Impact of Climate Change on Milk Production: Evidence from Rural Pakistan

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Certificate

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To My

Beloved Abbu (Late), Ami,

Brothers and Sisters

Certificate of Originality

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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Abstract

Climate change is the major threat and big challenge to mankind. The change in climate not only affects the crops sector, but livestock sector is also affected by the climate change. In Pakistan, the most of research is undertaken regarding impact of climate change on crops sector and little attention has been paid to examine its impact on livestock sector. Therefore, the main objective of this research is to study the impact of climate change as well as farmers' membership of the projects [Special Program on Food Security (SPFS) and Crop Maximization Program (CMP)] on milk yield in rural Pakistan. Study uses household survey data for 322 farmers who were involved in crop as well as livestock production activities in the project area. The results are suggestive that precipitation has a non-linear (U shaped) relationship with milk yield. Similarly, temperature also is related to milk yield in similar fashion (U shaped relationship). The variables like value of milking animal, use of concentrates, use of catalysts, and green fodder acreage per animal (adult units) have significant and positive impact on milk yield. The number of lactation months is found adversely related to milk yield. Age and education of head household, and credit availability to farmers turned out to be important determinants of project membership status of the farmers. The results are indicative that farmers' participation in the project had insignificants effect on milk yield.

CHAPTER 1

Introduction

Climate change is one of the gravest environmental challenges faced by humanity today. The causes and effects of this horrible change in addition to the potential solutions to this challenge, cut across each nation, and sector of the economy, eventually affecting human being (Hardy, 2003). Climate change has become the global issue now and Stern Review Report (2006) on the economics of climate change emphasizes that, at more modest levels of warming, the detailed studies of regional and sectoral impacts suggest that climate change will have serious impacts on world output, on human life and on the environment (Jeswani et al., 2008). Global surface temperature has increased ≈0.2°C per decade in the past 30 years (Hansen et al., 2006). The rise in global temperature is mainly attributed to significant increase in greenhouse gases (GHGs) especially carbon dioxide (CO_2) and Methane (CH_4) (Scafetta, 2010). Agriculture sector contributes as well as is affected by climate change. Livestock production is responsible for about one-fifth of total GHG emissions, and the climate change have a negative impact on health and food yields (McMichael et al., 2007). With changing climate the occurrence, in greater frequencies, of extreme events like storms, cyclones, floods, droughts, and changing rainfall patterns has been observed in various regions adversely affecting the crop and livestock productivity (Thornton et al., 2009).

The climate change has serious implications for various sectors of the economies including more importantly crops, livestock, and human health. The most damages are predicted to occur in developing and under developed countries because of their over reliance on low-input rain fed agricultural production. The majority of rural people in these countries usually also depend on livestock production heavily for their livelihoods. The livestock sector has been reported to be quite sensitive to climate change (Moreki et al., 2013; Musemwa et al., 2012). Climatic impacts like, on water availability, agricultural incomes, food security, and shift in production area of food and non-food crops across the world affect the welfare of the poor in rural areas having limited access to land, modern agricultural inputs and education (IPCC, 2014).

Climate change has direct and indirect impacts on livestock production. Livestock are homo-therms and regulate their body temperature within a relatively low range to keep on healthy and productive. The ambient temperature above or below the thermo-neutral range creates stress conditions on animals rise in temperature with humid conditions can cause heat stress in livestock that induce behavioral and metabolic changes, and reduce feed intake (Sirohi et al., 2007). Heat stress is known to alter the physiology of livestock and this one is significant factor in determining specific production environments today. With changing scenarios temperature is predicted to rises globally and with reduction in precipitation in many regions, especially in arid regions (Hoffmann, 2010). This would result in the direct effects associated to change in temperature and rainfall pattern. It would also have indirect effects through changes in feed resources associated with the carrying capacity of rangelands, the buffering abilities of ecosystems, intensified desertification processes, increased scarcity of water resources, and decreased grain production etc. Moreover, certain effects are also linked to the expected shortage of feed arising from the increasingly competitive demands of food, feed and fuel production, and land use systems (Moreki & tsopito, 2013). These associations have bearing on the physiology of the animal and influence the animal performance, for example growth and milk production. Heat stress leads to decline in milk production of dairy animals. Milk production and reproduction losses during the summer significantly influence the economic potential of dairy animals. Environmental factors like temperature, rainfall and air movement all are important for dairy animals (Zewdu et al., 2014).

The vulnerability of Pakistan due to climate change is quite high as most of the population is heavily dependent on natural resources and its agriculture sector (Mustafa, 2011). More than half (53 %) of people of Pakistan are of the opinion that life has got worse in past five years, within those 43 percent believed that there was increase in extreme weather events in the country. For instance the crops production is affected by this erratic rainfall that is resulting in reduced availability of water for drinking and irrigation purpose. Due to climate change there is also increase in pest attacks and incidences of diseases which have an adverse effect on both agriculture and the health of people and livestock. The main climatic changes observed in Pakistan are variation in temperature, change in rainfall patterns, shift of season periods, and intrusion of saline water. Along with these, there has been increased occurrence of extreme events like floods during 2008, 2010, and almost every year since then have affected various regions in Pakistan adversely affecting crop productivity, food availability and farm incomes

The agricultural sector in Pakistan is still among the most important sectors of the economy, as livelihoods of about 70 percent of the rural population, directly or indirectly is linked to this sector (Nomman Ahmed et al., 2011). Pakistan’s livestock is the major sub-sector of the agriculture sector and provides essential items of the human diet in the form of milk, meat and eggs etc. Livestock contributes about 56 percent in value added agriculture sector and 12 percent in GDP of Pakistan (Government of Pakistan, 2014) and is an important source of foreign exchange earnings. The foreign earning from the livestock sectors go beyond 35 billion rupees annually (about US$ 707 million). Pakistan has been ranked as world's second largest milk producer (FAO, 2012). The annual per capita production of milk in the country is 230 kg. The value of milk alone is greater than the combined value of wheat and cotton, and also from combined value of sugarcane and rice (Ahmad et al., 2012). It is observed that milk had a value addition about 60 percent higher as compared to that added by wheat, cotton together and twice as higher as that of sugarcane and rice combined (Bilal et al., 2005). Despite its significant contribution in terms of value addition, milk production in Pakistan failed to fetch the due attention as an important enterprise in research and development agenda.

Livestock also play significant role in employment generation in the rural areas and about 20 to 25 million of rural people are engaged in livestock related activities with an average livestock herd size of 2 to 3 large ruminants (cattle and buffaloes) and 5 to 6 small ruminants (sheep and goats) per household accounting for 30 to 40 percent of family income (Khan, m. j. et al., 2013). The total milk production in the country stands at about 51 billion liters during 2013-2014 (Government of Pakistan, 2014; Zia et al., 2011) The recent population of livestock in the country is 32.7 million buffaloes, 35.6 million cattle, 28.1 million sheep, 61.5 million goats and one million camels (Khan, m. j. et al., 2013). The livestock sector is the mainstay of agriculture sector though remained a neglected sector. The sector is performing a major role in the national economy as it provides, draught power, high in biological value animal proteins and valuable byproducts such as hides, skin, wool, mohair, bones, and manure (Sarwar et al., 2002).

