compared to the other two sub-districts. Moreover the summer season 2009 during the period for which data has been collected is relatively more drought affected. The farm income of Gujar Khan households, is relatively more dependent on rainfall, is more affected as compared to Chakwal.

The production diversity, cropping intensity and cost incurred on the cultivation of crops have no significant affect on per acre farm income. The reason may be the scarcity of water and absence of drought tolerant varieties. More than half area in winter is occupied by wheat and almost one third area in the summer season is occupied by groundnut because farmers don't have improved production technologies for the rest of crops. This reduces the production diversity in the area and hence affects farm income. Moreover different farm size categories don't make significant difference in per acre farm income. The important dummy variable for contact with extension agents included in the model has also no significant affect on farm income.

The relationship of age and education of farm household head with farm income is statistically insignificant. Although farmers become more skilful as they grow older yet learning by doing effect is attenuated as they approach their middle age and as their physical strength starts to decline (Liu and Zhuang, 2000). The average age of sample farm household heads is above fifty years and they are slow in the adoption of modern and tested agricultural technologies. Therefore the age and education of farm household head has no significant affect on farm income.

8.2 Determinants of Wheat Production

Table 8.2 shows the factors affecting wheat yield in the rain-fed *Pothwar* area of Pakistan's Punjab. Overall 21 independent variables are used in the production function to determine their relationship with wheat yield. These variables explain 48 percent variation in the dependent variable (R^2 0.48). Out of 21 independent variables 9 have significant affect on the wheat yield (kg/ha). The model is overall highly significant with F value 8.201. The mean value of VIF 2.439 shows that the model does not have serious problem of multi-collinearity.

The area owned and area under irrigation has significant positive affect on wheat yield (highly significant at 5 percent and 1 percent level) with an elasticity of 0.06 percent and 0.10 percent respectively. Increase in the wheat area sown decreases the wheat yield per acre by 0.31 percent. This may be due to the less per acre inputs application with increase in wheat area sown and also decrease in the share of irrigated wheat area to total wheat area sown. The results of model show that 1 percent increase in the wheat price results in 3.8 percent increase in wheat yield. Variable cost incurred on input's application has significant (at 10 percent level) positive affect on wheat yield with a coefficient of 0.23. Family labor has no significant affect on wheat yield while hired labor affects (significant at 1 % level) wheat yield positively with small coefficient (0.07). Tractor ownership contributes positively towards wheat yield (significant at 5 percent significance level) with the coefficient of 0.17. Large farm size category farmers have higher wheat yield as compared to small and medium farms. The farmers in sub district Chakwal have significantly higher per acre wheat yield as compared to those in Talagang and Gujar Khan Sub-districts.

Table 8.2 Results of Wheat Yield Ln-Ln Production Model

Dependent Variable: Wheat yield (Kg/ac)

R^2 0.48 F 8.201*** Mean VIF 2.439

Variables	Coefficients	Std. Error	t	Hypothesis
Constant	-9.567	4.873	-1.963*	--
Area owned (ac)	.063	.029	2.159**	Support H 2.1
Irrigated area (ac)	.098	.025	3.997***	Support H 2.2
Wheat area (ac)	-.308	.067	-4.617***	Reject H 2.2
Wheat price (PKR/kg)	4.199	1.406	2.987***	Support H 2.2
Crop diversity index	.116	.095	1.215	Reject H 2.3
Cropping intensity (%)	.022	.135	0.166	Reject H 2.3
Off farm income (PKR/anm)	.012	.009	1.453	Reject H 2.3
Frequency of plowing	.051	.060	0.853	Reject H 2.4
Seed rate (Kg/ac)	.038	.065	0.585	Reject H 2.4
Fertilizer (Kg/ac)	.016	.023	0.704	Reject H 2.4
Variable cost (PKR/ac)	.231	.135	1.716*	Support H 2.5
Family labor (Hrs/ac)	.048	.052	0.927	Reject H 2.6
Hired labor (Hrs/ac)	.071	.026	2.748***	Support H 2.6
Ownership of tractor (D)	.166	.067	2.490**	Support H 2.7
Contact with ext. dept (D)	-.181	.119	-1.522	Reject H 2.7
Age (yrs)	.142	.106	1.337	Reject H 2.7
Education (yrs)	.060	.039	1.537	Reject H 2.7
Medium farms (D)	.015	.092	0.165	--
Large farms (D)	.278	.132	2.109**	--
Chakwal sub-district (D)	.223	.088	2.544**	--
Talagang sub-district (D)	-.013	.089	-0.148	--

*Significant at 10 % level, ** Significant at 5 % level, ***Significant at 1 % level (No hypothesis is formulated for last four variables) Source: Based on Author's Survey data 2009

The age and education of farm household head, crop diversity index, cropping intensity, annual off-farm income and contact with extension agents has no significant affect on wheat yield. Most of the household heads are above the fifty years of age and less educated. They are reluctant to adopt the new varieties of major crops of area. Moreover some old farmers have the view that old wheat varieties have better taste and quality for eating. Due to these reasons age and education has no significant affect on wheat per acre yield. As this is the major winter crop occupying more than fifty percent area during winter season so diversification and increase in the cropping intensity has no significant affect on its yield. The reason for the no significant affect of off-farm income on wheat yield per acre may be the small amount of off-farm income investment for the wheat production.

8.3 Determinants of Groundnut Production

Groundnut is the only cash crop in the summer season of study area and is sown on more than one forth of the operational land holding of farm households. It has the lowest cost of production per acre as compared to all the other major crops of study area and highest percentage gross margins due to the fewer requirements of chemical fertilizers and frequency of plowings. The majority of farmers in the study area cultivate groundnut without applying fertilizers. Groundnut crop is a leguminous crop and fixes atmospheric nitrogen in to the soil and hence does not require much of the nitrogenous fertilizers. Phosphorous fertilizers are needed for improving crop yields but mostly farmers only rely on the atmospheric nitrogen instead of fertilizer application. Moreover as this crop follows immediately after winter crops, it utilizes the remaining phosphate fertilizers present in the soil which are applied for the previous winter season crops. Good amount of rainfall during summer monsoon season saves the cost of production for this crop which is required for winter crops in the form of excessive number of plowing/tillage for moisture conservation. This results in the least production cost and hence highest percentage gross margins.

Table 8.3 shows factor affecting groundnut production in the rain-fed area of Pakistan's Punjab. Overall 20 independent variables are used in production function to determine their relationship with groundnut production. These variables explain 71 percent variation in the dependent variable (R^2 0.71). Out of 19 variables 8 have significant effects on the groundnut yield (kg/ac). The model is overall highly significant with F value 18.667. The mean value of VIF 1.779 shows that the model does not have the serious problem of multi-collinearity.

Area under irrigation has significant positive affect on groundnut yield (highly significant at 5 % significance level) with the coefficient of 0.06. Average area sown for groundnut crop per farm household is more than double in the sub-district Talagang as compared to sub districts Chakwal and Gujar Khan. The rainfall is lowest while irrigated area is highest in Talagang as compared to Chakwal and Gujar Khan. These factors make the groundnut responsive to the increase in irrigated area. Increase in the groundnut area sown decreases the groundnut yield per acre. This may be due to the lower per acre inputs application with increase in groundnut area sown and decrease in the share of groundnut irrigated area to the rain-fed groundnut area sown. The price of groundnut has highly significant positive (at 1 % significance level) affect on its yield with an elasticity of 1.47 percent. The groundnut price used is of previous year as yield responds to prices with a time lag. As this crop is the main cash crop of area during summer season, farm households are price sensitive. Crop diversity index has negative affect on groundnut yield with the coefficient 0.21. This is due the fact that that more than half (55.7%) of the cropped area during summer season is under this crop. As the area under other crops increases, the farmers' attention is diverted towards other minor crops and hence the yield of this crop is affected.

Family labor has significant (at 10 percent significance level) negative affect on groundnut yield with the coefficient 0.10 while hired labor has positive affect (at 1% significance level) with the coefficient 0.09. The main reason may be the higher family labor availability than the needed for the farm operations of relatively small farms as compared to the requirement and hence the marginal productivity of family labor is low. In other words most of the families owning small and medium farms have disguised unemployment. The hired labor is applied (particularly by large farms) according to requirement so this has positive affect on groundnut yield. The farmers in sub district Chakwal have significantly higher per acre groundnut yield as compared to those in Talagang and Gujar Khan Sub-districts with strong coefficient (0.33). According to author's observation the reason for higher groundnut production in Chakwal sub-district may be better hoeing and weeding practice for this crop.

Operational land holding has no significant affect on groundnut yield. It is because almost half of the area is left fallow during summer season so the higher or lower level of operational land holding has no considerable affect on groundnut yield. The frequency of plowing for land preparation and seed rate has no significant affect on groundnut yield. Possible reason for the insignificant effect of land preparation and input application on groundnut yield may be comparatively less land preparation for groundnut sowing. Moreover the productivity of major inputs depends on the availability of sufficient soil moisture which remains relatively low due to low rainfall from monsoon season during the summer cropping season of year 2009, for which the survey data is collected (comparatively drought affected season).

Table 8.3 Results of Groundnut Yield Ln-Ln Production Model

Dependent Variable: Groundnut yield (Kg/ac)

R^2 0.71 F 18.667*** Mean VIF 1.779

Variables	Coefficients	Std. Error	t	Hypothesis
Constant	1.857	1.049	1.771*	--
Operational holding (ac)	-.001	.032	-0.046	Reject H 2.1
Irrigated area (ac)	.060	.027	2.270**	Support H 2.2
Area groundnut (ac)	-.274	.047	-5.786***	Reject H 2.2
Groundnut price (PKR/kg)	1.471	.087	16.898***	Support H 2.2
Crop diversity index	-.211	.124	-1.699*	Reject H 2.3
Cropping intensity	.039	.158	0.244	Reject H 2.3
Off farm income (PKR/anm)	-.004	.010	-0.412	Reject H 2.3
Frequency of plowing	-.126	.093	-1.348	Reject H 2.4
Seed rate (Kg/ac)	-.039	.026	-1.492	Reject H 2.4
Family labor (Hrs/ac)	-.102	.060	-1.706*	Reject H 2.6
Hired labor (Hrs/ac)	.089	.028	3.179***	Support H 2.6
Ownership of tractor (D)	.042	.076	0.550	Reject H 2.7
Contact with exten. (D)	-.066	.141	-0.468	Reject H 2.7
Age (yrs)	-.014	.122	-0.113	Reject H 2.7
Education (yrs)	.032	.043	.0737	Reject H 2.7
Small farms (D)	-.151	.141	-1.073	--
Medium farms (D)	-.233	.089	-2.632***	--
Chakwal sub-district (D)	.334	.089	3.766***	--
Talagang subdistrict (D)	.011	.093	0.116	--

*Significant at 10 % level, ** Significant at 5 % level, ***Significant at 1 % level (No hypothesis is formulated for last four variables) Source: Based on Author's Survey data 2009

Cropping intensity and off-farm income has no significant affect on groundnut yield. As almost half of the area is left fallow during summer and cropping intensity is low. So it has no significant affect on its yield. The annual amount of off-farm income may be insignificant due to its small investment for groundnut production. The tractor ownership has also no significant affect on groundnut yield. The reason may be the less land preparation for groundnut sowing. The farmers using their own tractor or using the rented tractor have no significant difference in production cost. The land size and the contact with the extension department have no significant affect on groundnut yield. The majority of farmers don't use fertilizers there is no significant difference in the yield of different farm size categories. Very few farmers have contact with extension departments for the improved production technologies. Even the farmers having contact with extension department are unable to completely follow production technologies due to water shortage in the area. The age and education of farm household head have also no significant affect on groundnut yield. The reason may be the slow adoption of improved production technologies by household heads with higher age and lower education.

8.4 Determinants of Chickpea Production

Table 8.4 shows factor affecting chickpea production in the rain-fed area of Pakistan's Punjab. Overall 19 independent variables are used in the production function to determine their relationship with chickpea production. They explain 42 percent variation in the dependent variable (R^2 0.42). Out of 19 independent variables 5 have significant affect on the chickpea yield (kg/ha). The model is overall highly significant with F value 2.477. The mean value of VIF 2.337 shows that the model does not have the serious problem of multi-collinearity.

The results show that the age has negative relationship with the per acre yield of chickpea. With one percent increase in the age the chickpea yield decreases by 0.47 percent. The old farmers are slow in adopting the improved varieties of this crop and hence get lower yield. With the increase in the chickpea area sown the chickpea yield per acre is reduced. This is highly significant (at 1 % significance level) with a coefficient of -0.32. This may be due to less per acre inputs application with the increase in the chickpea area sown. The price of chickpea has significant positive (at 10 % significance level) affect on its yield with very strong coefficient (2.64). This result confirms that the increase in the price of this crop may be a good incentive to the farmers of area for increasing the chickpea yield per acre.

Family labor has no significant affect on chickpea yield while hired labor has significant (at 1% significance level) positive affect on chickpea yield with a coefficient 0.15. The main reason may be more family labor availability than the needed particularly at small farms as compared to the requirement and hence the marginal productivity of family labor is low. The hired labor is applied (particularly by large farms) according to the requirement so this has positive affect on the chickpea yield. Contact with extension department has significant positive affect on chickpea with very strong coefficient (0.63). The main reason for the positive affect of farmers' contact with extension department is that the improved varieties of this crop do not require much of irrigation and fertilizers requirement. The farmers having contact with the extension department sow improved varieties and these varieties perform better in the marginal areas and rain-fed conditions.

