IMPACT OF CLIMATE CHANGE ON AGRICULTURAL LAND VALUES: AN APPLICATION OF RICARDIAN MODEL IN PUNJAB

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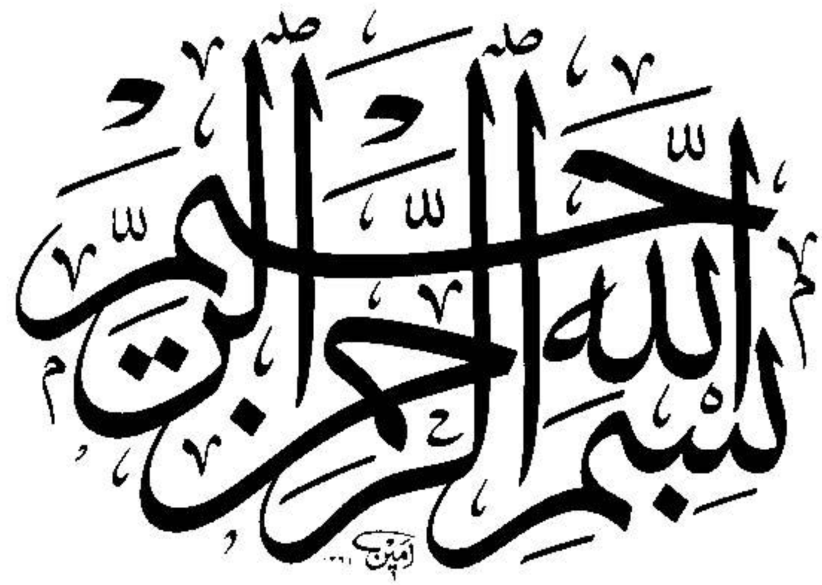
ISLAMABAD

2012



In the Name of Allah The most Gracious

The most Merciful

A report submitted to

Pakistan Institute of Development Economics Islamabad

as a partial fulfillment of requirements

for the award of the degree of

Master of Philosophy in Environmental Economic

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FINAL APPROVAL

This is to certify that we have read the thesis submitted by Mr. Syed Aqrar Hussain. It is our judgment that this thesis is of sufficient standard to warrant it's acceptances by the PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS for the Masters of Philosophy in Environmental Economics.

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DEDICATION

To my dearest parents, my family, friends and

respected teachers who

motivated, supported and encouraged me

in every aspect of our life.

DECLARATION

I hereby declare that this thesis, neither as a whole nor as a part there of has been copied out from any source. It is further declared that I have developed the study entirely on the basis of my personal efforts made under the sincere guidance of my supervisor. If any part of this project is found to be copied, we shall standby the consequences. No portion of the work presented in this report has been submitted in support of any application for any other degree or qualification of this or any other university or institute of learning.

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Date:-

ACKNOWLEDGEMENT

Although I am indeed the author of this thesis, I am by no means the sole contributor! Many people have contributed to my thesis, to my education, and to my life, and it is now our great pleasure to take this opportunity to thank them.

I am profoundly thankful to my supervisor Dr. Usman Mustafa who guided and helped me in making this thesis done.

This project would not have been possible without the support of many organizations. Thanks to the Punjab Applied Research Institute (PARI), Lahore and the Pakistan Meteorological Department (PMD), Islamabad for providing me the requisite data set on agricultural land values and all climatic variables, respectively. In this connection role of Dr. Abdul Quddus, Director, PERI and Dr. Ghulam Rasul, Chief Meteorologist, PMD are highly acknowledgeable.

I thank Mr. Ghulam Samad and Mr. Akbarullah for their kind support, invigorating for his valuable suggestions especially in model selection and data estimation techniques and other component information without which this work would have been very difficult. I am also grateful to my colleagues for their valuable hints, suggestions and motivation throughout my work.

Finally, I am forever indebted to my parents, brothers and sisters for their prayers, understanding, endless patience and encouragement when it was most required.