Recent estimate shows that due to the floods in 2010, there was slow growth in agriculture sector whereas livestock sector growth was 3.7 percent as compared to agriculture growth which is 1.2 percent. (Khan, m. j. et al., 2013)

Pakistan is among the main milk producing countries but is also one of the largest consumers of milk. Therefore, total milk production is not sufficient to fulfill the needs of population. Rapid growth rate of human population has outweighed the overall increase in the milk production (Bilal et al., 2006). Country's population has increased from 65 to 165 million over the past 3 decades and is forecasted to increase to 234 million by 2025 (Zia et al., 2011). The milk yields are quite low in Pakistan and major increase in milk production sources out from increase in total number of milk producing animals (Khan, m. j. et al., 2013).

Excessive heat and humidity causes heat stress in dairy animal resulting in reduced milk production (Mauger et al., 2015). The rise in temperature decreases the feed intake adversely affecting milk yield. It declines significantly as the summers set in after winters and recovers with the onset of rainy seasons (Sirohi & Michaelowa, 2007). With increase in milk yield of dairy cattle, the metabolic heat production has observed an increase and the ability to tolerate raised up temperatures has dropped (Dikmen et al., 2009). In longer term, solitary characteristic of selection for increased yields will cause the lower heat tolerance in animals. Measurement of the heat effect and other stressors is difficult. So for that the effect of heat stress on milk yield at specific time (specific seasons) is more immediate and easier to measure (Zumbach et al., 2008). Some adaptive strategies to control the loss of milk production due to heat stress include shading, wetting, increase in air circulation, air conditioning and livestock shelters (Rotter et al., 1999). Selection of species/breed is also one of the main adaptive strategies to deal with climate change (Kabubo-Mariara, 2008) because according to Eding (2008) breed is a cultural rather than a biological or technical entity. The breed is group of animals which have similar characteristics, that depend on geographical area and origin (Hoffmann, 2010). The selection of livestock species/breed having tolerance to heat stress may be more profitable for farmers.

1.1) Significance of Study:

Climate change has adverse impact on yields of different crops and also on performance of livestock including milk yield in different areas of the world. Most of the available literature on the subject mainly focused on estimating the effect of climatic factors on performance of crops (in terms of yields or net revenues) and impact of adaptation strategies adopted by the farmers to reduce the productivity losses (Deressa et al., 2011; Di Falco et al., 2009; Mandleni et al., 2012; Mauger et al., 2015; Singh et al., 2012). However, studies regarding the subject conducted in Pakistan have been scanty and narrow in scope in general and in particular those examining the impact of climate change on productivity of livestock. The lack of secondary data needed for such studies has been the main reason behind this neglect. The primary data collected through farm level surveys can provide a rich source of data. One of such surveys was conducted at Pakistan Institute of Development Economics (PIDE) during the year 2006. The main objective of the survey was to evaluate FAO sponsored Crop Maximization Programme and Special Programme on Food Security implemented in various districts of Pakistan. However, the survey also covered livestock production practices of the farmers interviewed. The survey data mapped with data on climatic factors (temperature and precipitation) shall provide a rich data to study the impact of climate change on milk production in the study area. The proposed study aims to estimate the effect of climatic variables (temperature and precipitation) on milk yield in rural Pakistan under the changing scenario of climate

1.2) Objective of the Study:

The purpose of this study is to analyze the impact of climate change on milk yield in the study area by using the survey data of Crop Maximization Program (CMP) /Special Program on Food Security (SPFS) conducted by Pakistan Institute of Development Economics (PIDE) during May-July of 2006. The more specific objectives of this study are to:

- quantify the impact of climatic factors (temperature and precipitation) on milk yield;
- study impact of the project on milk yield; and
- suggest policy recommendation based on empirical findings.

1.3) Hypotheses of the Study:

The specific research hypotheses that this study would test, in context of the climate change impact, include the following:

H_o: Overtime changes in climatic factors (temperature and precipitation) do not have significant effect on milk production.

H_1: Overtime changes in climatic factors (temperature and precipitation) have significant effect on milk production.

Ho: The project has no significant effect on milk yield.

H_1: The project has significant effect on milk yield.

1.4) Organization of Study:

To discourse our given objectives, our study proceeds in the following way. Chapter two presents literature review of the important studies on climate change and its impacts on milk production when controlled for the effect of other explanatory variables. Chapter three is about the methodological framework for explaining the impact of climate change on milk production. Chapter four states various sources of data used in this study, explains the construction of the variables and gives discussion about empirical model to be estimated. Estimation of the empirical model and discussion of the results is the subject of chapter five. The last chapter concludes and suggests policy recommendations.

CHAPTER 2

Review of Literature

1.1) Introduction:

There is significant literature available on climate change and dairy industry regarding different countries and regions. These studies vary in scope, time and space along with methodological frameworks applied. This chapter presents the review of existing literature related to the topic.

Moreki and tsopito (2013) explored the effect of climate change on dairy production in Botswana. The simulated results are suggestive that temperature (minimum and maximum) will increase over time and across the seasons causing decline in livestock productivity and increase in incidence of diseases due to climate change in Botswana. Similarly, evidence showed rainfall had declined over the period 2008 to 2037 resulting in decreased grazing resources and declined Stover availability which is used as feed in dry season.

Zewdu et al. (2014) evaluated the effect of macroclimate factors on milk production and reproductive efficiency of Holstein Friesian × Deoni crossbred cows in India. They used data of climatic variables for the period 1981-2010 and various parameters recorded for 256 crossbred cows with a total of 1485 lactations under the Marathwada Agricultural University Cattle Cross Breeding Project (CCBP). They also used the temperature humidity index as a measure of heat stress on the dairy animals. The regression estimates showed that crossbreed cows were sensitive for seasonal changes in terms of milk production and reproduction performance. A decline in milk production was observed on account of high values of temperature humidity index (THI) during the period of seven months (March- September).

Mauger et al. (2015) have studied impact of climate change on milk production in the United States using high resolution ($1/8^0$) gridded temperature and humidity data for the period from 1950 to 1999. They employed Global Climate Model based on projected temperature (for 2050s and 2080s) to analyze the relationship between heat stress and milk production losses in United States Holstein dairy cows. The outcome of study showed that the estimated production loss due to climate change was 1.9 percent and that would increase in future up to 6.3 percent, which was equivalent to $670 million per year and will rise to $2.2 billion per year by the end of the current century.

Mandleni and Anim (2012) studied the factors which affected the decisions to adapt to climate change made by small scaled cattle and sheep farmers using data collected from 500 households belonging to 3 districts in Eastern Cape of South Africa. The results of binary logistic regression model are suggestive that factors like non-farm income, livestock ownership, and annual average temperature affected the adaption decisions.