Table 8.4 Results of Chickpea Yield Ln-Ln Production Model

Dependent Variable: Chickpea yield (Kg/ac)

R2 .42 F 2.477*** Mean VIF 2.337

Variables	Coefficients	Std. Error	t	Hypothesis
(Constant)	.237	5.554	0.043	--
Operational holding (ac)	.153	.181	0.844	Reject H 2.1
Irrigated area (ac)	.022	.046	0.485	Reject H 2.2
Area chickpea (ac)	-.319	.092	-3.462***	Reject H 2.2
Price chickpea (PKR/kg)	2.645	1.446	1.829*	Support H 2.2
Crop diversity index	-.383	.241	-1.590	Reject H 2.3
Cropping intensity (%)	-.085	.342	-0.248	Reject H 2.3
Off farm income (PKR/an)	.027	.024	1.132	Reject H 2.3
Plowing frequency	-.019	.105	-0.182	Reject H 2.4
Seed rate (kg/ac)	-.010	.035	-0.270	Reject H 2.4
Family labor (Hrs/ac)	-.044	.129	-0.342	Reject H 2.6
Hired labor (Hrs/ac)	.151	.051	2.994***	Support H 2.6
Tractor ownership (D)	.127	.140	0.907	Reject H 2.7
Contact with exten. dept (D)	.629	.283	2.223**	Support H 2.7
Age (yrs)	-.467	.233	-2.005**	Reject H 2.7
Education (yrs)	-.075	.094	-0.796	Reject H 2.7
Small farms (D)	.208	.318	0.655	--
Medium farms (D)	-.024	.175	-0.137	--
Chakwal sub-district (D)	.096	.205	0.470	--
Talagang sub-district (D)	.190	.198	0.960	--

*Significant at 10 % level, ** Significant at 5 % level, ***Significant at 1 % level (No hypothesis is formulated for last four variables) Source: Based on Author's Survey data 2009

Crop diversity index, cropping intensity and off-farm income has no significant affect on chickpea yield. More than half (52.39%) of the cultivated area during winter season is under wheat crop while area under chickpea and other major crops is relatively small. This may be the cause of insignificant affect of cropping intensity and crop diversity index on chickpea production. The majority of farmers in the study area cultivate chickpea with out applying fertilizers. Chickpea crop is a leguminous crop and fixes atmospheric nitrogen in the soil and hence does not require much of nitrogenous fertilizers. Phosphorous fertilizers are needed for the pod formation and improvement in the crop yield but mostly farmers only rely on the atmospheric nitrogen instead of applying chemical fertilizers. Due to this the independent variable of fertilizer application is not included in the model.

The number of plowing for land preparation and seed rate has no significant affect on chickpea yield. The possible reason may be shortage of water and comparatively less land preparation for this crop. The productivity of major inputs depends on the availability of sufficient soil moisture which remained low due to inadequate rainfall during the winter season of year 2008-09. Farm household head's education, operational land holding and area under irrigation have no significant affect on chickpea yield. The reason may be that this crop is cultivated only on marginal and purely rain-fed areas. So the farmers' management skills and the irrigated area don't influence its yield. The tractor ownership has no affect on chickpea yield. The reason may be the less land preparation for chickpea sowing. Due to this the farmers using their own tractor or using rented tractor have not significant difference in the cost of production and hence no significant affect on chickpea yield. The different farm size categories of farmers and different sub-district dummies have also no significant affect on chickpea yield.

8.5 Determinants of Mustard Production

Table 8.5 shows factor affecting mustard production in the rain-fed area of Pakistan's Punjab. Overall 21 independent variables are used in the production function to determine their relationship with mustard production. They explained 80 percent variation in the dependent variable (R^2 0.80). Out of 21 variables 6 have significant affect on the mustard yield (kg/ac). The model is overall highly significant with F value 7.576. The mean value of VIF 3.206 shows that the model does not have the serious problem of multi-collinearity.

Operational land holding has significantly negative affect on mustard production with strong coefficient (-1.893). The reason may be that the farmers with higher operational land holding pay more attention towards wheat which is the major crop of winter season. This crop is also used as fodder for livestock during winter season, so small farmers owning higher livestock per unit area give more importance to this crop. Hence farmers with lower operational land holding have higher per acre crop yield. Mustard area sown and mustard price has significant (at 10 % and 1 % significance level respectively) positive affect on mustard yield per acre with strong coefficients (0.99 and 1.30). The results of model show 1 percent increase in the mustard area and price results in 0.99 and 1.30 percent increase in the mustard yield. The Crop diversity index has negative affect on mustard yield with the coefficient 1.74. This is due the fact that as the area under other crops increases, the farmers' attention is diverted towards these crops (particularly wheat which is the major crop in winter season) hence the yield of this crop is affected. The tractor ownership contributes positively towards mustard yield (significant at 10 percent significance level) with the coefficient 0.92. The reason for this strong relationship is the excessive land preparation for mustard sowing. The farmers having their own tractor can prepare their land far better in less cost as compared to the farmers who use costly rented tractor.

The frequency of plowing for land preparation, seed rate, fertilizer application, family and hired labor and variable cost has no significant affect on mustard yield. The possible reason may be the shortage of water and sowing of old variety seed which is not responsive to the higher inputs application. The majority of farmers takes seed from the last year produce or borrow from fellow farmers for the sowing of this crop. Moreover the productivity of major inputs depends on the availability of sufficient soil moisture. The year for which data is taken received rainfall below the normal level (during the winter season of year 2008-09).

Area under irrigation, cropping intensity and off-farm income has no significant affect on mustard yield. As the major area on which mustard crop sown is rain-fed, the farm area under irrigation has no significant affect on farm income. Wheat is the major crop occupying more than half (52.39%) of the cultivated area during winter season while area under mustard and other major crops is relatively small. This may be the cause of the insignificant affect of cropping intensity and crop diversity index on mustard production. The annual amount of off-farm income may be insignificant due to its small investment for mustard production.

The age and education of household head has no significant affect on mustard yield. Reason may be the slow adoption of improved production technologies by household heads with relatively higher age and lesser education. Contact with extension department has no significant affect on mustard yield. The reasons are the same as mentioned in the previous sections for the groundnut crop. The large and medium farms have significantly higher mustard yield per acre as compared to small farms. According to author's observation the reason for lower mustard yield for small farms is the more use of this crop as fodder for livestock. The farmers in all the three sub districts don't have significantly different mustard yield with one another.

Table 8.5 Results of Mustard Yield Ln-Ln Production Model

Dependent Variable: Mustard yield (Kg/ac)

R^2 0.80 F 7.576*** Mean VIF 3.206

Variables	Coefficients	Std. Error	t	Hypothesis
(Constant)	2.518	12.281	0.205	--
Operational holding (ac)	-1.893	.772	-2.450**	Reject H 2.1
Irrigated area (ac)	.240	.156	1.543	Reject H 2.2
Area mustard (ac)	.987	.556	1.773*	Support H 2.2
Price mustard (PKR/kg)	1.305	.172	7.597***	Support H 2.2
Crop diversity index	-1.741	.814	-2.139**	Reject H 2.3
Cropping intensity (%)	.118	.903	0.131	Reject H 2.3
Off farm income (PKR/an)	-.018	.073	-0.253	Reject H 2.3
Frequency of plowing	-.681	.420	-1.619	Reject H 2.4
Seed rate (Kg/ac)	-.622	.382	-1.625	Reject H 2.4
Fertilizer (Kg/ac)	-.046	.161	-0.287	Reject H 2.4
Variable costs (PKR/ac)	1.217	.858	1.418	Reject H 2.5
Family labor (hrs/ac)	.239	.543	0.440	Reject H 2.6
Hired labor (hrs/ac)	.063	.209	0.303	Reject H 2.6
Ownership of tractor (D)	.916	.554	1.652*	Support H 2.7
Contact with extension (D)	.317	.724	0.437	Reject H 2.7
Age (yrs)	-1.131	.896	-1.262	Reject H 2.7
Education (yrs)	-.258	.351	-0.734	Reject H 2.7
Small farms (D)	-2.863	1.129	-2.536**	--
Medium farms (D)	-.790	.662	-1.194	--
Talagang sub-district (D)	.551	.770	0.715	--
Gujar khan sub-district (D)	-1.099	.832	-1.321	--

*Significant at 10 % level, ** Significant at 5 % level, ***Significant at 1 % level (No hypothesis is formulated for last four variables) Source: Based on Author's Survey data 2009

8.6 Factors Affecting Major Crops yield

Linear regression models for four major crops are overall highly significant at 1 percent significance level. The coefficient of variance ranges from 0.42 to 0.80 which shows that variables included in the models describe the sufficient variance in the dependent variable. Operational land holding has significant positive affect on wheat yield while it has inverse relationship with mustard yield. It has no affect on groundnut and chick pea yield. Irrigated area has positive affect on wheat and groundnut yield while no significant affect on chick pea and mustard yield. The reason is that the major share of irrigated area is devoted to wheat in winter and groundnut in summer season.

Table 8.6 Comparative Results of Determinants of Major Crops
Dependent Variable: Yield (Kg/ac)

Variables	Wheat	Groundnut	Chickpea	Mustard
R^2	0.48	0.71	0.42	0.80
F	8.201***	18.667***	2.477***	7.576***
Mean VIF	2.439	1.779	2.337	3.206
(Constant)	-9.567*	1.857*	0.237	2.518
Operational holding (ac)	0.063**	-.001	0.153	-1.893**
Irrigated area (ac)	0.098***	0.060**	0.022	.240
Area sown (ac)	-.308***	-.274***	-.319***	.987*
Product Price (PKR/kg)	4.199***	1.471***	2.645*	1.305***
Crop diversity index	0.116	-.211*	-.383	-1.741**
Cropping intensity (%)	0.022	0.039	-.085	0.118
Off farm income (PKR/annum)	0.012	-.004	0.027	-.018
Frequency of plowing	0.051	-.126	-.019	-.681
Seed rate (Kg/ac)	0.038	-.039	-.010	-.622
Fertilizer (Kg/ac)	0.016	--	--	-.046
Variable costs (PKR/ac)	0.231*	--	--	1.217
Family labor (hrs/ac)	0.048	-.102*	-.044	0.239
Hired labor (hrs/ac)	0.071***	0.089***	0.151***	0.063
Ownership of tractor (D)	0.166**	0.042	0.127	0.916*
Contact with extension (D)	-.181	-.066	0.629**	0.317
Age (yrs)	0.142	-.014	-.467**	-1.131
Education (yrs)	0.060	0.032	-.075	-.258
Small farms (D)	--	-.151	0.208	-2.863**
Medium farms (D)	0.015	-.233***	-.024	-.790
Large farms (D)	0.278**	--	--	--
Chakwal sub-district (D)	0.223**	0.334***	0.096	--
Talagang sub-district (D)	-.013	0.011	0.190	0.551
Gujar khan sub-district (D)	--	--	--	-1.099

*Significant at 10 % level, ** Significant at 5 % level, ***Significant at 1 % level (No hypothesis is formulated for last four variables) Source: Based on Author's Survey data 2009

Area sown has inverse relationship with the respective crop yield for wheat, groundnut and chick pea while for mustard it has positive relationship. Product price has significant positive affect on all major cops per acre yield with high coefficient. This shows that the yield of major crops is responsive towards financial incentive to farm households. Cropping intensity, off-farm income and various inputs have no significant affect on commodities yield due to limited moisture availability. Hired labor has positive relationship with the per acre yield for all the crops except mustard. The ownership of tractor being the important dummy variable due to the extensive land preparation for moisture conservation has significant positive affect on wheat and mustard yield. It has no significant affect on groundnut and chick peas per acre yield as these crops require relatively less land preparation. Contact with extension department has no significant affect on crops yield except for chick pea as extension department has week contact with the farmers of area. Large farms are good in producing wheat, groundnut and mustard while for chick pea yield farm size does not matter significant. The farmers of Chakwal are better in wheat and groundnut production while for the chick pea and mustard production the farmers of all the three sub-districts are at par. Overall wheat being the staple diet of farm households of area and groundnut as the major cash crop attract much of the attention of farm entrepreneurs while the chick pea and mustard (mostly grown for fodder purposes) crops are relatively given less importance.

8.7 Factor Analysis for Risk Sources and Risk Management Strategies

This section presents the results of factor analysis of different risk sources and risk management strategies. The data used for this analysis is based on farmers' statements about different variables as risk sources and risk management strategies. The data varied from 1 to 5, namely strongly disagree to strongly agree, collected by using a five options lickert scale. The data regarding the risk sources and risk management strategies purely depends on farmers choices.

8.7.1 Risk Sources

Data about risk sources are gathered under the measures of the strength of 19 different variables. The measure of the strength of these variable varied from 1 (strongly disagree) to 5 (strongly agree). The highest average value of any variable shows that according to farmers view it is the most important risk source for their farm income. The results presented in Table 8.6 show that the most effective sources causing risk for the farm households of study area, are inadequate extension services (4.91) and the lack of information sources (4.90) followed by the inadequate rainfall (4.87), fluctuation in input costs (4.39), marketing dishonesty (4.33), lack of marketing facilities (4.32), inadequate research activities (4.11), natural disasters (4.09), fluctuation in product prices (4.04) and fluctuation in input prices (4.00). Crops and animal health problem and lack of farmers' cooperative are least effective risk sources mentioned by sample farmers. According to the data gathered from farm household international policy change, epidemics, agricultural produce theft, accidents/human health problems, changes in land prices and interest rate fluctuation are not important risk sources affecting their farm income. The results in Table 8.7 show that the lack of information and rainfall shortage are the most important risk sources for the farm households of study area. These results confirm hypothesis 3.1 regarding important risk sources for farm households.