Syed Aqrar Hussain

ABSTRACT

The study instigates the incident of climate change and its impact on agricultural land value of Punjab primarily addressing the adaptation factor. A Ricardian analysis approach has been used to walk around the subject how idiosyncratic climate patterns affect land value in Punjab while considering twenty districts of the province Punjab. Data on agricultural land values for each district is taken from Punjab Economic Research Institute from 2004-2008. In order to estimate the climate change model, EGLS technique with cross section white covariance is used in the study. From the assessment it is very much clear that average rainfall has a highly significant U-shaped relationship with agricultural land values. It implies that 1mm increase in rainfall will result in decrease in agricultural land values by 650214 Pak rupees per hectare. On the other hand, the square term of average precipitation shows a positive and highly significant relationship which confirms the hill-shaped relationship among land values and climatic variables. This concludes that the present level of precipitation is inadequate for the agricultural land which results in departure of land value downward. Similarly, in case of humidity the linear relationship between land value and humidity is positive. . It predicts that if humidity increases by 1 per cent it results in increase in land value by 302798 Pak rupees per hectare. Unlike other studies, the present study predicts that maximum temperature plays a negligible role in farmer's decision making.

The study has given a broader look of the subject matter by including the district wise interactive dummies for each district to further elucidate the analysis. To see the

district wise effects of rainfall, we have included nineteen dummies as interactive terms in our estimated equation.

Similarly, the same procedure has been carried out for the rest of the district dummies. This means that we have allowed slop coefficient for rainfall to vary from district to district. Our result shows that the highest positive effects of rainfall are in district Rawalpindi where one millimeter increase in average rainfall lead to increase the land value by more than a half million of Pak rupees.

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List of Abbreviations

IPCC	Intergovernmental Panel on Climate Change
UNCCD	United Nations Convention to Combat Desertification
IFAD	International Fund for Agricultural Development
GDP	Gross Domestic Product
TFCC	Task Force on Climate Change
GHG	Green House Gas
PCM	Parallel Climate Model
AOGCM	Atmosphere- Ocean Global Circulation Model
CCC	Canadian Climate Centre
CCSR	Centre for Climate Systems Research
AEZs	Aero Ecological Zones
USD	United States Dollar
PMD	Pakistan Meteorological Department
PERI	Punjab Economic Research Institute
OLS	Ordinary Least Square
EGLS	Estimated Generalized Least Square

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CHAPTER I

1. BACKGROUND

The first part of the study highlights the concise introduction of the topic and its historical consequences all over the world. The subsequent section discusses the objectives of the study. The climatic situation and the agricultural status of the country are also examined in detail where different categories of the land used for the agricultural purposes and their share in the agricultural GDP of the country are reported. Similarly, the mixed taxonomy of the agricultural land and the variations in the temperature and precipitation patterns are presented while the reasons of Pakistan's susceptibility to climate change are presented thoroughly. Furthermore, Pakistan's share in total world emissions in terms of per capita GHG emissions and Pakistan's status among the countries of the world in terms of CO2 emission is given in detail in a tabulated form in the chapter.

1.1 PREAMBLE

"Warming of the climate change system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level"(IPCC, 2007).

Climate change is a huge threat for the mankind in 21st century. The global climate is changing more rapidly than anticipated earlier. The phenomenon of climate change is multidimensional, multi-sectoral, immediate and long term in its nature. Developing countries in Asia and Africa including India and Bangladesh are predicted to be extremely vulnerable countries to climate change (Amin et al., 2008). Furthermore, it is evident from the literature that the poor are the most susceptible to climate risks. This is reconfirmed from the IPCC- report that it is the poor in the developing countries who are exposed to indecency of climate change. The poorest are at the frontline which are hit the hardest by various climatic calamities like floods, droughts, salinity etc. which results in affecting physical environment, ecosystems, agricultural and natural resources. There is a growing concern that agricultural activities are rigorously affected in developing countries with changing global climate (IPCC, 1990). Hence the impact of climate change on agriculture is a matter of great concern in case of developing countries. It is because, in low income countries, majority of the people are living in rural areas having dependency on agricultural sector. Since the agricultural sector is an economic activity which highly depends on climatic settings and is primarily responsive to climatic changes. Therefore, it is imperative to realize that to what extend these climatic abnormalities may affect agricultural yield and fertility.