Singh et al. (2012) studied impact of climate change on livestock and adaptation strategies for sustaining livestock production using data collected from 120 respondents. The study covered two agro climatic region of India namely Western Himalayan Region and Middle Gangetic Plan Region. The results are suggestive that respondents were aware that climate change was happening, and this had negative impact on performance of livestock. An adverse effect of climate change on milk production and lactating length was respectively noticed by about 57 and 58 percent households. The most common adaptive strategies adopted by the farmers included storing fodder in form of Hay in extreme cold season and providing cold water along with shady place in hot season.

Deressa et al. (2011), studied the major factors which influence the farmers' decisions to adapt to climate change in Nile Basin of Ethiopia. The study is based on primary data collected from 1000 farm households involved in crop and livestock production during 2004-05. The Heckman sample selection model estimates are suggestive that the adaptation decisions of farmers were related to the age, wealth, and knowledge of the household regarding climate change. The factors which significantly affected the adaptation to climate change decisions included education of household head, family size, availability of credit, and temperature.

Di Falco et al. (2009) studied the determinants of adaptation to climate change and its implications for food production in Ethiopia using data collected from 1000 rural household in Nile Basin of Ethiopia. They used pseudo fixed effect and two stage least square models for their analysis. The outcome of the study show that climate change and climate change adaptation had significant impact on farm productivity. Extension services and access to credit, information on future climate changes affect adaptation positively and significantly.

Kabubo-Mariara (2008) used Probit model to study the impact of climate change on the decision of farmers to engage or not to engage in livestock activities. The results based on data collected from 816 farm households from 38 districts of Kenya during 2004 and secondary data regarding climatic factors are suggestive that a non-linear relationship exists between global warming and decisions to engage in livestock production. Further, the impact of temperature was greater than that of precipitation.

Sirohi and Michaelowa (2007) presented the review of the studies addressing the question what happened to livestock sector in the past due to changing climate scenario in India. They included research conducted by various authors on different aspects of climate change and livestock covering 25 districts of India. It is concluded that climate change and livestock both affect each other. Livestock produce Methane gas which was the main component of global warming. Due to which temperature increased, rainfall pattern changed and resulting feed/fodder shortage along with increase in heat stress caused decline in milk productivity.

Kadzere et al. (2002) studied the factors which influenced the heat stress in lactating dairy cows and examined effect of the heat stress on milk production. They used data for the period 1935-1997 regarding 100 countries of United State and found that increase in temperature (Hot Weather) had negative impact on milk production.

Rotter and Van de Geijn (1999) reviewed various approaches used to examine the impact of climate change on plant growth, crop yield and performance of livestock. Most of the studies have used crop simulation model in combination with agro-ecological database. The results show that crop and livestock both had nonlinear relationship with changing climate. But livestock had some positive point that the animals can move to some place to save them from sun heat (shady place) or heavy rainfall. So impact on livestock of climate change was less as compared to crops.

The above literature show that earlier studies dealing with the impact of climate change on livestock and especially milk yield are related to countries other than Pakistan (Mauger et al., 2015; Moreki & tsopito, 2013; Zewdu et al., 2014). These studies conclude that increase in temperature level and changing rainfall pattern had negative impact on livestock productivity. These studies also show that farmers adopt certain adaptation strategies to avoid the adverse impacts (Deressa et al., 2011; Di Falco et al., 2009; Singh et al., 2012). In given literature used different estimation techniques to estimate the impact of climate factors and the adaptations to climate change. (Deressa et al., 2011) used Heckman Sample Selection Model and (Di Falco et al., 2009) used Pseudo Fixed Effect and Two Stage Least Square Models in their studies. However, there is not much of literature available on how Pakistan’s livestock sector is being affected by climate change and what is happening to milk production as a result of change in climate. This research is aimed at to fill this gap.

CHAPTER 3

Methodological Framework

3.1) Introduction:

There are different factors which affect milk yield, for these factors we give some schematic diagram in this chapter, which indicates the factors including climatic factors that affect milk yield in rural Pakistan. Later section includes theoretical framework for milk yield and climate change model.

3.2) Schematic Diagram:

This diagram guides us to find out that how milking yield is affected by different factors. The direct and indirect factors which affect the milk yield are shown in Figure 3.1. The direct factors affecting mild yield includes breed; use of concentrate feeds, green fodder, and catalyst (salt and gur); and length of lactation period in months (Aktürk et al., 2010; Laben et al., 1982; Ngongoni et al., 2006; Ploumi et al., 1998). The breed (Local, Cross or Exotic) and type (specie) of animal (Cow or Buffalo) play vital role in milk production because environment condition varies from place to place and one type of breed never fits in all conditions. So one should be careful about the selection of animal because this selection helps the farmer to get good milk production. Concentrate is one of the main and most important factor in milk production because it contains balanced diet for animals, which directly helps in increase of milk production. Along with concentrate, green fodder is also important. The concentrates and green fodder mixed with each other in proper proportion fulfill the animal nutritional requirement and have a positive impact on milk yield. In Pakistan dairy animals are commonly fed roughages, green grass and leaves, and other feeds which have thick cell wall and large amount of cellulose in them and which are hard to digest. Farmers feed their animals with salt and gur/molasses as catalyst to speeds up the enzymes to help in digestion process of such feeds. After feed, animals usually lick salt stone, and gur mixed in feed to help in develop taste as well as help in digestion. When food digested properly, animal will give good milk which is better in quality and quantity as well. Another factor which directly relates to milk production is lactation months. After parity (gravidity) animal milk production goes in increasing trend for some period (up to few months) and then declining afterwards as the time passes.