Individual risk source variables are influence by some common factors according to their association with these factors. The higher factor loadings of two or more risk sources with one factor show their association with one common risk factor. Factor analysis is conducted to reduce risk sources measures into minimum common risk factors affecting the farm household income. The primary objective of factor analysis is to determine the number of common factors influencing a set of different variables and the strength of relationship between the each factor and each observed measure of variables. Factor loadings obtained from the factor analysis with respect to the risk sources considered important by sample respondents are presented in Table 8.7. As a result of factor analysis seven factors with eigen values greater than one, for 19 risk sources are identified. These seven factors explained almost 68.07 percent of cumulative variance. Factors in the order of importance are imperfect markets risks, catastrophe, lack of information risks, weather and lack of insurance risks, price risks, drought and disease risks and financial risks. Factor 1 has strong relationship with marketing dishonesty and lack of marketing facilities with high factor loadings. Due to the high factor loadings of these variables this factor is termed as imperfect markets risks. Factor 2 has positive relationship with the agricultural produce theft, human health problems and changes in land prices with high factor loadings. Because of the inclusion of these variables and their large loadings this factor is referred as catastrophe. The large loadings and inclusion of lack of information sources and inadequate extension services makes the factor 3 as lack of information risks. Factor 4 can be termed as the weather and lack of insurance risks due to the inclusion of severe weather conditions, natural disasters and lack of farmers' cooperatives with high factor loadings. Factor 5 is expressed as the rice risks because of the large factor loadings of fluctuation in input and product prices.

Table 8.7 Factor Loadings of Risk Sources

Bartlett's Test of Sphericity: X^2 = 1279.977***

Risk Sources	**Mean***	**Factors****						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Inadequate extension services	4.91	.050	.060	***.923***	-.024	-.015	-.050	-.034
Lack of information sources	4.90	.035	-.034	***.930***	-.094	-.021	-.040	.058
Inadequate rainfall	4.87	.120	-.108	-.052	-.001	.043	***.716***	.045
Severe weather conditions	4.39	.330	-.124	-.117	***.510***	.057	.447	.037
Marketing dishonesty	4.33	***.836***	-.029	.207	.080	-.018	.198	-.075
Lack of marketing facilities	4.32	***.860***	.000	.110	-.025	-.019	.172	.127
Inadequate research activities	4.11	-.167	-.049	.153	.337	.052	.187	-.741
Natural disasters	4.09	.188	.099	.061	***.745***	-.026	-.142	-.132
Fluctuation in product prices	4.04	.132	.071	.037	.155	***.821***	.020	-.204
Fluctuation in Input prices	4.00	-.012	-.023	-.072	-.054	***.870***	.011	.144
Change in agricultural polices	3.50	-.389	.330	.050	-.327	-.112	.489	-.111
Crops/animal health problems	3.19	-.660	.185	.158	-.248	-.161	.187	.244
Lack of farmers' cooperatives	3.11	-.021	-.272	-.270	***.561***	.141	-.094	-.038
International policy change	2.93	-.510	.185	.215	-.189	-.187	.293	.169
Epidemics	2.05	-.009	.437	-.036	-.202	.004	***.519***	-.122
Agricultural produce theft	2.05	-.111	***.839***	-.009	-.021	.070	.050	-.011
Human health problems	2.04	-.209	***.708***	.038	.236	-.063	-.021	.188
Changes in land prices	1.98	.065	***.706***	.038	-.308	.023	-.049	.026
Interest rate fluctuation	1.87	-.348	.088	.188	.118	.013	.155	***.697***
Eigen values	--	2.64	2.20	2.01	1.70	1.54	1.51	1.30
Total variance	--	14.08	11.6	10.5	8.93	8.12	7.94	6.83
Cumulative variance	--	14.08	25.7	36.4	45.17	53.30	61.24	68.1

*Likert-type scale: 1 (Strongly disagree) to 5 (Strongly agree) Source: Author's Survey data 2009
**Factors: 1. Imperfect markets risks, 2. Catastrophe, 3. Lack of information risks, 4. Weather and lack of insurance risks, 5. Price risks, 6. Drought and disease risks, 7. Financial risks

Factor 6 is named drought and disease risks due to high factor loadings and positive relationship with risk sources inadequate rainfall and epidemics. Factor 7 is referred as financial risk due to the large loadings of fluctuation in interest rate.

8.7.2 Risk Management Strategies

In this study risk strategies are gathered under 13 main variables. The results presented in Table 8.8 show that the most affective risk management strategies are small dams construction/ turbine schemes (4.94) and weather forecasting (4.84) followed by the up to date market information (4.82), off-farm income sources (4.82), production diversity (4.80), contract farming (4.68), more crop variety, breeds or dual purpose animals (4.10), keeping debt low (4.01), monitoring of pests, diseases, crops and prices (3.99), and maintaining inputs/feed reserves (3.97). Debt management monitoring is least effective risk management strategy. Cooperation of farmers and security safeguarding are not important risk management strategies. Construction of small dams/turbine schemes (4.94) and weather forecasting (4.84) are most important risk management strategies considered by farm households. Off-farm income (4.82) and production diversity (4.80) are also important risk management strategies for farm households. These results are also in line with hypothesis 3.2 regarding risk management strategies.

Factor loadings obtained from factor analysis with respect to risk strategies considered important by sample respondents are presented in Table 8.7. As a result of factor analysis six factors with eigen values greater than one for 13 risk management strategies are identified. These six factors explain almost 62.01 percent of cumulative variance. Factors in order of importance are planning and policy, infrastructure development, research and information management, diversification and off-farm employment generation, financial management and security, and input management. Factor 1 is termed as planning and policy because it has positive relationship with variables cooperation of farmers and pests, diseases, prices monitoring with high loadings (0.665 and 0.593). Factor 2 is expressed as infrastructure development as this factor has positive relationship with small dams/turbine schemes (0.668). Because of the inclusion of variables up-date market information, weather forecasting and more crop varieties/animals breeds with large loadings (0.634, 0.600 and 0.664) factor 3 is referred as research and information management. Factor 4 is expressed as diversification and off-farm employment generation due to the inclusion and large loadings of off-farm income sources (0.845) and production diversity (0.750). Factor 5 is named as financial management and security because of comparatively the large factor loadings of keeping debt low (0.791) and contract farming (0.615). Factor 6 is named input management due to high factor loadings and positive relationship with maintaining input/feed reserves (0.875).

Table 8.8 Factor Loadings of Risk Management Strategies

Bartlett's Test of Sphericity: $X^2 = 196.941^{***}$

Risk management strategies	Mean*	Factors**					
		1	2	3	4	5	6
Small dams/turbine schemes	4.94	-.208	***.668***	-.034	-.071	.033	.251
Weather forecasting	4.84	-.063	-.114	***.600***	.084	.062	.079
Up to date market information	4.82	-.085	.314	***.634***	.172	-.043	-.043
Off-farm income sources	4.82	.138	-.118	.004	***.845***	.047	.092
Production diversity	4.80	-.199	.161	.101	***.750***	-.089	-.106
Contract farming	4.68	.046	*.512*	-.140	.062	***.615***	-.011
More varieties/breeds	4.10	.252	-.061	***.664***	-.130	-.046	.008
Keeping debt low	4.01	.102	-.227	.049	-.052	***.791***	-.114
Pests, diseases, prices monitoring	3.99	***.593***	.159	-.262	.101	-.370	-.039
Maintaining inputs/feed reserves	3.97	.025	.016	.080	-.003	-.100	***.875***
Debt management monitoring	3.44	*.730*	-.075	.040	-.055	.239	.310
Cooperation of farmers	3.12	***.665***	-.112	.269	-.085	.137	-.321
Security safeguarding	2.12	-.121	-.656	-.052	-.071	.188	.181
Eigen values	--	1.53	1.39	1.39	1.37	1.28	1.10
Total variance experienced	--	11.77	10.69	10.68	10.53	9.86	8.48
Cumulative variance experienced	--	11.77	22.46	33.13	43.66	53.52	62.01

*Likert-type scale: 1 (Strongly disagree) to 5 (Strongly agree) Source: Author's Survey data 2009

**Factors: 1. Planning and policy, 2. Infrastructure development, 3. Research and information management, 4. Diversification and off-farm employment generation, 5. Financial management and security and 6. Input management.

8.7.3 Socio Economic Features by Farmers Risk Attitude Groups

Given that farming is a business activity subject to risky events such as drought, an important factor in understanding the behaviour and managerial decisions of farmers is their attitude toward risk. For example, the more risk-averse farmer would like to take managerial decisions that emphasize the goal of reducing variation in income rather than the goal of maximizing income. In the literature farmers are divided in to three distinct risk attitude groups on the basis of their risk preferences regarding different farm level decisions (Akcaoz and B. Oykan. 2005). Choice under uncertainty is often characterized as the maximization of expected utility. Utility is often assumed to be a function of profit with a positive first derivative. The utility function whose expected value is maximized is concave for a risk averse agent, convex for a risk seeker, and linear for a risk neutral agent.

Table 8.9 Farm Characteristics of Farm Households by Risk Attitude Groups

Risk Attitude Groups	**Risk averse**	**Risk neutral**	**Risk seekers**	**All**	**F**
Percent farmers	49.52	30.95	19.52	100.00	--
Age (yrs)	53.07	53.83	51.07	52.91	0.503
Farming experience (yrs)	29.47	30.03	31.44	30.03	0.234
Operational land holding (ha)	5.19	5.24	4.96	5.16	0.037
Education (yrs)	7.65	7.51	7.17	7.51	0.262
Family size	5.88	5.82	6.17	5.92	0.212
Farmers having off farm work (%)	91.30	90.80	80.50	89.00	1.928
Off-farm income (000 PKR/an)	269.34	262.34	170.43	247.86	3.316**
Farm Income (000 PKR/an)	290.35	326.76	278.44	299.30	0.521
Area Wheat (%)	56.75	45.28	52.61	52.39	6.040
Area Chickpea (%)	5.84	5.20	4.09	5.30	0.479
Area Lentil (%)	3.12	4.91	4.60	3.97	0.920
Area Mustard (%)	1.94	3.47	9.67	3.92	20.061***
Area Groundnut (%)	28.45	35.31	19.20	28.77	6.295***
Cropping intensity (%)	125.34	112.48	117.62	119.85	4.199**

Source: Author's Survey data 2009

Risk averse is the farmer who always wants to avoid risk by not adopting innovative production activities unless certain compensation is guaranteed in the case of crop failure. A risk averse farmer would diversify among a variety of production choices, taking account of their risk features, even though doing so would lower the expected return on the overall portfolio. In crop production choices a risk neutral farmer would be able to choose any combination of risky production activities and invest exclusively in the asset with the highest expected yield, ignoring its risk features relative to those of other choices. The risk neutral farmer portfolio would have a higher expected return, but also a greater variance of possible returns. Risk seekers/lovers are the farmers who take the challenge of greater income volatility and uncertainty in farm production decisions in exchange for anticipated higher returns. A risk seeker is the farmer who is willing to take big risks to maximize the profits on his investment.

Cluster analysis is performed for the seven factors determined from the risk source variables through factor analysis. Three groups of farmers are identified on the basis of this cluster analysis. These three groups of farmers are named as risk averse, risk neutral and risk seekers according to their risk attitudes towards different risk sources. Overall almost 50 percent of farmers are placed in risk averse category, 31 percent in risk neutral category while 19 percent in the risk seekers category. Same results are shown by Binici (2003) that the majority of farmers (are risk averse) are likely to make production decisions that reduce risk, even if the decisions translate into lower income. The average age of risk averse and neutral farmers is higher (53.07 and 53.83) as compared to risk seekers (51.07) while farming experience is smaller in risk averse (29.47 yrs) as compared to that in risk neutral (30.03 yrs) and risk seekers (31.44 yrs). There is not much difference in education and family size. More risk averse farm households have some off-farm income source as compared to risk neutral and risk seekers. Farm and off-farm income of risk averse and risk neutral farmers is considerably higher as compared to risk seekers. Percent area wheat, chickpea, groundnut and cropping intensity is also high for risk averse as compared to that of risk seekers group. Higher off-farm income, the cropping intensity and area of major crops confirm the risk attitudes of farm households of study area.

This chapter depicted the determinants of farm income and the yield of wheat, groundnut, chickpea and mustard. Important factors affecting farm income positively include off farm income, irrigated area, the number of livestock on farm, cost incurred on livestock, hired labor used for farm operations and the ownership of tractor. Farmers of Chakwal sub-district also have the higher farm income than those of Talagang and Gujar Khan sub-districts. Operational land holding has inverse relationship with per acre farm income. Area owned, irrigated area, wheat price, variable costs incurred on wheat production and hired labor has positive relationship with wheat yield. Chakwal sub-district and large farms have higher per acre wheat yield as compared to other sub-districts and farm size categories. Wheat area sown has inverse relationship with wheat yield. Irrigated area, groundnut price and hired labor have positive relationship with groundnut yield per acre. Moreover the farmers of sub-district Chakwal have higher groundnut yield while groundnut area, crop diversity index and family labor involved in farm operations has negative relationship with groundnut yield. Medium farms have lower groundnut yield as compared to small and large farms. Chickpea price, hired labor and contact with extension department have positive affect on chickpea per acre yield while the age of farm household head and the area of chickpea have inverse relationship with chickpea yield. The area sown and price of mustard and the ownership of tractor have positive affect on mustard yield. Large and medium farms have higher mustard yield as compared to small farms. Operational land holding and crop diversity index has negative relationship with mustard yield.

Important risk source mentioned by the farmers of study area include the lack of information source due to inadequate extension services, the inadequate rainfall, fluctuation in input costs, marketing dishonesty, lack of marketing opportunities, inadequate research activities, natural disasters and fluctuation in input and product prices. The important risk management strategies include small dams construction/turbine schemes, accurate weather forecasting, up to date market information, off-farm income sources, production diversity, contract farming, improved crop varieties and animals breeds, and keeping debt low. Overall seven important factors for agricultural risk sources are sorted out by factor analysis. These factors include imperfect markets risks, catastrophe, lack of information risks, weather and lack of insurance risks, price risks, drought and disease risks, and financial risks. Six factors are sorted for risk management strategies which include planning and policy, infrastructure development, research and information management, diversification and off-farm employment generation, financial management and security, and input management. The farm households are categorized into three distinct groups on the basis of cluster analysis performed for risk factors identified through factor analysis. These three groups of farmers are named as risk averse, risk neutral and risk seekers according to their risk attitudes towards different risk sources.