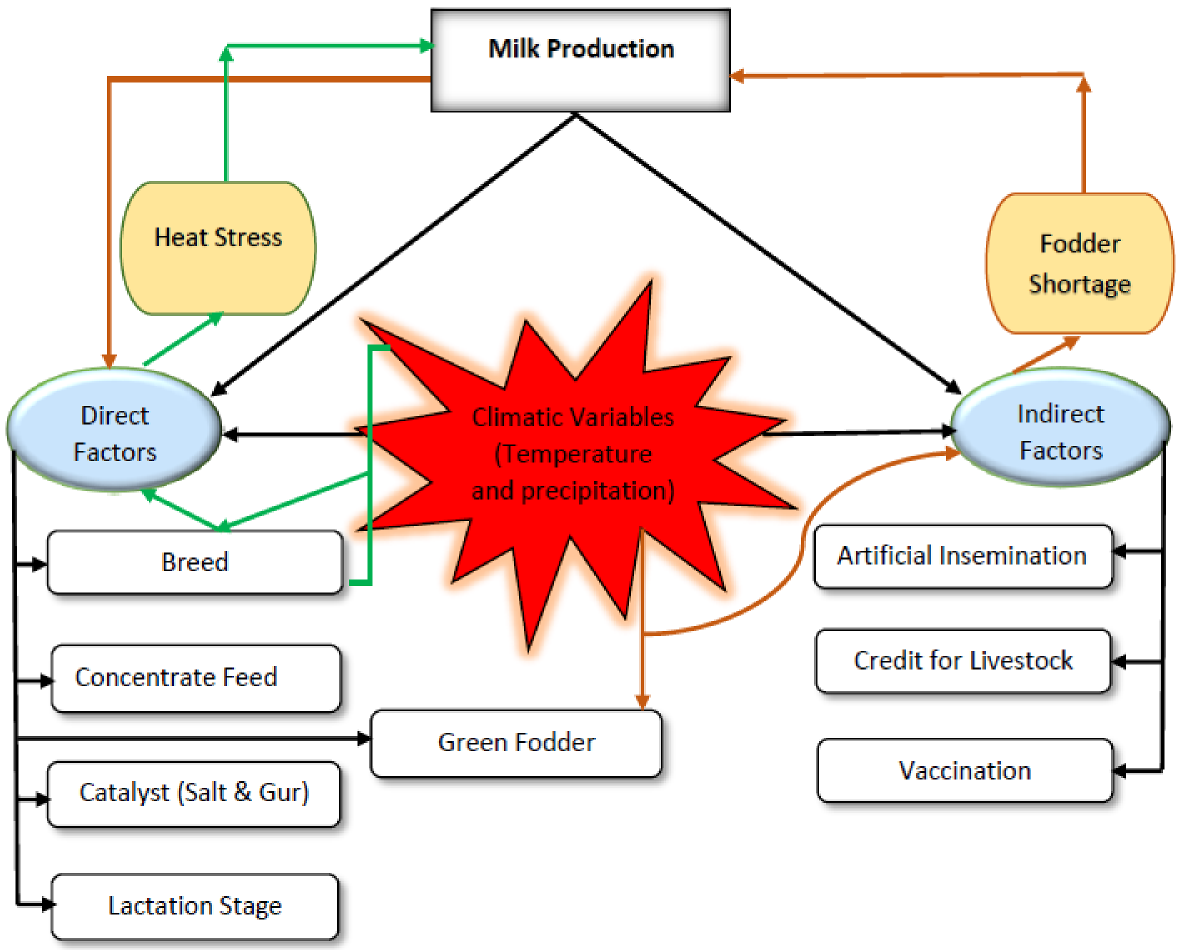

Figure 3.1: *Different Factors Influencing the Milk Yield*

On the other side there are some indirect factors which relate to milk yield. These include adoption of Artificial Insemination (AI), use of credit for livestock, and vaccination of animals (Aktürk et al., 2010; Lucy, 2001). These factors play role in milk production in following ways. First, through AI we can get better and suitable to environment breed, which can have ability to adjust with environment. Second through AI best quality of two breeds (say stress tolerance and high milk yield) can be transferred to an improved one breed (cross breeds) thus leading indirectly to good milk yields. Third, AI results in higher conception rate (Lucy, 2001) and thus increased milk production. Fourth, farmers need money to finance purchases of various inputs and services and usually thy lack such resources thus availability of credit play a vital role – when credit is available to the farmers they will give better and controlled environment by using technology. This will definitely help in milk production. Fifth, proper control of diseases through timely vaccination can enable farmer to avoid losses in milk production and animal deaths by securing their animals from disease attacks. The outbreak of various diseases often results in heavy losses to farmers in Pakistan due to reduced milk yields and even death of animals.

The last, besides above mentioned factors (direct and indirect), climatic factors are highly important which affect the milk production in both way direct and indirect way (Sirohi & Michaelowa, 2007). As shown in the diagram that links various direct and indirect factors to milk production, climate change (increase in temperature) has direct effect on dairy animal which causes heat stress (Hoffmann, 2010; Lucy, 2001). On other side, this change in temperature and pattern of rainfall causes disaster changes like flood and drought which result in shortage of fodder for animal (Moreki & tsopito, 2013) and when there is no food, how animal can perform in efficient way, thus this factor also decreases the milk production indirectly (Sirohi & Michaelowa, 2007).

3.3) Theoretical Framework:

There are three main approaches to study the impact of climate change on agricultural production (crops and livestock), which are Ricardian approach, production function approach, and agronomic crop simulation models.

The first, Ricardian approach attributed to David Ricardo (1772-1823) relies upon the standard theory of land rents, which stated that "land rents reflect the net productivity of farmland". The approach has been frequently used by researchers to examine the impact of climatic factors and other variables on farm revenue form livestock and land value (Kabubo-Mariara, 2008). Theoretical pinning of Ricardian framework showed that land value is the implicit value of discounted profit received by land which is represented by land rent. Land rent for any agricultural land depicts the productivity of land, location of land etc. Mendelsohn et al. (1994). Few limitations of Ricardian approach as pointed out by (Schlenker et al., 2006) critiques on the Ricardian approach that this have failure to account the cost of adjustment to climate change, so this underestimate the impact of climate change and omitted variables bias or model specification. Another critique on Ricardian approach is that it uses the wide farm level data which is usually not available in developing countries. (Schimmelpfennig et al., 1996), stated that Ricardian model doesn't assess how the climate change effect might be distributed among agricultural producers and consumers. The Ricardian rents don't provide information about the welfare implications of climate change.

Second, approach is Agronomic Approach and is usually used in analysis of the impact of climate change on crop production. This analytical model makes use of well-calibrated crop models from carefully controlled experiments in which crops are grown in laboratory setting that simulates different climates and levels of carbon dioxide (Mano et al., 2007) but, there are some limitations in these models, which are: physiological process data use in these models, and mostly variability in explained by non-linear forms of these variables. So it's difficult to interpret the results due to non-linearity of variables.

Another problem is that model treats all the information about the production function as exogenous, so neglect the adaptive response of farmers.

The third approach is called production function approach originally attributed to (Solow, 1956, 1957) and improved to be used for measuring the effect of environmental input on agriculture production (Mundlak, 1961; Mundlak et al., 1999). The best part of this production approach is that all explanatory variables are exogenous, and are not affected by error term, due to this there is less chance of endogeneity problem. In production function, the output is the function of input and the productivity of output calculates the productivity of all inputs. The limitation in this approach is that it fails to incorporate the economic substitution of crop due to climate change so usually overestimate the damages (Mendelsohn et al., 1994).

In production function approach output depends on inputs used which farmers use/select for production process. Here is the simplest functional form of production function:

$Y = f(X)$-- (1)

Y is output produced by using vectors of inputs X. Input variables includes conventional inputs, climatic factors and socioeconomic variables (Deressa et al., 2009). In our study we will use this production approach to find the relationship between the inputs of milk production, including climatic variables. For cross-sectional data, the regression equation for the above production function can be written as:

$Y_i = f(X_i) + U_i$-- (2)

In our study Y is the milk yield, i represents the farm households, X is vector of quantities of inputs, and U is the disturbance term. Each variables has some parameter with it. When we introduce parameter in the above regression equation, it can be written in the linear farm as :

$Y_i = X_i\beta_i + U_i$ -- (3)

CHAPTER 4

Data Description and Methodology

4.1) Introduction:

This chapter presents discussion on the study area, distribution of the sample, construction of variables, sources of the secondary data used, and the analytical approach adopted in this research.

4.1.1) Study Area and Sample Size:

This study is based on household survey data collected from 18 sampled villages of Crop Maximization Program (CMP) and Special Program on Food Security (SPFS) implemented in Punjab, Sindh, NWFP (presently KP), and Baluchistan. The total sample consisted of 440 farm households from eight districts of Pakistan[1] (three districts from Punjab province, two districts each from Sindh and NWFP, and one district from Baluchistan). Out of the total sample of 440 farm household 322 families were involved in livestock production and included 192 member farms and 130 non-member farms[2].

4.1.2) Data Source:

The analysis conducted in this study is based on primary data as well as secondary data. The primary data was collected in 2006 by Pakistan Institute of Development Economics, Islamabad under the project "Impact Evaluation of Crop Maximization Program and

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[1] See Appendix 1

[2] See Appendix 2

Special Program on Food Security". The total sample consists of 440 farm household belonging to randomly selected 8 districts of Pakistan covered by the projects. Out of total sample 320 farm households belong to project districts covered by Crop Maximization Program and 120 farm households come from project area of Special Program on Food Security. The sample size includes 322 farm household with livestock inventories in eight sampled districts namely Sargodha, Sialkot, Muzaffargarh, Larkana, Nawabshah/ (presently Shaheed Benazirabad), Bannu, Dera Ismail Khan and Jaffarabad. The detailed distribution of overall sample and the livestock holders is given in Appendix 1 and Appendix 2.

The collected data includes information regarding household profile, number of livestock inventories, total milk production, input use, credit availability etc. The data on climatic variables (monthly precipitation and monthly average of temperature) have been retrieved from Pakistan Meteorological Department for twenty years (1987-2006) regarding the sampled villages using village level longitude and latitude information. The Data on climatic factors were mapped with farm level data using the village ID.

The proportion of dairy animals owned by the sample farm households is shown in Figure 4.1. The whole livestock inventory is divided into three proportions: large ruminants (cows and buffaloes in milk), small ruminants (sheep and goat), and others (includes dry cows and buffaloes, their young stock and heifers, breeding bulls, bullocks, and donkeys). It is evident that large ruminant in milk constitute only 26 percent of the total livestock held be the sample households. Besides these small ruminants are 24 percent and others are 50 percent.

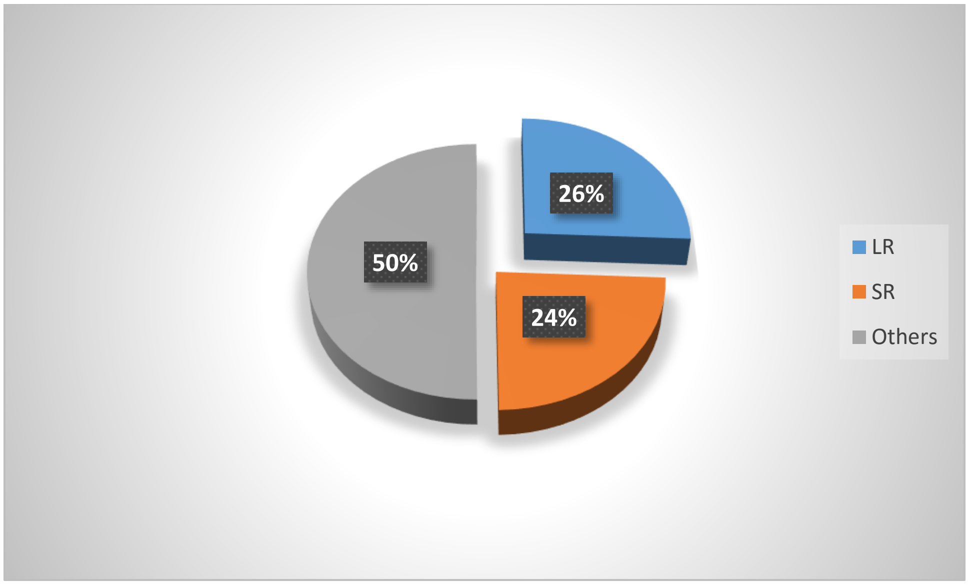

Figure 4.1 *Proportion of Dairy Animals*

The composition of animal in milk is presented in Figure 4.2. Buffaloes are more popularly raised by the livestock farmer as dairy animal. Among the milking animals buffaloes and cows respectively constitute 64 percent and 36 percent of the total animals in this category.

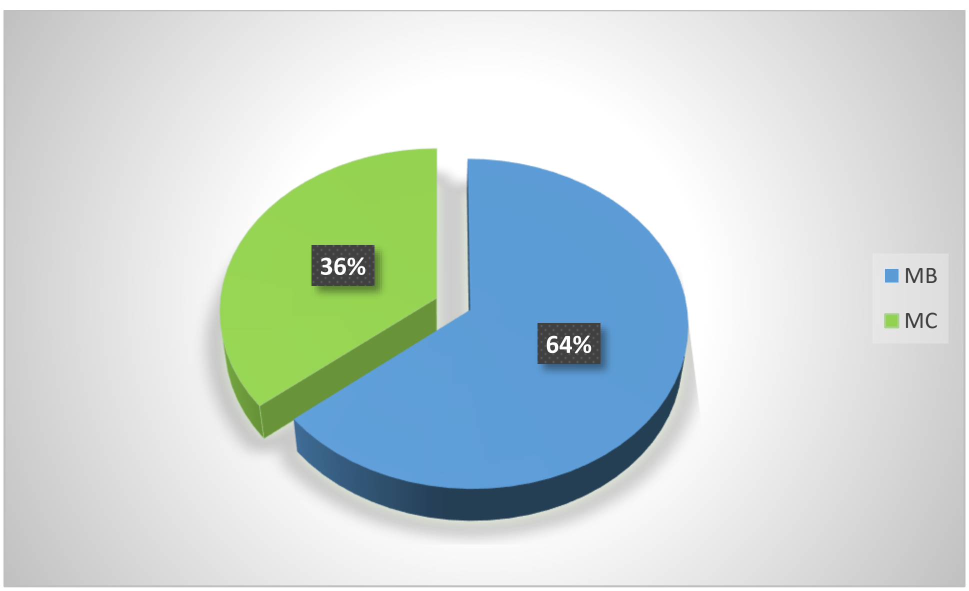

Figure 4.2: *Milking Buffalo and Cow Proportions*

4.1.3) Variable Description:

The study uses a number of variables in the analysis. The symbols used to represent each of these variables; brief description of the variables; and related units of measurement are reported in the following table.