CHAPTER 9: DISCUSSION

This chapter depicts the comprehensive discussion of overall salient findings of research investigation. The results are evaluated in the light of hypotheses formulated for the present research investigation and the previous research studies in the relevant field. The discussion is divided into different sections according to the research hypothesis formulated regarding different research questions and study objectives. Obtained results about the role of off-work, production diversity, mixed farming, farm size and land productivity, household characteristics and farm management skills, cropping intensity and input costs, labor productivity, contact with extension department, the determinants of wheat yield, risk sources and risk management strategies are discussed in detail.

9.1 Off-Farm Work and Income

Agriculture is a part time business for the majority of farm households. They have also some off-farm income sources such as remittances from abroad (unskilled/semi skilled labor in Middle East) as well as low paid jobs in govt and private institutions. These off-farm income sources are important coping strategy in severe drought periods. Annual off-farm income has positive relationship with per acre farm income. That is how it helps in ensuring the food security of rural households by contributing directly towards consumption expenditure and also in agricultural investment and farm income. This result confirms the research hypothesis of positive relationship of off farm income with farm income. This result is in agreement with the study conducted by Babatunde and Matin (2010) about the impact of off-farm income on the food security and nutrition of farm households in the Kwara State of Nigeria. The results of descriptive and econometric analyses of their study show that off-farm income contributes to improved calorie supply at the household level. According to them in Kwara state where the shortage of capital is a major constraint for farm income, can even contribute to more intensive farming and higher food production and farm income.

Mc Nally (2002) argued that the off-farm work may result in less time being devoted to the management of farm business. This might result in the neglect to the farm operations and an increase in the use of inputs like pesticide and fertilizers. This does not hold true for the study area of current investigation. The reasons may be the subsistence type of agriculture of area and the abundant family labor force. The average household consist of six adult family members. The overall operational land holding of area is small while family labor is more than the farm operation's requirement of majority of small and medium farms. The household head is usually the eldest male of family. In most of the cases he is the only person fully involved in farm operations. His sons or younger brothers having a little education as well as in some cases the females of family are involved in small paid jobs out side the farm. Moreover they help their household head by taking leave from their employers during the harvesting time of both summer and winter seasons. Hence the involvement of some of the farm household members in off-farm activities doesn't affect the farm operations. On the contrary, the income from off-farm activities play very important role in the smoothening of consumption of farm families. Gasson (1988) and Ellis et al (1999) supported the positive role of off-farm work in the more environment friendly performance of farm operations, less intensive production methods and greater production diversity.

9.2 Production Diversity

Production diversity has the positive affect on farm income but it is statistically insignificant. The insignificance of positive affect of production diversity may be due to the scarcity of water in the study area. The sign of result of production diversity with farm income is in accordance with the research hypothesis. This result is also supported by study conducted by Ansoms et al. (2008). They conclude that the risk-coping mechanisms of small-scale farmers, such as farm fragmentation, the higher frequency of multi cropping and more crop diversification seem to pay off in terms of the productivity. Rahman (2009) also declared the crop diversification as the desired strategy for agricultural growth in Bangladesh. Block and P. Webb (2001) has also almost similar finding in their study on livelihood diversification in rural Ethiopia. According to their results diversification is a key to greater wealth and to reduced vulnerability. This leads to many analysts to equate support for diversification with support for the poor and small farm households. According to Ali (2001) the doubling of diversity in crop production in Pakistan's Punjab will increase total farm productivity by 56 percent. On the other side farms showing quick diversification reduction in Austria have been found to face the highest probability of exiting from the agriculture sector (Weiss, 1999).

Kurosaki (1995) concluded that farms shift in enterprise composition towards livestock products (production diversity) reduces the farm household income variability. This result is in agreement with the finding of present study that the inclusion of livestock in farm activities has positive affect on farm income. Kurosaki (2002) found that farm households adapt the production choices in response to the consumption price risk to avoid the price fluctuations in the consumption commodities. This suggested that empirical and theoretical work on risk should avoid putting an exclusive emphasis only on yield and output price risk. Households might produce their own food in order to self-insure against food price fluctuations even when food markets are present. This describes the utility maximization theory's aspect of farm households. This theory fits into the present investigation. The results show that groundnut and lentil crops have higher percent gross margins but farmers allocate more area to wheat production as compared to these crops to avoid food price risk (wheat is the staple food in study area) and ensure the food security of farm household members.

9.3 Mixed Farming

The livestock sector plays important role in stabilizing the farm income in the risky type of rain-fed agriculture. The number of livestock and their cost of production have significant and positive relationship with farm income (significant at 1 percent significance level). These results are supporting the research hypothesis of the positive relationship of livestock with farm income. Several studies on mixed farming support this result (Kurosaki 1995). According to Zakria, et al. (2007) daily income from the milk sale plays important role in the daily farm household expenditure. Moreover females play very important role in keeping livestock. According to author observation in most cases women also control the income earned from livestock products as they have to run the daily household consumption expenditures. Amin et al. (2010) conducted study on Gender and Development: Roles of Rural Women in Livestock Production in Pakistan. She described that the more number of wives

(37.5%) participated in livestock production activities as compared to the husbands (17%). This encourages the women of area for taking part in farm production decisions. These empirical results suggest that rise in the share of livestock sub-sector in agricultural value added in Pakistan should have improved the welfare position of households with substantial livestock holding. Since the small land holders have relatively more livestock per hectare of their operational land in the study area, this might have an equity-improving effect as well. Moreover, because livestock have an additional welfare value as an affective insurance measure, the small farms might have a stronger incentive to accumulate livestock in the absence of formal insurance cover. Large farms can maximize expected profit from crops sub-sector as they are comparatively resourceful and can bear the risk of crop failure. The findings of present study conducted in the rain-fed Punjab are in agreement with the findings of study titled “Risk and Insurance in a Household Economy: Role of Livestock in Mixed Farming in Pakistan” conducted by Kurosaki (1995).

9.4 Farm Size and Land Productivity

The important result of study shows that operational land holding has strong inverse relationship (IR) with the per acre farm income of area. The findings of this study suggest the need for implementing more equitable land holding/ownership distribution to increase per acre farm income. By redistributing the land from large farms to the small ones the overall land productivity will increase. This result also confirms the research hypothesis of inverse relationship of operational land holding and farm income. A lot of literature supports the theory of inverse relationship of farm size and land productivity. Ansoms et al. (2008) identifies the same strong inverse relationship between farm size and land productivity in Rawanda, under the land management system when taking into account farm fragmentation, crop diversification, the frequency of multi-cropping and household size.

In literature various obvious and less obvious reasons and explanations for this inverse relationship have been tested and proven. These reasons include failure in the different types of production factor markets: land market (Platteau, 1996), credit market (Assuncao and Ghatak, 2003), insurance market (Dercon and Krishnan, 1996) and labor market (Barrett, 1996; Assuncao and Braido, 2007). Malfunctioning or a complete absence of these markets will lead to suboptimal resource allocation on farm level implying inefficiencies. The study area is characterized by the subsistence type of agriculture production, and factor and product markets are imperfect which lead to the farm level inefficiencies and inverse relationship of land holding and productivity. The presence of imperfect factor and product markets violate the assumption of profit maximization theory. In this scenario farmers choose farm activities resulting to the utility maximization and risk averse options. Heltberg (1998) conducted study titled Rural Market Imperfections and the Farm Size-Productivity Relationship: Evidence from Pakistan. He concluded the presence of a strong inverse relationship between farm size and yield in the sample, even when household fixed effects are used to account for unobserved heterogeneity.

Differences in soil quality lead to differences in soil productivity which affect output, with the assumption that the small farms are more productive because of having plots of better quality. All revised studies on this issue show a decrease in the severity of inverse relationship when controlling for soil quality (Lamb, 2003 and Assuncao and Braido, 2007). Barrett et al., (2010) explained that only a small portion of inverse productivity–size relationship is explained by market imperfections and none of it seems attributable to the omission of soil quality measurements. A second set of missing variables are household specific characteristics such as household size, dependency ratio, and the gender of household head (Assuncao and Braido, 2007; Barrett et al., 2010). However none of studies cited up to now has proven household characteristics to solely explain the IR. The present study results show an insignificant positive correlation between the operational land holding and the soil quality. So the arguments against validity of inverse relationship (IR) that if land quality is negatively related to the farm size then omission of land quality in regression would cause a downward bias in the estimate, is not applicable for the results of present investigation. This result of present study is in agreement with Barret et al., (2010).

Fatma Gül (2006) also confirmed the very strong inverse relationship over inverse-size yield relationship in the case of Turkey. Labor input per decare seems to be driving the inverse farm size-yield relationship in Turkey. Even though land heterogeneity explains the part of inverse size-yield relationship, inverse relationship is still very robust and significant despite controlled land heterogeneity. Given the inverse productivity- land size relationship in agriculture, the redistribution of land from large to small farms along with technical and financial assistance would solve the low productivity problem of sector. These findings of study are in complete agreement with the present study.

Thapa (2007) examined the farm size and productivity relationship using data from the Mardi Watershed Area of Kaski district in the western hills of Nepal. The results of extended regression equations do not support the hypotheses in this model that the IR is due to variations in regions as well as access to resources among farm owners. The paper also estimated total cash input and labor hours per acre in order to measure the productivity differentials. The results are significant and consistent with the models of output per acre, reflecting that small farms use more input and labor unit per acre than do large farms. The coefficients of family size both in output and in labor hours per acre reveal the importance of family labor on farm productivity in most part of the rural areas. The paper applied the Cobb Douglas (CD) production function in order to find returns to the scale and impact of production factors in the Nepalese agriculture. The evidence found constant returns to scale at 10 percent level of significance in the hilly region of Nepal, rejecting the hypothesis that the IR is due to decreasing returns to scale. The overall results of this paper confirm the IR between farm size and output per acre which are in agreement with the results of present investigation.

Masterson (2007) assessed the relationship between farm size and productivity. Smaller farms are found to have higher net farm income per acre, and more technically efficient than larger farms. The study's most important contribution to the continuing debate over the relationship between productivity and farm size is an affirmation of inverse relationship in the case of Paraguay. The land productivity is significantly greater for smaller farms (especially the smallest farms). Masterson and Rao (1999) also confirm this result. This study also augments the argument for the redistribution of land among small holders which is in agreement with the present research investigation. Giving land to smaller farms will increase overall production, as well as improve the welfare of small and landless farmers. The labor productivity and income will also improve with the increase in land ownership of small farms.

9.5 Farm Household Characteristics and Management Skills

Some literature suggests that household specific characteristics such as household size, dependency ratio, and the gender of household head has affect on the farm productivity (Assuncao and Braido, 2007; Barrett et al., 2010). Lipton (2010) argues that differentiation in farm management skills as an explanatory variable of farm productivity is not yet sufficiently tested in empirical research. According to the present study results age and education have no significant affect on farm productivity. The research hypothesis regarding these has not been statistically confirmed. According to the field observations of author most of the farm household heads who are involved in the farm production decisions are old and less educated. The higher age and lower education hinders the adoption of innovative and improved agricultural production technologies. This ultimately leads to the insignificant positive affect of these variables on farm income. Ibeke (2010) results about the age of household head are in agreement with the results of present study about its insignificant affect on the farm income.

9.6 Cropping Intensity and Input Costs

Increasing cropping intensity in the area has no significant impact on per acre farm income. This result does not confirm the research hypothesis of inverse relationship of cropping intensity with the per acre farm income. The main reason is the scarcity of water, uneven rainfall distribution and cyclical drought conditions. These reasons are also responsible for overall low cropping intensity in the study area and keeping significant area fallow particularly in summer season. The direct costs incurred on crop inputs have also no significant affect on farm per acre income. This result is also not in accordance with the research hypothesis of positive relationship of cost incurred on crop inputs with farm income. The reason may be the shortage of water and drought conditions of study area. Costs incurred on the major factors of production are complementary to the sufficient availability of water for their positive affect on farm productivity. This argument is supported by the results of farm income model which shows that area irrigated has positive relationship with farm income. The household income increases with the irrigated area.

9.7 Labor Productivity

Opportunity cost on family labor has no significant affect while cost incurred on hired labor has strong positive relation with farm income. The result about family labor has not confirmed the research hypothesis while the hypothesis about hired labor is confirmed. The rising shares of household labor employed in agriculture result in the lower productivity and efficiency (Masterson 2007). The present study results are in agreement with the results of this study. This is in opposition to theory on this point that household labor requires less supervision and is more motivated than hired labor, and so should be more productive and efficient. The share of family labor in total labor is significantly negatively correlated with the amount of operational land holding of farm household. This results in the decreasing marginal productivity of family labor with the increase in farm size. Another possible explanation is that there is a process of selection happening, households' better farmers opt to hire themselves out, rather than working on the farm. This makes sense if the wages they can earn are higher than the expected returns of working on their own farm. Moreover opting to work on other farms also involves the minimum risk than to work on their own farms.

9.8 Contacts with Extension Department

The farmers contact with extension department has no significant affect on farm income which is not in accordance with the hypothesis of positive relationship. This result does not match with the results of Ibeke (2010) study on the determinants of farm households' income in the Orlu Agricultural Zone of Imo State, Nigeria. According to him the extension services are positively correlated with the farm household income. Main reasons for the no significant affect of contact with the extension department may be that the extension agents are not well equipped with fresh knowledge and latest research in agricultural production and marketing field due to week coordination between education, research and extension institutions. The extension department mainly concentrates on the production technology of two major crops while the other crops of area have not been given the due importance.

Moreover the farmers who have contact with extension department use the improved varieties of major crop i.e. wheat, but they are unable to follow the recommended production technologies for these improved varieties. The improved varieties also require relatively more water for the better yield. The result is that the yield of these varieties at farmers' field level is well below their potential yield. This scenario results in the insignificant affect of farmers' contact with extension department.

9.9 Determinants of Wheat Yield

Wheat is an important crop of area grown on more than half of operational land holding of farm households. Wheat is grown on the higher percentage area of small farms as compared to medium and large farms. Self sufficiency in wheat production is the prime priority of farm households. Small land holders have to allocate more portion of the land for wheat growing to fulfil the household consumption requirement of wheat. Higher area irrigated increases the wheat yield because the major portion of small irrigated area is allocated to wheat sowing. The wheat per acre yield decreases with the increase in the wheat area sown. The possible reason may be the decrease in the ratio of wheat sown irrigated area to the wheat sown rain-fed area with the increase in total wheat sown area. Government usually announces the support price before the sowing of different major crops. The government of Pakistan increased the support price of wheat from PKR 625 to PKR 950 per 40 kg (more than 50 %) for the year 2008-09. The data has been collected for the same year. Along with support price announcement government ensures minimum guaranteed price to farm households. This considerable and timely increase (well before the sowing of wheat) in the wheat support price have strong affect on wheat yield. This result is in agreement with the study titled "Determinants of Higher Wheat Productivity in Irrigated Pakistan" conducted by Iqbal et al., (2001).

The number of plowing for land preparation, seed rate and fertilizer application has no significant affect on wheat yield. These results of major crops yield Ln-Ln model indicate that cash inputs like seed and fertilizers have no significant affect on major crops yield. These results are in agreement with the study conducted by Thapa (2007). The author concludes that the impact of cash inputs is insignificant in the sample farms. The possible reason may be the shortage of water. The productivity of major inputs depends on the availability of soil moisture which remained relatively low during the winter cropping season 2008-09.

Family labor has no significant affect on wheat yield while hired labor affects wheat yield positively. The main reason may be the higher family labor as compared to smaller operational land holding, particularly for small and medium farms. The tractor ownership contributes positively towards wheat yield. The reason for this strong relationship is excessive land preparation for wheat sowing. The farmers having their own tractors can prepare their land far better for wheat production in less cost as compared to the farmers who use costly rented tractor. Large farm size category farmers have higher wheat yield as compared to small and medium farms. The large farms being more resourceful can better adopt the modern wheat production technologies and hence get good per acre wheat yield.

The contact with extension agents has no significant affect on wheat yield. The reason may be the lack of finance to adopt the modern wheat production technologies (costly improved seed and the higher amount of fertilizers needed for improved wheat varieties). Moreover most of the improved wheat varieties perform better with the combination of higher fertilizer application and sufficient moisture availability. The majority of farmers are unable to arrange the costly fertilizers and irrigation water facilities. The farmers in sub district Chakwal have significantly higher per acre wheat yield than those in Talagang and Gujar Khan Sub-districts. The main reasons may be the less cropping intensity in Chakwal district and more area under irrigation as compared to Gujar Khan. The rainfall during winter 2008-09 remained low in sub-district Talagang, which affected badly the rain-fed wheat germination and overall production.

9.10 Risk Sources and Risk Management Strategies

Important risk source mentioned by the farmers of study area include the lack of information source due to inadequate extension services, the inadequate rainfall, fluctuation in input costs, marketing dishonesty, lack of marketing opportunities, inadequate research activities, natural disasters and fluctuation in input and product prices. The important risk management strategies include small dams construction/turbine schemes, accurate weather forecasting, up to date market information, off-farm income sources, production diversity, contract farming, improved crop varieties and animals breeds, keeping debt low and monitoring of pests, diseases, crops, prices and maintaining inputs/feed reserves. Blicok and P. Webb (2001) confirmed that most households did believe that earning off-farm income (non farm employment and livestock activities combined) is a key to reduce risk. Rehman (2009) emphasized the development of rural infrastructure for improved technical efficiency and also to promote crop diversification by opening up opportunities for technology diffusion, marketing, storage facilities and resource supplies in Bangladesh. The present research investigation confirms the results presented by Rehman (2009).

Overall seven important factors for agricultural risk sources are sorted out by factor analysis. These factors include imperfect markets risks, catastrophe, lack of information risks, weather and lack of insurance risks, price risks, drought and disease risks, and financial risks. The six factors are sorted for risk management strategies which include planning and policy, infrastructure development, research and information management, diversification and off-farm employment generation, financial management and security, and input management. Akcaoz and Oykan (2005) conducted study in the Cukutova region of Turkey to identify the groups of farmers who differ in their risk sources and risk management strategies. They labeled risk sources as environmental, price, catastrophe, input costs, production and technological, political, finance, personal, marketing, and health and social security. They name important risk strategies as diversification, off-farm income, marketing, planning, financing and security. The results of present investigation are in agreement with the results of Akcaoz and Oykan (2005)

Madai (2008) gave an overview of risk attitudes of Hungarian sheep producers. The results reveal that the economies of scales and lack of capital are major difficulties to continue sheep farming. The most widely applied risk management strategies are the cooperation between farmers and joining to producer groups, which is applied by 74.4 percent of farmers and scored to 3.8. The results of present study depict a little different result in this regard. The farm households are indifferent in quoting the lack of farmers' cooperatives as the farm income risk source and formation of cooperative farming as the risk management strategy. The reason for this attitude may be the failure of past cooperative farming experience in the region. In the above mentioned study, farmers view about gathering market information and monitoring as useable tool for decreasing risk is in agreement with the farmers' view of present study.

Maldai (2008) reveals the security and safeguarding as the important risk management strategy for corresponding risk sources with the score of 3.8. In contrast, farm households in the present study disagree with this risk source (theft of agricultural produce) and risk management strategy (Security safeguarding) and gave only score of 2.05 and 2.12 respectively. The reason may be the chance of theft of sheep is comparatively higher as compared to crops and large ruminants. The off-farm income/investment and the debt management monitoring are more important risk management strategies for the households of present study as compared to the Hungarian sheep producers. The reason may be that the sheep farming is the commercial activity and the producers may get enough income from the activity and don't need the off-farm income activities. Moreover, they are able to repay the debt by the sale of their sheep products and don't think the debt management as an important risk management strategy. The farm households of present study are producing subsistent agriculture and think the off-farm income activities as very important risk management strategy for meeting the household consumption expenditure. Moreover the risky nature of agriculture of area due to the severe weather conditions (particularly the inadequate and erratic rainfall) makes them conscious about the debt. The majority of farm households avoid taking debt/credit from institutional sources having the fear of default due to complete crops failure (drought damage).

CHAPTER 10: SUMMARY AND RECOMMENDATIONS

This chapter summarizes the salient findings of research investigation and draws some important conclusions from the empirical results of study. Moreover, based on the conclusions, some recommendations regarding rain-fed agriculture are formulated for government policy, NGOs working in the study area, research and extension institutions, development planners and farming community. In addition directions for future research are also discussed. This thesis has examined farm and farmers' characteristics, the cost of production, productivity analysis, the determinants of farm income and the yields of major crops and risk sources and risk management strategies of sample farmers of rain-fed Punjab of Pakistan.

10.1 Summary of Important Results

The majority of farm households in the study area are involved part time in subsistence agriculture and they behave risk averse against the repeated drought conditions. The agriculture of area is mixed farming involving crops and livestock enterprises. The crop sector includes the major crops of wheat, groundnut, chickpea, lentil and mustard. The area lacks the high value and labor intensive crops such as fruit and vegetables. The underground water level is deep and it is available in small quantity which makes it difficult and comparatively expensive to irrigate the land on large scale. Government has constructed small dams in some areas where feasible but these dams cover the small part of whole area. Severe weather conditions particularly frost and weather disasters like hailstorms are also add to risk. Most of the farmers of area have small landholding. The majority lacks information sources regarding the production technology and marketing of agricultural products. Most farmers prefer to grow only major grain crops due to water scarcity, lack of information about the production technology and marketing opportunities about high value crops. This results in fluctuation in the product prices and hence variation and reduction in farm income. The summary of some important results of research investigation is presented in the following sub-sections.

Water scarcity

Inadequate and uneven rainfall with cyclical drought attack is the major cause of lower crop production in the area. The cost of production increases due to excessive tillage for water conservation in the soil during land preparation for winter season crops. Small percentage of area is irrigated with the construction of small dams and turbine schemes. A few farmers own tractor which is the important part of farm machinery in the scenario of excessive soil tillage for water conservation. This is the major cause of agricultural production risks and lowering the net farm income.

Fluctuation in Input/Output Prices

Chemical fertilizers and other input prices increase during the time of crop sowing which plays an important role in increasing production cost and reducing farm income. Fluctuation in the product prices of major cash crops is the cause of price risk for the farm households which results in the farm household income variability.

Marketing Problems

The marketing of agricultural produce attracts the least attention in the area due to the small marketable surplus of majority of small farmers. The small marketable surplus increases per unit transactions costs for the marketing of produce. This further aggravates due to the lack of farmers' cooperatives. The majority of farmers are illiterate and they don't know the complicated weighing and billing procedures of commission agents. According to the perception of sample respondents, the majority of market intermediaries are dishonest and they make illegal deductions from their produce and pay lesser price by cartelization. This reveals that the factor and product markets in the study area are imperfect.

Research Institutes

There are two research institutes established particularly for agriculture research in the study area. The research efforts of one institute are mostly confined to major grain crops such as wheat, groundnut and chickpea while high value cash crops such as fruits and vegetables are not given due importance. Moreover there is no special focus of research regarding evolving the drought resistant varieties. Second research institute is focusing soil and water resources conservation. It has the facility of soil testing laboratories at nominal cost but the majority of farmers don't test the soil fertility before applying fertilizers. There is the lack of research facilities for improving local livestock breeds. The majority of farmers, rear foreign cross bred animals which are not well adaptable to the local climate. This causes the livestock mortality and frequent disease attack and hence huge financial loss to the farm households of area.

Extension Department

The results of research investigation show that the contact with extension department has no significant affect on farm income. Agriculture education and extension services are week in the area as compared to the irrigated areas of Punjab. These are not well coordinated with the agricultural research institutes and universities for equipping themselves with the latest agricultural production technologies. The government pays more attention to the agriculture of irrigated areas while the rain-fed agriculture is neglected. According to survey results the extension department of study area is not well connected with small and medium land holders. The department has few contacts with a few owners of large farms. This weak extension link to the majority farmers is the major cause of low farm income. This also results in the indirect effect on farm households' income because of the poor quality seed, improper seed and fertilizer quantity used and other improper farm operations. Moreover, the research and extension activities in the area have more focus towards the dissemination of production technologies of only two major crops. Farmers lack technological support from research and extension departments for the production technologies of high value crops. Farm productivity can be improved to a great extent by strengthening and improving the working of extension department.

Credit Availability

Credit availability is the major problem of study area. The majority of respondent farmers are unwilling to take the credit from institutional sources. They bear the loss in their farm income by applying lesser and unimproved inputs but don't opt for taking the credit to improve the farm income. The main reason is the fear of default due to the risky nature of rain-fed agriculture and high interest rate charged on agricultural production loan. Moreover the complicated procedure to get loan is also the major hindrance in access to credit. The unproductive use of credit, particularly on the daily household consumption and marriages of children is responsible for the debt trap of farming community of area.

Determinants of Farm Income

The determinants of the farm income and major crops yields of farmers are analyzed by applying Ln-Ln production function. The results show inverse relationship between land holdings and farm income. The higher the irrigated area the higher is the farm income despite the fact that the small area of study area is irrigated through tube well and dug wells.

Combining the livestock with crops increases farm income significantly and reduces the production risk to a great extent. The livestock plays important role in the farm household income. Livestock substantiate the risky income from crops production. The income from milk sale helps in the daily household income expenditure while the presence of farm livestock acts as buffer stock and farm asset to avoid the financial risk in the study area. The majority of households prefer to have mix farming. They use fodder crops for feeding their livestock and in return invest their income from livestock on growing crops. The results of Ln-Ln production function show that the number of livestock on farm and cost incurred on livestock has strong positive affect on farm income. The results of model show that the crop diversity has no significant affect on per acre farm income. Farmers usually do not grow the high value crops due to the shortage of supplementary irrigation water, cyclic drought conditions and uneven rainfall.

The amount of off-farm income earned by household members has significant positive affect on the farm income. The sample respondents usually invest the small part of their off-farm income on the farm production activities. In the absence of easy agricultural credit access this investment plays the important role in increasing farm income. Tractor plays key role in agriculture of area as all major winter season crops' production requires more cultural practices for land preparation and soil moisture conservation. The extensive plowing and tillage is done to conserve the soil moisture for the germination of winter crops. The farmers having their own tractor can save more cost of production on land preparation as compared to the farmers using rented tractor. This results in the significant positive contribution of tractor ownership towards per acre farm income.

Erratic rainfall and repeated drought conditions result in the insignificant affect of cropping intensity and crop costs on farm income. This also results in overall low cropping intensity and significant fallow area particularly in summer season. The higher cost incurred on crop production shows the use of higher amount of inputs particularly fertilizers. The application of more fertilizers with out sufficient water results in the insignificant affect on major crops yield.