Table 4.1: *List and Description of the Variables used in Treatment Effect Model*

Symbols of Variables	Name of Variables	Description of Variables	Unit
F	Farm Status	Dummy variable representing membership status of the farm and taking value of one if the sample farm household is member of the project and zero otherwise	Dummy
Y	Milk Yield	Total milk production per day divided by number of lactating animals (large ruminants in milk)	Kg
VMA	Value of Milking Animal	Weighted average price of milking animal. Value of Milking Animal = [sum of values of milking cows + sum of values of milking buffaloes] / [(sum of cow and buffalo in milk)]	In 000 Rs.
LL	Lactation Length	Average of lactating months of milking buffaloes and cows	Months
HS	Herd Size	Number of animals in the herd measured in adult cow equivalent units by assigning weights depending on age and type of animals[3].	cow equivalent units

[3] See Appendix 3

CoQ	Concentrate Quantity	Monthly cotton seed cake and oil seed cake quantity.	Kilo Gram
CaQ	Catalyst Quantity	Monthly Gur and Salt quantity, they act as catalyst in digestion process.	Kilo Gram
Fod	Fodder Availability	Area of green fodder (Berseem, *Lucerne* and Sorghum etc) in Kanals, divide by size of herd (adult cow equivalent units) herd.	
DCed	Dummy Credit	Farmer Obtain Credit = 1, otherwise = 0.	Dummy
DVac	Dummy Vaccination	DVac=1 if Farmer Vaccinated Animals otherwise =0	Dummy
Age	Age	Age of household head in completed years	Years
Edu	Education	Number of completed schooling years by household head.	Years
OA	Operational Area	Size of operational area = Owned farm area+ rented in area+ shared in area - rented out area - shared out area.	Kanals (1/8th of an acre)
T	Temperature	Averages of mean monthly temperature of for the last 20 years (1987-2006).	Centigrade
DT	Deviation of Temperature	Current year's average of monthly mean temperature minus the 20 years average temperature.	Centigrade
P	Precipitation	20 years averages of precipitation (1987-2006).	Millimeter
DP	Deviation of Precipitation	Current year's monthly average precipitation received minus 20 years monthly average precipitation (1987-2006).	Millimeter
iTP	Interaction term of Temperature and Precipitation	20 years average temperature multiplied by 20 years monthly average precipitation received.	

4.2) Analytical Model:

The sample selection model by Heckman was developed using an econometric frame work for handling limited dependent variables. It is important to note that in Sample Selection Models the outcome variable of regression equation is observed only for which the dummy variable indicating treatment condition takes value of one (the data on outcome variable is not observed for values of dummy equal to zero). Maddala (1984) extended the sample selection perception to the valuation of treatment effectiveness. Before going in detail of selection model, we first discuss Heckman model because this model is the basis for the sample selection model and approach to correcting selection bias. Similarly Heckman model also gives base for understanding the treatment effect model. In our study we basically focus on treatment effect model because this offers practical solution to evaluation of various types of programs. In 20th century, the Heckman's sample selection model is one of the most significant works. The main point of discussion in sample selection model is to develop new statistical procedures to resolve the problem of selection bias.

The two main traits of limited dependent variables are truncation[4] and censoring[5]. When we take sample from large population, then truncation occurs, and when values of dependent variable are replaced by single value than censoring occurs (Madala 1983). For example: in the present study sample of farmers with livestock inventories drawn from overall population of farmers in the projects, this is truncation. The sampled

[4] Truncation: The effect of data gathering, instead of data generation (Madala 1983).

[5] Censoring: When all values in a certain range of Dependent Variable are transformed for the whole population (Madala 1983).

households that are not members of the project are coded as 0 (zero) and member household are coded as 1 (one), this is censoring. Selection bias involves estimation of Inverse Mills Ratio[6] in turn used as additional explanatory variables in outcome equation. If the Inverse Mills Ratio is significant then, it will confirm that there will be selection bias in the model. The focused model by Heckman was two type of selection bias: one was self-selection bias and second was selection bias made by data analysts. To deal with these problem there are two main equations in sample selection model. One is regression equation, which determines the outcome variable and second is selection equation that considers a part of sample, observed and mechanism of outcome, which determine the selection process.

4.2.1) Treatment Effect Model:

The sample selection model is among the most important contributions to program evaluation; however the treatment effect is partial solution of various types of evaluation problems. The development of the selection model researchers formulated many new models termed as "Heckit" models by (Greene, 2003). The more important development of model is direct application of sample selection model to estimation of treatment effects in observational studies. The approach is named as Treatment Effect Model and unlike the Sample Selection Model the outcome variable of regression equation is observed for both D=1 and D=0. A Heckman-type treatment effect model always involves two equations:

[6] Inverse Mills Ratio is defined as the ratio of probability density function to the cumulative distribution function. It is named after the John p. Mills and also known as selection hazard or Lambda (Heckman, 1979).

i) The regression equation or outcome equation, determining the outcome or dependent variable.

ii) The selection equation determines the selection process.

4.2.2) Econometric Model:

Closely following model used by (Di Falco et al., 2009), decision to join project and effect of climate change on milk production can be modeled by two equation framework. For that we will apply Heckman type treatment effect model to estimate the project intervention and climate change on milk production. The simplest approach to examine the impact of project to climate change on milk production would be to include member dummy variables in outcome equation. The model is expressed in following two equations.

$Y_i = X_i\beta + F_i\delta + \varepsilon_i$--Outcome Equation 4.1

$F_i^* = \mathrm{R_i}\alpha + \mathrm{u_i}$--Selection Equation 4.2

with $\mathrm{I_i} = \begin{cases} 1 \\ 0 \end{cases}$ If $\mathrm{I_i^*} > 0$ otherwise,

Where Y_i is milk yield per animal, Xi represent the vector of inputs (e.g., climatic variable, lactation month, ratio of cows to total milking animals, herd size, labor, use of concentrates, catalyst inputs, green fodder availability, and other socio-economic variables); β is the column vector of parameters, and F_i is binary variable that come directly from the selection equation, δ estimate the milk yield difference of member and non-member of projects. The dummy variable F takes a value of one in outcome equation if farmers is member of project and zero otherwise.

The latent variable F* captures the expected benefits of member to non-member, the vector R represents the variables that affect the farmers' decision to join project or not to join. These factors may include characteristics of farmers and livestock herd, climatic factors (rainfall, temperature), and other socio-economic variables that can influence the probability of joining the project.

Finally the error terms ε_i and u_i in equation (1), (2) are assumed to have a bivariate normal distribution, with zero mean and covariance matrix= $\begin{bmatrix} \sigma_{\varepsilon} & \rho \\ \rho & 1 \end{bmatrix}$

Given the sample selection and F is an endogenous variable the problem is to use the observed variable to estimate the regression coefficient β, while controlling the selection bias included by the non-ignorable treatment factors.

4.3) Empirical Model:

The following yield function[7] is used in this study to find the impact of climate change

Outcome Equation:

$$Y_i = \beta_o + \beta_1 (Edu)_i + \beta_2(VMA)_i + \beta_3(LL)_i + \beta_4(HS)_i + \beta_5(CoQ)_i + \beta_6(CaQ)_i + \beta_7(Fod)_i + \beta_8(DVac)_i + \beta_9(DCed)_i + \beta_{10}(P)_i + \beta_{11}(P)_i^2 + \beta_{12}(T)_i + \beta_{13}(T)_i^2 + \beta_{14}(DP)_i + \beta_{15}(DT)_i + \beta_{16} iTP_i + \beta_{17}F_i + \varepsilon_i \text{ ---------------------------- } 4.3$$

Selection Equation:

$$F_i = \alpha_o + \alpha_1 (Age)_i + \alpha_2(Edu)_i + \alpha_3(HS)_i + \alpha_4(OA)_i + \alpha_5(DCed)_i + \alpha_6(P)_i + +\alpha_7 T_i + u_i \text{ --- } 4.4$$

The climatic variables (temperature and precipitation) as well as squares of these variables are included in the outcome equation to account for the possible non-linear impacts of these factors on milk yield.