The study area is characterized by the small land holdings of farm households. The family size and family labor available for farming is higher particularly for the small farms. This result in the lower family labor productivity in the area and has no significant affect on farm income. Most of the farm operations are operated by farm machinery except crop harvesting. More farm mechanization has reduced the importance of farm family labor and ultimately the marginal productivity of labor. Hence the family size does not have significant positive affect on farm income.

The model results show that the age and education of farm household head have no significant affect on farm income. The farmers of study area involved in agriculture are aged. The average age of majority of sample farmers is above fifty years with low education level. Relatively the younger and educated members of households prefer to have the off-farm job instead of looking after farm due to the subsistence nature of agriculture. The decision power regarding the farm operations and input use lies with relatively older farm household heads. They have good farming experience but are laggards and slow in adopting the innovative and improved agricultural production technologies. This results in the overall low production of major crops in the study area. The education of sample household heads also does not have significant affect on the farm income due to the lack of bold decision power of aged household heads.

10.2 Conclusions and Recommendations

Infrastructure Development

The minor share of area is irrigated with the small dams and turbine schemes. Relatively higher number of small dams in Attock District has substantially improved the agriculture production and farm income. Certain areas in Chakwal and Rawalpindi districts with natural slope and ideal topography are best suited for the small dam construction. Moreover turbine schemes are running successfully in areas having enough ground water. The number of these turbine schemes can effectively be increased by giving subsidy to the farmers of area. This may enhance the agricultural production of overall area and the farm income of farming community. Tractor is also very important implement for the agriculture of area as land preparation cost is the major part of overall production cost of crops. Government can play important role in reducing the cost of production by providing the subsidy for purchasing tractor for the willing farmers of area. The community organizations of farmers can be organized in villages. Small scale infrastructure schemes like turbines and farm implements can be given to these farmers' community organizations on the certain level of subsidies. This can be implemented through the joint venture of NGOs already working in the rural areas (National Rural Support Programme and *Khushhali* Bank-A micro credit bank) and government institutions like agricultural extension and water management departments.

Agricultural Research and Extension

The rain-fed areas of *Pothwar* have been neglected in agricultural research and the extension policies of Pakistan, due to water shortage and their small contribution to total agricultural GDP. The government does not pay proper attention towards the improvement in the research institutes and extension department of area. This resulted in the lower agricultural total factor productivity and farm income. These areas have great potential for increasing the overall agricultural production by improving the research capabilities of research institutes and the dissemination of improved agricultural production technologies by affective agricultural extension department.

Agricultural extension can play an important role in the dissemination of innovative and improved agricultural production technologies and agricultural marketing information. Hence improvement in agricultural extension department may solve many problems and the bottlenecks of agriculture of area. The department can be strengthened by improving the service structure and salaries of officers and supporting staff of extension department. Punjab government can play major role in this regard with small extra finance and affective management.

Government should increase funding to the research institutes of area to enhance research activities particularly for evolving more drought resistant varieties, improved production technologies for high value crops, the development of intercropping production technologies and high yielding dual purpose animals (meat and milk).

Weather Forecasting

Improved weather forecasting and dissemination mechanism can help farmers in planning their land preparation and setting crop rotations according to the expected amount of rainfall during the season. Pakistan Meteorological Department is working on the weather forecasting and research activities related to weather. This department should be strengthened by giving more finance for the purchase of latest equipment used in weather forecasting. Moreover the coordination between metrological department, agricultural research and extension department may be strengthened for the affective use of weather forecasting information for agricultural crops planning. Keeping in view the importance of weather related information particularly for rain-fed agriculture, government should install small weather stations at least at the circle level where there is the office of agriculture officer of extension department. This will help farming community to get the localized and latest weather related information.

Development of Small and Medium enterprises

The contribution of agriculture to the potential improvement of households' livelihoods is different. The implication for policy makers should be to rethink their focus on smallholder agriculture. The options for diversification out of agriculture for these small farms are limited and they are confined to low paid irregular jobs on other peoples farms or businesses. The development of small and medium enterprises (SMEs) for off-farm income sources may increase the marginal productivity of labor by reducing the burden of excessive labor on major crops' production. Moreover the return from SMEs can productively be reinvested in the agricultural high value and labor intensive crops requiring relatively higher investment costs. On macro level this may contribute to utilize the under employed labor force for increasing the GDP and export earnings of country. These enterprises can affectively be established by the local governments managed by district administration.

Contract Farming

The agriculture of area is of risky nature which hinders farmers to make heavy investments. The farmers may be encourage to invest in producing crops particularly high value crops like fruits and vegetables by offering contract farming. Government should encourage big companies and super markets to have contract directly with farmers. Farmers may supply their produce directly to these companies to ensure the competitive price by reducing the market intermediaries and market margins. This may solve the problem of huge market margins earned by the more number of market intermediaries and avoid the price fluctuation risks. The contractors may also provide financial assistance and improved production technologies packages to the farm households to increase farm production.

To increase labor productivity the more labor intensive crops like vegetables and fruits may be introduced at small scale, where water is available through installing tube-wells/turbines. This may reduce government's burden for the creation of more off-farm income generating activities for the disguised unemployed labor in the agricultural sector of rural population of study area. This will also help in reducing the farm income variability and ensuring the farm household food security.

Cooperative Marketing

The farmers of area are small and hence they can't handle their small marketable surplus produce in affordable transaction costs. Hence the transaction cost per unit produce becomes high and make small farmer uncompetitive in open wholesale market. The small farmers prefer to sell their small marketable surplus in the local market to the village level dealers to avoid higher transaction costs. In this process they are unable to get the competitive market price of their produce. Cooperative marketing or marketing in groups may increase their net profit though getting high price by getting higher negotiating power with commission agents and reducing the per unit transaction costs. The local NGOs can play an important role in making the community groups of small farmers for group marketing.

Credit Scheme

A special credit scheme with lower interest rates or interest free may be introduced for the farming community of rain-fed areas involved in the risky agriculture. This may encourage farmers to invest more in the agricultural sector by spending on improved inputs usage. Moreover, farmers may invest this money in high value agriculture. This more investment on more input use and in high value agriculture may not only enhance their farm income and ensure food security but also can fulfill the fruits and vegetables demand of urban population of study area.

Future Research

Exploring for new better-paid and protected rural off-farm income opportunities for the smallest farms is an important area for further research. Many of previous studies gave much importance to better off-farm income opportunities for the vast majority of small farms. Another topic that may be explored in details in the near future is the possible agricultural policy options for optimizing farm production. This includes possibilities for exploiting the economies of scale by reducing the land inequalities and redistributing the land among small land holders. The effect of land tenure structure on farm income is also an important area to work in the rain-fed agriculture. Moreover the detail research investigation about the role of research and extension in rural poverty alleviation through enhancing farm income in the marginal areas of Pakistan's Punjab is relevant and economically important.

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APPENDICES

Appendix 1 Farm size structure of *Pothwar* region

Farm Size Category (ac)	***No of farms (%)***	***Farm area (%)***	***Cultivated area (%)***	***Cultivated area (% farm area)***	***Av. Farm size (ac)***	
					Farm area	**Cultivated area**
Rawalpindi						
<1	30	4	5	87	0.5	0.4
1 to < 2.5	33	16	17	92	1.5	1.4
2.5 to < 5.0	18	19	21	92	3.3	3.0
<5.0	**81**	**39**	**43**	**90.3**	**1.8**	**1.6**
5.0 to < 7.5	9	17	18	89	5.7	5.1
7.5 to < 12.5	6	17	17	83	9.4	7.8
5.0 to < 12.5	**15**	**34**	**35**	**86**	**7.55**	**6.45**
12.5 to < 25.0	2	12	12	78	15.8	12.4
25.0 to < 50.0	1	8	7	65	31.4	20.4
50.0 to < 100.0	*	4	2	42	60.4	25.4
100.0 to< 150.0	*	1		59	106.5	63.2
≥ 150.0	*	2	1	52	230.5	120.5
≥12.50	**3**	**27**	**22**	**59.2**	**88.9**	**48.4**
All farms	**100**	**100**	**100**	**83**	**3.1**	**2.6**
Chakwal						
<1	7	*	*	91	0.4	0.4
1 to < 2.5	21	4	5	94	1.6	1.5
2.5 to < 5.0	20	8	9	92	3.4	3.2
<5.0	**48**	**12**	**14**	**92.3**	**1.8**	**1.7**
5.0 to < 7.5	17	11	13	92	5.8	5.3
7.5 to < 12.5	17	18	20	87	9.5	8.3
5.0 to < 12.5	**34**	**29**	**33**	**89.5**	**7.65**	**6.8**
12.5 to < 25.0	9	17	18	83	16.9	14.0
25.0 to < 50.0	7	22	21	73	28.4	20.9
50.0 to < 100.0	1	10	7	55	59.5	32.9
100.0 to< 150.0	*	4	2	39	113.2	44.3
≥ 150.0	*	6	4	48	186.5	90.3
≥12.50	**17**	**59**	**52**	**59.6**	**80.9**	**40.5**
All farms	**100**	**100**	**100**	**77**	**8.8**	**6.8**
Pothwar						
<1	17	1	1	89	0.5	0.4
1 to < 2.5	27	7	8	93	1.5	1.4
2.5 to < 5.0	20	11	13	92	3.4	3.1
<5.0	**64**	**19**	**22**	**91.3**	**1.8**	**1.6**
5.0 to < 7.5	13	12	14	89	5.7	5.1
7.5 to < 12.5	12	18	19	84	9.5	7.9
5.0 to < 12.5	**25**	**30**	**33**	**86.5**	**7.6**	**6.5**
12.5 to < 25.0	7	18	18	78	16.5	12.8
25.0 to < 50.0	4	17	15	69	29.6	20.4
50.0 to < 100.0	1	8	5	54	59.9	32.6

100.0 to< 150.0	*	3	2	47	112.1	52.9
≥ 150.0	*	5	4	58	252.6	146.4
≥12.50	**12**	**51**	**44**	**61.2**	**94.1**	**53.0**
All farms	**100**	**100**	**100**	**78**	**6.2**	**4.8**
Punjab						
<1	10	1	1	92	0.5	0.4
1 to < 2.5	24	5	6	97	1.6	1.5
2.5 to < 5.0	22	10	11	96	3.4	3.3
<5.0	**56**	**16**	**18**	**95**	**1.8**	**1.7**
5.0 to < 7.5	15	12	13	96	5.8	5.5
7.5 to < 12.5	14	19	19	94	9.6	9.0
5.0 to < 12.5	**29**	**31**	**32**	**95**	**7.7**	**7.2**
12.5 to < 25.0	10	22	22	92	16.3	14.9
25.0 to < 50.0	4	17	16	89	30.8	27.3
50.0 to < 100.0	1	8	8	87	61.3	53.2
100.0 to< 150.0	*	2	2	81	114.2	91.9
≥ 150.0	*	4	4	79	235.5	186.0
≥12.5	**15**	**53**	**52**	**85.6**	**91.6**	**74.7**
All farms	**100**	**100**	**100**	**92**	**7.2**	**6.6**

Source: Punjab agricultural census report 2000 *Value less than 0.5

Appendix 2 Questionnaire for the study titled "Determinants of Farm Income and Agricultural Risk Management Strategies: The Case of Rain-fed Farm Households in Pakistan's Punjab

1. Particulars of Respondent

Date__________ Interviewer ____________________ Village__________________

Union Council________________Tehsil_______________ District______________

Name____________________________________ Age____________________ yrs

Education ________________________ yrs Experience ___________________ yrs

2. Land Ownership (Acres)

Area owned_______ Waste land________ Rented in_______ Rented out_________

Shared in__________ Shared out_____________ Operational holding___________

Irrigated______________ Rain-fed_______________

3. Farm Equipment and Soil Type

Farm traction power 1= Bullock, 2= Tractor, 3= Both		Ownership of tractor 1= Own, 2= Rented	
Irrigation source 1= Tubewell/turbines, 2= Small dams, 3= Dug wells, 4= Rain-fed		Water lifting device 1= Peter, 2= Electric motor, 3=Tractor	
Soil Type 1. Clay 2. Clay Loam 3. Loamy 4.Sandy Loam 5. Sandy		Soil Quality 1= Good, 2= Average, 3=Poor	

4. Cropping Pattern

Crops/Veg (*Rabi*)	**Area (ac)**	**Production (Kg/mds)**	**Price (PKR/md)**	**Crops/Veg (*Kharif*)**	**Area (ac)**	**Production (Kg/mds)**	**Price (PKR/md)**
Wheat				Groundnut			
Chickpea				Sorghum			
Lentil				Millet			
Mustard				Maize			
Oat				Guara			
Berseem				Mung			
Barley				Other			
Other				Other			
Peas				Okra			
Cauliflower				Bitterguard			
Turnip				Tinda			
Radish				Bringal			
Carrot				Chilies			
Spinach				Pumpkin			
Onion				Cucumber			
Garlic				Orchard			
Fallow				Fallow			

5. Crop Management Practices

Costs per acre	Unit	Wheat	Chickpea	Lentil	Mustard	Groundnut
Deep plowing	Ac					
Ord. Plowing	No.					
Lavelling 1=y, 2=n						
Leveling	Ac					
Leveling	Hr					
Sowing method	*					
Name of Variety						
Type 1. Old 2. Improved						
Seed rate	Kg					
Seed source	**					
Seed price	PKR					
Sowing time	w/m					
Seed change	Yrs					
FYM applied	Ac					
Trollies/carts	No.					
Urea	Kgs					
DAP	Kgs					
NP	Kgs					
SSP	Kgs					
Other	Kgs					
Other	Kgs					
Irrigation small dams	No.					
Tubewell/dugwells	No.					
Manual weeding	Mda					
Weedicides	No.					
Price	PKR					
Pesticide sprays	No.					
Price	PKR					
Type of diseases						
Economic loss	%					
Harvesting						
Threshing						
Home consumption	Mds					
Byproduct	PKR					

*1=Drill, 2=Pora/kera, 3=Broadcast
**1= Punjab Seed Corporation, 2= Agricultural research station, 3= Seed dealers, 4= Fallow farmers, 5= Own, 6= Other

6. Weather during the Cropping Seasons

Seasons	Weather effect 1. Good 2. Average 3. Bad	Rainfall 1. High 2. Medium 3. Low	Quality destroyed %
Rabi			
Kharif			

7. Farmer's Source of Information

Are you satisfied with the agricultural information received 1. Yes 2. No
Do you watch / Listen Agriculture Programmes on TV / Radio 1. Yes 2. No
Do agriculture extension department visit you 1. Yes 2. No
Frequency of visit: 1. Weekly 2. Monthly 3. Once/season 4. Never
Do you visit to extension office 1. Yes 2. No If Yes
Frequency of visit: 1. Weekly 2. Monthly 3. Once / season 4. Never
Do you visit to agriculture research institute 1. Yes 2. No If Yes
Frequency of visit: 1. Weekly 2. Monthly 3. Once/season 4. Never

8. Sources of Information

Information Type	**Extent of information***	**Source of Information****
Production Technology/Input usage		
Pesticide Spray		
Time of input operation		
New Varieties		
Support Price		
Credit facility		
Market prices		
Crop Insurance		
Government Purchasing points		

*1= Complete Information 2=Incomplete 3=No information at all
**1=TV; 2=Radio, 3=Newspapers, 4=Extension agents, 5=Fellow Farmers, 6=any other

9. Livestock composition

Animal type	**Stock**	**Value (PKR)**	**Sold**	**Value (PKR)**	**Purchased**	**Value (PKR)**
Buffaloes (milk)						
Buffaloes (dry)						
Buff. young stock						
Cow (milk)						
Cows (dry)						
Cow young stock						
Adult goats						
Young goats						
Draft Animals						

10. Fodder Feeding of Animals

Fodder	**Unit**	**Qty. cons./day**	**Price (PKR)**	**Amount (PKR)**
Green Fodder	Maunds			
Wheat Straw	Maunds			
Concentrate	Kg			
Health cost	PKR/Year			
Miscellaneous	PKR/Year			

11. Milk Production and Consumption

Total milk produced (liters/day)_______Milk consumed at home (liters/day)________

Milk Sold (liters/day)_______________ Average Price (PKR/liter)_______________

12. Marketing and Post harvest Handling:

Activity	Crops	Vegetables	Fruits	Milk
*Selling place				
Storage facility 1=y, 2=n				
Marketing in group 1=y, 2=n				
**Market channel				
Price fluctuation 1=y, 2=n				
Processing 1=y, 2=n				
Grading 1=y, 2=n				
***Packing material				
Material cost (PKR)				
Transportation method****				
Transportation cost (PKR)				
Type of Govt support*****				
Type of NGOs support*****				

* 1= At spot, 2= Local Market, 3=City/Wholesale market, 4= Other
** 1=Dealer, 2= Commission agent, 3= Wholesalers, 4= Retailers, 5=Consumers
*** 1=Wooden carton, 2=Jute Bags, 4=Poly bags, 5=Dulls, 6=Loose marketing, 7=Drums
**** 1=Cart, 2=Truck, 3=Tractor trolley, 4=Cycle Rickshaw, 5=Pickup van
***** 1=Financial, 2=Technical, 3=Consultancy, 4=Other

13. Farm Hired Labor

Permanent hired labor________________Nos.
Wage____________________PKR/month
Causal farm labourer_____Nos Hiring Time__________Days
Wage__________PKR/day
Tractor driver_______Nos Hiring Time_______Months
Wage____________PKR/month

14. Credit Availability

1. During the last Kharif season 2008, did you borrow money from any person or institution: 1. Yes 2. No

2. Why did not you borrow money during the last Kharif season 2008

(1) No need (2) Believed would be refused (3) Too expensive (4) Do not like to be in debt (5) Do not know any lender (6) Default in the past (7) Other (Specify)

3. Could you obtain as much as you wanted? (1) Yes (2) No

5. What are the difficulties in obtaining credit? :

(1) Repayment in default (2) No guarantors (3) No valuable security (4) Very far from house to bank (5) I do not know how to obtain credit (6) There is no credit to my requirement (7) Cumbersome procedure (8) Other (Specify)

Source and Amount of Credit Obtained

	Amount (PKR).	Interest Rate (%/year)	Duration (Months)	Purpose of Loan *	Amount Outstanding
Banks					
NGOs					
Relative/friends					
Traders/Dealer					
Other (specify)					

*1= Purchasing inputs, 2= Purchasing farm machinery and equipment, 3= Purchasing food items 4= Marriage of son/daughter, 5= Construction of house, 6=others (Specify)

15. Importance of Different Risk Sources

Options: 1. Strongly disagree, 2. Disagree, 3. Indifferent, 4. Agree, 5. Strongly agree

1. Inadequate rainfall during the year
2. Fluctuation in product prices
3. Fluctuation in input costs
4. Other weather conditions
5. Changes in agricultural policies
6. Epidemics
7. Theft of agricultural produce
8. Accidents or human health problems
9. Crops and animal health problems
10. Marketing dishonesty
11. Lack of marketing opportunities
12. Lack of information sources
13. Inadequate research activities (drought resistant varieties)
14. Inadequate extension services
15. Changes in international policies and economy
16. Natural disasters (excessive frost, hail storm, heavy rainfall)
17. Changes in land prices and rent costs
18. Lack of farmers' cooperatives
19. Fluctuation in interest rates

16. Risk Management Strategies Applied

Options: 1. Strongly disagree, 2. Disagree, 3. Indifferent, 4. Agree, 5. Strongly agree

1. Cooperation of farmers
2. Maintaining inputs/feed reserves
3. Up-to-date market information
4. Monitoring of pests, diseases, crops and prices
5. Weather forecasting
6. Security safeguarding
7. More crop variety, breeds or dual purpose animals
8. Production diversity
9. Irrigation of crops (small dams construction/provision of turbines scheme)
10. Off-farm income sources
11. Debt management monitoring
12. Keeping debt low
13. Contract farming

17. Farm Implements

Implement	No.	Implement	No.	Implement	No.
Tractor		Rotavator		Power sprayer	
Cultivator		Rabi drill		Thresher	
Subsoiler		Kharif drill		Trolley	
Disk plough		Seed cum fertilizer		Electric motor	
Disk harrow		Leveler		Peter engine	
Raja Plough		Laser leveler		Other	
Ridger		Hand sprayer		Other	

18. Education status of family members

Adult Family member		Total	Illiterate	Primary	Middle	Matric	F.A.	Graduate
Adult	Males							
[ ]	Females							

19. On-farm employment status of family members (Adult>15)

Family members		Age (yrs)	Working on-farm 1. Full time 2. Part time	If part time (No. of days/year)	Work/day (hrs)
Adult:	Male				
	Female				

20. Off-farm employment status of family members (Adult>15)

Family members		Age (yrs)	Off-farm Work place*	Off-farm work type**	Off-farm income (PKR/m)
Adult:	Male				
	Female				

*1. Same union council, 2. Same district, 3. Other district, 4. Other province 5. Abroad
** 1. Farm labor on others farm 2. Government civil job 3. Pak Army 4. Private job 5. Private business 6. Job abroad

21. Major problems of overall agriculture

1= land levelling 2= low productivity 3= drought damage/water shortage, 4=damage of pests and diseases, 5=weeds damages, 6=damage by wild animals, 7=difficulty in renting farm machinery, 8=labor shortage, 9=lack of credit availability 10=others (specify)______________

22. Major agricultural marketing problems

1=low selling prices 2=lack of transportation facilities 3=lack of storage facilities
4=problems of product quality 5=lack of packing material 6=lack of farm to market road
7=other (specify)__________

23. Major Problems for purchasing Farm Inputs

1=not available 2= not available when needed 3=available only in small quantity

4=expensive 5=transportation problem 6=lack of finance
7= adulteration in fertilizers 7=adulteration of pesticide 8=black marketing
10=other (specify)

24. Are there NGOs in your area contributing towards improving farm productivity?

1. Yes 2. No If yes what type of help they provide?

1. Provide loan 2. Provide technical help 3. Provide information 4. Organize farmers' days/seminars 5. Demonstration plots 6. Infrastructure development like small dams 7. Any other

Is there any improvement in farm productivity due to NGOs intervention? 1. Yes 2. No

25. Are there Farmers Associations in your area contributing towards improving farm productivity?

1. Yes 2. No If yes what type of help they provide?

1. Provide loan 2. Provide technical help 3. Provide information 4. Organize farmers' days/seminars 5. Demonstration plots 6. Infrastructure development like small dams 7. Any other

Is there any improvement in farm productivity due to NGOs intervention? 1. Yes 2. No

DEUTSCHE ZUSAMMENFASSUNG

Landwirtschaftliches Wachstum hat historisch eine große Rolle in Pakistans Entwicklung gespielt und ist nach wie vor von entscheidender Bedeutung für Wirtschaftswachstum und Armutsbekämpfung. Durch eine stark verbesserte Bewässerungsinfrastruktur und die Zunahme der Anbaufläche konnte der Verlust landwirtschaftlich genutzter Gebiete durch Urbanisierung und Bodendegradation ausgleichen werden. So blieb die landwirtschaftliche Fläche seit der Gründung des Landes (1947) konstant. Kontinuierliches Bevölkerungswachstum ohne Erhöhung der Land- und Wasserressourcen seit 1970 haben allerdings zu einem Rückgang der Pro-Kopf-Ackerfläche und der Wasserverfügbarkeit geführt. Die Entwicklung der Bewässerungswirtschaft kann nicht Schritt halten mit dem Anstieg der Anbauintensität. In diesem Szenario sind Strategien zur Produktionssteigerung sowie zur Erhaltung der natürlichen Ressourcen wichtig. Diese sollten auf der einen Seite, die Nachhaltigkeit der Landwirtschaft und auf der anderen Seite die Lebensmittelversorgung einer wachsenden Bevölkerung sicherstellen.

In den landwirtschaftlichen Bewässerungssystemen Pakistans haben Intensivierung, Monokulturen, konventionelle Bodenbearbeitungspraktiken und Fehlmanagement der Wasserressourcen zur Verschlechterung des Böden und zur Verknappung der Wasserressourcen geführt. Mehr und mehr Indikatoren weisen auf einen Niedergang der Boden- und Wasserproduktivität und eine Erosion der natürlichen Ressourcen hin. Die stetige Bevölkerungszunahme und das langsame Wachstum der landwirtschaftlichen Produktion durch Zerstörung der natürlichen Ressourcen führen zu einer immer größeren Diskrepanz zwischen Angebot und Nachfrage landwirtschaftlich erzeugter Güter. Es ist daher notwendig die Faktoren, die für die insgesamt niedrige Produktivität der Landwirtschaft in Pakistan verantwortlich sind, tiefergehend zu erforschen.

Für die empirische Forschung wurde die Region „*Pothwar*“ ausgewählt. Obwohl die Landwirtschaft in dieser regenreichen Region zum Auskommen reicht, aber gleichwohl durch eine niedrige Land- und Arbeitsproduktivität sowie unstetige Witterungsverhältnisse gekennzeichnet ist, weist sie einige Vorteile gegenüber

künstlich bewässerten Anbauflächen auf. Verglichen mit künstlich bewässerten Flächen ist die Anbauintensität in *Pothwar* um 15% geringer, so dass Bodenstruktur, organische Substanz und natürliche Fruchtbarkeit des Bodens größtenteils bewahrt werden. Die Kluft zwischen dem Gewinn, welcher auf Bauernmärkten erzielt wird und dem was sich an Ertragspotential auf den experimentellen Feldern von Forschungsinstituten ergibt ist im Regenfeldbau größer als in der Bewässerungslandwirtschaft. Dies zeigt, dass diese Gebiete ein deutliches Potenzial zur Erhöhung der landwirtschaftlichen Gesamtproduktion haben, um der ständig steigenden Nachfrage der pakistanischen Bevölkerung nach Nahrungsmitteln gerecht zu werden und Nahrungsmittelimporte zu senken.
In Anbetracht der Bedeutung des Regenfeldbaus analysiert die vorliegende Studie mögliche Gründe für das hohe Risiko der Landwirtschaft, sowie die geringe Produktivität in der Untersuchungsregion. Dabei werden alle Determinanten des Gesamteinkommens der der landwirtschaftlichen Haushalte einbezogen. Außerdem beschäftigt sich diese Studie mit den wichtigsten Risikovorsorgestrategien der Landwirte in der Region. Die Hauptfragestellungen denen in dieser Studie nachgegangen wird, lauten: Wie ist die Wirtschaftlichkeit der wichtigsten Kulturpflanzen in der Region „*Pothwar*“? Was sind die wichtigsten Faktoren des Gesamteinkommens landwirtschaftlicher Haushalte? Welches sind die wichtigsten Risikofaktoren der landwirtschaftlichen Produktion, sowie die Risiko-Bewältigungsstrategien der landwirtschaftlichen Haushalte in den Regenfeldbaugebieten? Welche Faktoren beeinflussen die Produktion des Hauptfruchtanbaus im Untersuchungsgebiet?