We use Treatment Effect Model to find out that how did the climate change affect milk yield and what impact the project participation had on milk yield.

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[7] P= Linear form of precipitation, P^2 = Quadratic form of precipitation, T= Linear form of precipitation, T^2 = Quadratic form of precipitation.

Deal about other variables given in table 4.1.

CHAPTER 5

Results and Discussion

In this chapter we will discuss the results that we obtained from descriptive statistics and econometric analysis. This chapter is divides into two sections. The first section deals with explanation of the results of descriptive analysis and the second section presents discussion of results of econometric analysis.

5.1) Descriptive Analysis:

The descriptive analysis of the two climatic factors (temperature and precipitation) and non-climatic variables included in the model was performed and the results are reported in Table 5.1 through Table 5.5.

5.1.1) Climatic Factors

The results of the descriptive analysis indicate that the study area received low precipitation with large variations as indicated by the mean precipitation value of 38.34mm with standard deviation of 16.84mm. The range of precipitation varied from 14.72mm to 67.26mm. The 20 years average temperature in the area is 24.89^{0}C with a standard deviation of 3.08^{0}C. The long run average temperature ranged 13.79^{0}C to29.6^{0}C in the study area. The temperature and precipitation on the average remained slightly above the long run normal of the study area.

Table 5.1 *Descriptive Statistics of Climatic Variables*

Variables	Mean	Std Dev	Min	Max
Precipitation	38.34	16.84	14.72	67.26
Temperature	24.89	3.08	13.79	29.6
Deviation Precipitation	4.07	4.72	3.4	15.6
Deviation Temperature	0.32	0.32	0.26	0.71
Source of Data: CMP and SPFS Projects (Pakistan Institute of Development Economics)				

5.1.2) Credit Availability:

Availability of credit for livestock in rural area (formal or informal) have significant role to deal with climate change and protect livestock. An increase access to credit may increase farm level productivity and improved incomes. In our study there were 47 percent farmers who had access to credit (Table 5.2).

Table 5.2 *Credit Availability to Farmers*

Credit Availability	Frequency	Percent
Yes	152	47
No	170	53
Total	322	100
Source of Data: CMP and SPFS Projects (Pakistan Institute of Development Economics)		

5.1.3) Use of Various Feed Types:

For better milk production the animals should be fed with a balanced feed including green fodder and concentrates. Such feed has a high nutritional value and helps in increasing milk productivity. Along with feeds some other ingredients (like Gur and Salts) helps animal in digestion process. The results of descriptive analysis of use of various feed types are presented in Tables 5.3 through Table 5.5. The results are indicative that majority of the farmers 83 percent of farmers feed milking animals with concentrates and 81 percent feed animals with green fodder. The use of catalyst ingredients like Gur and Salts was also quite common (46 percent) at the sampled farms.

Table 5.3: **Use of Concentrates**

Concentrates Feed	Frequency	Percent
Yes	267	83
No	55	17
Total	322	100
Source of Data: CMP and SPFS Projects (Pakistan Institute of Development Economics)		

Table 5.4 **Use of Green Fodder**

Green Fodder	Frequency	Percent
Yes	260	81
No	62	19
Total	322	100
Source of Data: CMP and SPFS Projects (Pakistan Institute of Development Economics)		

Table 5.5 **Use of Catalysts (Gur and Salts)**

Catalyst Usage	Frequency	Percent
Yes	152	47
No	170	53
Total	322	100
Source of Data: CMP and SPFS Projects (Pakistan Institute of Development Economics)		

5.2) Empirical Results and Discussion

The results obtained from Treatment Effect Model are reported in Table 5.6 and Table 5.7. The treatment scores show that whether variables included in the outcome equation result in an increase or a decrease in milk yield. The Wald Chi-square value shows that the model is best fitted. The results are suggestive that the project had an insignificant effect on milk yield at the farms of member and non-member farmers. This is due to the fact that most of the farmers mainly emphasis on crop production for their livelihood and livestock production supplements their incomes. Moreover, the interventions of the projects for the members were also mainly focused on crop production as reflected in the names of the project (Special Program for Food Security and Crop Maximization Program). The projects though have interventions related to livestock production but were implemented ineffectively

Table 5.6 **Average Treatment Scores**

Farmer Status	Scores	Std. Error	p-value
Member/ Non-member (F)	8.547046	47.85109	0.858

Table 5.7 **Estimates of the Treatment Effect Model**

Variable	Coff-Value	p-value
Outcome Equation		
Dependent Variable		
Milk Yield		
Independent Variables		
Education	-0.5184218	0.633
Value of milking animals	0.0003103	0.007
Lactation months	-7.766666	0.000
Herd size	-4.605165	0.020
Concentrate	0.0410786	0.006
Catalyst	0.3325359	0.023
Vaccine	-3.219403	0.726
Green fodder	1.422906	0.099
Prep	55.52641	0.028
Sq_Prep	-0.1518714	0.004
Temp	27.5623	0.052
Sq_Temp	-4.085184	0.066
D_Prep	-6.426729	0.009
D_Temp	-54.42197	0.320
I_PrepTemp	-1.808624	0.055
Dummy_Membership	8.547046	0.858
Selection Equation		
Age	0.0202861	0.001
Education	0.0569218	0.001
Herd size	0.0139485	0.459
Operational Area	0.00026070	0.755
Dummy _Obtain Credits	1.27888700	0.000
Prep	0.01381440	0.062
Temp	0.0556780	0.143

The results of the outcome equation are suggestive that value of milking animal (used to be indicative of improved breed of dairy animals) is related to milk yield positively and significantly. The results is in agreement with finding of (Ngongoni et al., 2006) who also found that breed type have positive impact on milk yield.

Length of lactating period (in months) has a negative and significant relationship with milk yield. After the parity, animal milk production tends to increase for certain period (1-2 months) and then starts declining as the time passes. Other studies have alos found that lactating months play a vital role in determining milk yield (Laben et al., 1982; Lucy, 2001; Ploumi et al., 1998).

The size of herd also relates to milk yield negatively and significantly because as the herd size increases the management efforts are diluted. A similar relationship between herd size and milk yield was found by Lucy (2001).

The results are suggestive that use of concentrates has positive and significant impact on milk yield. Concentrate feeds have balanced amount of fats and proteins in it for diary animals (Anderson et al., 1979; Johnson et al., 2002; Ngongoni et al., 2006) which are the needed ingredients by these animals.

Dairy animals are also fed in Pakistan with roughages, green grass/fodder and leaves as well as other feeds which are with thick cell wall and have large amount of cellulose in them – are hard to digest. The farmers usually feed gur and salt to animals which help in digestion. The use of gur and salt is found to have a positive and significant effect on milk yield. The results are suggestive that feeding of one additional Kg of catalyst to dairy animal would increase average daily milk yield of the herd by 0.33 Kgs.

Similarly, a positive and significant relationship was also observed between green fodder availability per animal (adult cow equivalent) and milk yield. The green fodders are important determinant of milk yield as they have high protein and energy in them (Aktürk et al., 2010)..

The results show that climatic variables are important determinant of milk yield. A negative and significant impact of temperature on milk yield was also reported by (Sirohi & Michaelowa, 2007) who observed a non-linear (U-shaped) relationship between temperature with milk yield. High temperature cause heat stress, which decrease the efficiency of the animal resulting in decline of milk yield (Klinedinst et al., 1993). Similar relationship (non-linear U shaped) is also observed between precipitation and milk yield. The high precipitation cause some factors which effect negatively to the milk yield which are; humidity, the prevalence and extent of internal and external parasites (Vercoe, 1999). The weather shocks (deviations of precipitation from long run normal) are also observed to have a negative and significant impact on milk yield. However, deviation of temperature from local long run normal had no significant effect on milk yield. The warming (rise in long run normal of temperature) in addition to its direct effect on milk yield as indicated also has a joint impact with precipitation. The results are indicative that high temperature in interaction with high precipitation has a joint impact on milk yield which is adverse and significant. Increase in temperature along with high precipitation causes humidity as water particles trap more heat that increases the temperature (Khan, A. N. et al., 2011). This results in decreased milk yield.

5.2. Selection Equation

The estimates of selection equation[8] are suggestive that education and age of farm households, and precipitation are important determinant of probability of joining the project as member. All the three variables affected the probability of joining the project positively and significantly. However, no evidence was found that temperature has any significant relationship with decision to join the project (Table 5.7).

[8] See equation 4.4.

CHAPTER 6

Conclusion

This study explored the impact of climatic variables and effect of the projects (participated by the farmers) on milk yield. The research is based on primary data collected from 322 farm households involved in crop and livestock production. The results are suggestive that temperature and precipitation both have a negative and significant (non-linear) impact on milk yield in Pakistan.

Among non-climatic variables, value of milking animal, feeding of concentrate, use of catalysts, and green fodder availability were found to have a positive and significant relationship with milk yield. However, no evidence was found that the projects had any significant effect on milk productivity. The variables like education and age of the household head, and precipitation are found to be important factors determining probability of a household to join the project.

Policy Recommendation

The floods, excessive rains, heat weaves, and droughts are occurring in Pakistan with quite increased frequencies in various regions of Pakistan. It often results in excessive losses in livestock sector and damage to the crops in addition to loss of human lives and destruction of infrastructure. In order to enhance the milk production and performance of the livestock sector while confronting climatic factors, government should strengthen and enhance the capacity of institutions related to climate change, disaster management, weather forecasting, research and extension services. Most importantly the adaptation capacity of the livestock farmers needs to be enhanced. The breeding programs for dairy cows and buffaloes need to be strengthened and low yielding and non-descript breeds of animals should be systematically replaced by improved breeds. Use of livestock feeds and concentrates, vaccination, artificial insemination need to be promoted. The area allocated to production of green fodder is declining over time in Pakistan and this decline need to be compensated through development of high yielding fodder varieties with greater nutritional value and good digestibility.

The animals employ physiological mechanisms to counter the heat stress. The adaptation to higher temperature is also complemented by the behavioral process, such as buffaloes prefer wallowing during high temperature to reduce thermal loads and maintain thermal equilibrium. So there should be human intervention for physical modification of the environment and improvement in nutritional management practices would be additionally required.

In Pakistan, the research on livestock often lack funding and face shortage of qualified experts in various field of animal sciences. The government need to attach high priority towards this sector in its research and development (R&D) programs.

6.1. Limitations of Study

There are a number of limitations of the present study and these include the following:

- The data set lacked information on breed of dairy animals as most of animals kept by the farmers belonged to non-descript breeds.

- The farm specific data regarding climatic factors was not available and village level data was matched with each of the farms.
- The data regarding use of labor specifically involved in livestock related activities was not available as such information was not asked in the survey schedules.

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Appendices

Appendix 1:

Total Sample Size: 440

Table A.1 *District and Village-vise Sample Distribution Based on Member and Non-member*

Sr.No	Provinces	Districts	Villages	Member	Non-member
1	Punjab	Sargodha	Chak 44/SB	60	40
2			Chak 45/SB		
3			Chak 55/SB		
4		Sialkot	Malo Mahi	60	40
5			Gane Kay		
6			Dale Kay		
7		Muzaffargarh	Jhanger Marah	20	20
8			Marah Gharbi		
9	Sindh	Larkana	Channa Village	20	20
10			Kumbi		
11		Nawabshah/ Shaheed Benazirabad	Sat Puri	20	20
12			Dalel Dero		
13	KPK	Banno	*Derre Piari Kalla*	20	20
14			Abrahim Khel		
15		Dera Ismail Khan	Thatha Balochan	20	20
16			Dhap Shaumali		
17	Baluchistan	Jaffar Abad	Goth Dur Mohd Lashari	20	20
18			Noor M Nawra		
Total		**8**	**18**	**240**	**200**

Appendix 2:

Total Sample Size (Livestock Ownership): 324

Table A.2 *District and Village-vise Sample Distribution of Farmer Having Livestock Ownership Based on Member and Non-member*

Sr.No	**Provinces**	**Districts**	**Villages**	**Members**	**Non Members**
1	Punjab	Sargodha	Chak 44/SB	53	29
2			Chak 45/SB		
3			Chak 55/SB		
4		Sialkot	Malo Mahi	50	20
5			Gane Kay		
6			Dale Kay		
7		Muzaffargarh	Jhanger Marah	15	16
8			Marah Gharbi		
9	Sindh	Larkana	Channa Village	12	11
10			Kumbi		
11		Nawabshah/ Shaheed Benazirabad	Sat Puri	16	15
12			Dalel Dero		
13	KPK	Banno	*Derre Piari Kalla*	13	12
14			Abrahim Khel		
15		Dera Ismail Khan	Thatha Balochan	17	14
16			Dhap Shaumali		
17	Baluchistan	Jaffarabad	Goth Dur Mohd Lashari	16	15
18			Noor M Nawra		
Total		**8**	**18**	**192**	**132**

Appendix 3:

Table A.3 *Cow Equivalent Animal Units*

Animal Type	Age and Sex Composition	Weight
Buffaloes	Buffaloes in milk	1.50
	Buffaloes (dry)	1.20
	Heifer Buffaloes	0.60
	Young stock (Buffaloes)	0.30
	Male Buffaloes	1.20
Cow	Milking Cow	1.00
	Breeding Bull	1.00
	Heifer Cow	0.40
	Young stock Cow	0.25
	Dry Cow	0.80
	Bullocks	1.20
Goat and Sheep		0.25
Camel		1.50
Horses		1.00
Donkeys		0.50

Iqbal et al. (2000)