Die vorliegende Studie wurde in Pakistan in der Region „*Pothwar* Plateau“ durchgeführt. Im Jahre 2009 wurde hierfür eine Umfrage in den Distrikten Rawalpindi und Chakwal durchgeführt. Zudem wurden Sekundärdaten von Betriebsgrößen, Kulturpflanzen, Produktions- und Ertragszahlen aus verschiedenen Publikationen und Internet-Quellen gesammelt, sowie Wetterdaten der messtechnischen Abteilung des „*Barani* Agricultural Research Institute“ und des „Soil and Water Concervation Research Institute“ zusammengetragen. Um die zu befragenden Landwirte auszuwählen wurde die Methode der gezielten und geschichteten Zufallsstichproben angewandt. Auf Ebene der landwirtschaftlichen Betriebe wurden Daten von 210 landwirtschaflichen Haushalten aus 30 Dörfen aus den drei Unterdistrikten „Chakwal“, „Talagang“ und „Gujar Khan“ aus den Bezirken „Chakwal“ und „Rawalpindi“ gesammelt. Es wurden persönliche Interviews mit Hilfe eines strukturierten Fragebogens geführt zur Datenanalyse wurden die landwirschaftlichen Haushalte ihrer Größe entsprechend in folgende Gruppen eingeteilt: kleine Betriebe (<2 ha), mittlere Betriebe (2-5 ha) und Großbetriebe (> 5 ha).

Größtenteils für den Eigenverbrauch werden als Hauptfrucht Winterweizen, Kichererbsen und Linsen angebaut. Für den Erwerbsanbau spielen Erdnüsse die größte Rolle. Daneben betreiben die Bauern Viehwirtschaft und bauen im Zuge dessen Senf und Hirse als Viehfutter an. Diese Studie analysiert landwirtschaftliche Produktionskosten und Rentabilität, sowie den finanziellen Beitrag zum Gesamteinkommen bäuerlicher Haushalte. Die vorherrschenden Marktpreise der wichtigsten Inputs sind zur Abschätzung der Herstellungskosten verwendet worden. Der Gesamtumsatz pro Hektar wurde ermittelt durch die Aufsummierung der Erlöse aus allen Kulturen und der Viehhaltung, geteilt durch die landwirtschaftliche Nutzfläche. Die Bruttomargen der Höfe bestehen aus den Werten von allen Feldfrüchten und Viehbestand, die zusätzlich zur Bruttomarge addiert wurden. Der Nettogewinn wurde durch Abzug aller indirekten oder Fixkosten (Grundrente und Zinsen) von den Bruttomargen berechnet.

Die lineare Form der „Cobb-Douglas-Produktionsfunktion“ wurde eingesetzt, um den Zusammenhang zwischen verschiedenen erklärenden Variablen und den landwirtschaftlichen Einkommen (abhängigen Variablen) zu untersuchen. Die gleiche Produktionsfunktion wurde verwendet um die Determinanten von Weizen, Erdnuss, Erbsen und Senf pro Hektar Ertrag herauszufinden. Mit Hilfe einer Likert-Skala wurden die Daten in Bezug auf landwirtschaftliche Präferenzen der Haushalte im Bezug auf landwirtschaftliche Risikoquellen und Risikomanagement-Strategien dargestellt. Faktoren wurden auf Basis der Höhe ihrer Faktorladungen mit den Likert-Skalameßdaten dieser Variablen benannt.

Die Ergebnisse zeigen, dass die durchschnittliche operative Betriebsgröße 5,16 ha beträgt. Insgesamt 22 % der Betriebe gehören zur Kategorie der Kleinbetriebe, während 40 % zur mittleren Größenkategorie und 38% zur Gruppe der Großbetriebe gehören. Die durchschnittliche Betriebsgröße für kleine Betriebe betrug 1,19 ha, für mittlere 3.27 und für große Betriebe 9 ha. Die Befragten gaben an, dass durchschnittlich nur 9% der Nutzfläche bewässert wird. Weizen, Erbsen, Linsen und Senf sind die wichtigsten Winterkulturen; sie machen 66% der landwirtschaftlichen Gesamtfläche in der Wintersaison aus. Fast ein Drittel (32%) der landwirtschaftlichen Nutzfläche lag in der Wintersaison 08/ 09 brach. In der Sommersaison belegten Erdnüsse und Hirse rund die Hälfte der gesamten landwirtschaftlichen Fläche. Die wichtigste zum Verkauf bestimmte Frucht im Sommer ist die Erdnuss in allen drei Sub-Distrikte des Untersuchungsgebietes. Im Sommer liegt die Hälfte (48,4%) der landwirtschaftlichen Nutzfläche brach. Die Anbauintensität wurde auf 120% und die Vielfalt der Kulturpflanzen im Rahmen des „Crop diversity index“ auf 3,06 geschätzt. Für 99% der Landwirte ist der Traktor das einzige landwirtschaftliche Nutzungsfahrzeug. Insgesamt 62 % Bauern mieten Traktoren, während 38 % ihren eigenen besitzen.

Die außerlandwirtschaftlichen Einkommen waren am höchsten (275.220 PKR / Jahr) bei den Eigentümem großer Betriebe und am niedrigsten, bei denen mit mittleren Betrieben (221.129 PKR / Jahr). Insgesamt stieg das landwirtschaflische Einkommen von knapp 0,33 Mio. Pak R. pro Jahr bei kleinen Betriebsgrößen und auf fast 0,64 Mio. Pak R. p.a in großen Betrieben. Insgesamt liegt der Anteil der Ernte von Kulturpflanzen als Einkommen des gesamten landwirtschaftlichen Einkommens bei 40 Prozent. Dieser Anteil ist höher (51%) in großen Betrieben als bei kleinen und mittleren Betrieben (41 und 30%) im Vergleich. Dies zeigt, dass Großbauern mehr vom Einkommen aus der Ernte der Kulturpflanzen abhängig sind, während kleine und mittlere Betriebe stärker abhängig sind vom Einkommen aus der Tierhaltung. Nach den Ergebnissen der ökonomischen Analyse auf Betriebsebene sind die Gewinnanteile höher für Großbauern (94,5%) als für kleine und mittlere Bauern (72,3 und 73,5%). Zu den wichtigsten Marktfrüchten im Untersuchungsgebiet zählt die Erdnuss, da aufgrund der niedrigen Produktionskosten damit hohe Reingewinne erzielt werden können. Im Bezug auf die Analyse der Produktivität sind die Bauern im „Chakwal“ Sub-Distrikt produktiver im Hinblick auf die totale Faktoren, Arbeit und Boden. In der gesamten Untersuchungsregion sind Kleinbauern produktiver in der

Nutzung von Arbeit und Boden, jedoch sind Großbauern wirtschaftlicher im Hinblick auf die totale Produktivität.

Zu den wichtigen Risikofaktoren die von den Landwirten genannten wurden, gehören der Mangel an Informationen, aufgrund der unzureichenden Beratungsmöglichkeiten, die unzureichenden Niederschläge, Fluktuation der Input-Kosten-, Marketing-Unehrlichkeit, mangelnde Vermarktungsmöglichkeiten, unzureichende Forschungsaktivitäten, Naturkatastrophen und Fluktuation der Produktpreise. Die wichtigsten Strategien für das Risikomanagement sind der Bau kleiner Dämme mit Turbinensystemem, präzise Wettervorhersagen, aktuelle Marktinformationen, nebenlandwirtschaftliche Einkommensquellen und eine Produktionsvielfalt. Insgesamt sieben wichtige Faktoren sind als landwirtschaftliche Risiken durch die Faktorenanalyse herausgearbeitet worden. Zu diesen Faktoren zählen die Risiken des unvollkommenen Marktes, Katastrophen, Mangel an Informationen, Wetter und der Mangel an Versicherungen, Preisrisiken, Dürre und Krankheiten, und finanziellen Risiken. Die sechs Faktoren für die Risiko-Management-Strategien umfassen, Planung und Politik, Verbesserung der Infrastruktur, Forschung und Information Management, Diversifizierung und Beschäftigungsmöglichkeiten außerhalb der Landwirtschaft für die nächste Generation, Finanzplanung und -sicherheit, und Input-Management. Die landwirtschaftlichen Haushalte wurden in drei verschiedene Gruppen unterteilt, die auf Grundlage der „Cluster-Analyse“ für Risikofaktoren durch die Faktorenanalyse identifiziert wurden. Diese Gruppen wurden als risikoscheu, risikoneutral und risikofreudig nach ihren Einstellungen gegenüber verschiedenen Risikoquellen benannt.

Im Folgenden werden einige wichtige Empfehlungen genannt, um den Gestaltern der Politik und den Entwicklungsplanern des ländlichen Raums die Möglichkeit zu einer Verbesserung der Einkommenssituation der Landwirte der Region beizutragen:

- Die Regierung hat in einigen Gebieten, wo dies möglich ist, kleine Dämme gebaut, aber diese decken nur einen kleinen Teil des gesamten Areals ab. Bestimmte Bereiche in den Bezirken „Chakwal“ und „Rawalpindi“ mit natürlichem Gefälle und idealer Topographie sind am besten für den Bau von mehreren kleinen Staudämmen geeignet. Außerdem laufen Turbinensysteme erfolgreich in den Regionen, die über genügend Grundwasser verfügen. Die Zahl dieser Turbinensysteme könnte erhöht werden, indem man die Landwirte der Region subventioniert. Die Traktoren sind auch sehr wichtig für die Landwirtschaft der Region, da die Kosten der Landbearbereitung den größten Teil der Gesamtkosten der Produktion von wichtigen Kulturpflanzen ausmachen. Die Bearbeitungskosten für die Landwirte können deutlich gesenkt werden, indem man ihnen Subvention für den Kauf von Traktoren zur Verfügung stellt.

- Die Region „*Pothwar*“ hat ein großes Potenzial zur Erhöhung der gesamten landwirtschaftlichen Produktion durch die Verbesserung der Forschungskapazitäten und der Verbreitung von verbesserten landwirtschaftlichen Produktionstechnologien durch verbesserte landwirtschaftlich beratende Abteilungen. Die Abteilungen können durch die Verbesserung der Beratungstruktur und der Gehälter der Beamten und Hilfskräfte verstärkt werden. Die Forschungsaktivitäten vor allem für die Entwicklung von mehr trockenheitsresistenten Sorten, verbesserte Fertigungstechnologien für hochwertige Pflanzen und ertragreichen Mehrzwecktieren (Fleisch und Milch) kann durch eine Erhöhung der Mittel für Forschungseinrichtungen der Region verbessert werden.
- Verbesserte Wettervorhersagen und Verbreitungsmechanismen können den Landwirten bei der Planung ihrer Bodenbearbeitung und ihrer Fruchtfolgen, entsprechend der zu erwartenden Regenmenge während der Saison, helfen. Das „Pakistan Meteorological Department“ sollte gestärkt werden, indem sie mehr Geld für den Kauf von neuer Ausrüstung im Bereich der Wetterforschung erhalten. Darüber hinaus sollte die Koordination mit den landwirtschaftlichen Forschungs- und Beratungsabteilung für eine effektive Nutzung der Wettervorhersage für die Planung von landwirtschaftlichen Kulturen verbessert werden. Die Bereitstellung der lokalen und aktuellen Wetterinformationen für die Landwirtschaft könnte zur Verbesserung der landwirtschaftlichen Produktion durch bessere Ernteplanungen führen.

- Die Gründung von kleinen und mittleren Unternehmen (KMU) für nebenlandwirtschaftliche Einkommensquellen kann die Produktivität der Arbeit erhöhen, bei gleichzeitiger Verringerung der Belastung durch übermäßige Arbeit mit Kulturpflanzen. Darüber hinaus könnten die Einnahmen aus den KMU produktiv in die Landwirtschaft mit hochwertigen Pflanzen reinvestiert werden. Auf der Makro-Ebene kann dies dazu beitragen, die unterbeschäftigten Arbeitskräfte zur Steigerung des BIP und der Exporteinnahmen des Landes zu nutzen.
- Die Regierung sollte die großen Firmen und Supermärkten davon überzeugen, direkt mit den Landwirten die Produktion von hochwertigen Nutzpflanzen zu vereinbaren. Dies könnte einen höheren Verkaufspreis für die Landwirte sichern, indem die Zahl der Zwischenhändler und die Höhe der Margen reduziert und die Preisfluktuationen gedämpft werden.
- Landwirte der Umgebung haben nur kleine Betriebe und können daher nicht damit umgehen, ihre geringen marktfähigen Überschüsse bei erschwinglichen Transaktionskosten zu verkaufen. Dadurch sind sie im Großhandel nicht wettbewerbsfähig. Kooperative Vermarktung könnte ihren Nettogewinn erhöhen durch stärkere Verhandlungsmacht gegenüber Aufkäufern und eine Verringerung der Transaktionskosten pro Einheit.

Besondere Kredite mit vergünstigten Zinssätzen sollten den Landwirten in Bereichen mit Regenfeldbau bereitgestellt werden. Das könnte die Landwirte dazu anreizen, mehr in den landwirtschaftlichen Sektor zu investieren. Diese erhöhten Investitionen und eine effizientere Produktion könnten die Einkommen der Landwirte verbessern und zu einer ausreichenden Versorgung mit Nahrungsmitteln beitragen.

The research presented in this book explores the reasons for the low productivity of rain-fed agriculture and risky nature of agriculture of Pothwar region with focus on the determinants of overall farm income and major crops yield. The results show that operational land holding is inversely proportional to per acre farm income. The area irrigated, off-farm income, the number of livestock, cost incurred on livestock, hired labor, and tractor ownership show significant positive effects on farm income. Irrigated area and respective prices of crops has positive affect on yield of major crops of area.

The seven important factors for agricultural risk sources include imperfect market risks, catastrophe, lack of information risks, weather and lack of insurance risks, price risks, drought and disease risks, and financial risks. The six factors sorted for risk management strategies include planning and policy, infrastructure development, research and information management, diversification and off-farm employment generation, financial management and security, and input management. The farm households are categorized into three distinct groups on the basis of risk factors' cluster analysis according to their risk attitudes towards different risk sources. These three groups of farmers are named as risk averse (49.5 % farmers), risk neutral (31.0 % farmers) and risk seekers (19.5 % farmers).

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