Climate change can have direct and indirect as well as positive and negative effects on overall wellbeing of the inhabitants of a country which is heavily dependent on natural resources such as agriculture, forest and fisheries for their livelihood and these people are likely to be the most vulnerable to climate risks. In this regard there is a general consensus among experts that change in temperature and precipitation result in changes in land and water regime that consequently affects agricultural productivity (World Bank, 2003). In case of developing countries, climate change impact on agriculture is becoming a forefront issue with changing global climate (IPCC, 1996). In this connection several attempts have been made to evaluate this impact (Thapa and Joshi, 2010; Lippert et al., 2009; Seo et al., 2008; Seo and Mendelsohn, 2007 and Maddison et al., 2006). The IPCC 4th assessment report also states that climate change; particularly increased risks of torrential rain and droughts are expected to have harsh impact on South Asian economies, more especially those which rely on agriculture, forestry and fisheries sector.

In South Asia mostly people (about 70%) live in rural areas out of which about 75% are poor, who are the most impacted by the climate change (UNCCD). Since most of the South Asian population used to live in rural areas which solely depend on agriculture for their livelihood. The changing patterns of rainfall and the break cycles of monsoon along with chanting modes of critical temperatures in the region are more frequent which results in significant change in crop yield. Temporal and special changes in temperature along with shortage of water plays key implications for agriculture, especially in relation with decrease in crop yields. Climatic impacts on agriculture vary according to locality, altitude and other geographical conditions, but it is quite clear from many climate models that have been projected a 15-30% decrease in output of most cereals and rice across the region. Furthermore, these models also suggest that, facing with 2-4C^0 temperature increase, rice yields are expected to decline by 0, 75 tons/ ha. In the same line it is expected that the overall crop yield will decline up to 30% in the region by the mid 21st century. Further debate reveals the fact that the most negative impacts are more likely in the arid zones and the flood affected areas, where agriculture is already at the edge of the climate change risks. Moreover, it is estimated that water demand for arid and semi-arid regions is likely to increase by 10% as temperature is increased by 1C^0. Although it is apparent that climate change effects can lead to a significant change in crop production, storage capacity and distribution, but all these changes are not obvious generally because of geographical difference in growing seasons, crop management etc. Thus the inhabitants of pastoral areas having with low income are the first victims of climatic anomalies, largely those who rely on conventional agricultural activities or use to cultivate marginal lands (IFAD, 2011).

Other than climatic variables, some socio economic variables like human pressure jointly with changing hydrology are having a visible burden on production and the resilience of South Asia's agricultural and ecological systems. Similarly, the availability of fresh water is highly dependent of seasonal changes with about 75% of annual rainfall occurring during the monsoon months. As the availability of water is highly seasonal, therefore, these supplies will be threatened by higher temperatures, changes in river systems and the larger events of coastal flooding. Therefore, it is certain that availability of water is likely to shrink intensely particularly in dry seasons. The main target of climate change in South Asia is Himalayan glaciers melt which results in increase in flooding and severely affecting water resources in the region. These glaciers ply a significant role in the provision of water for the rivers in the region. These snowfields currently provide 85% of the dry season flows in the great rivers of the Northern Indian plane. It is forecasted that this inflow of water could be reduced to about 30% over the next 50 years (IFAD, 2011). Thus it is asserted that developing countries have to face more threat to sustainable development because they have lesser resources and these countries are more vulnerable because a greater portion of their economy depends on climate sensitivity sector like agricultural sector (Mendelsohn et al., 2000).

Agriculture has been a pivotal in economic activities in the history. It is not only indispensable for food supply and labor force absorption but also supplies raw material to industries. In case of natural resources, agricultural sector is susceptible to climate changes and inexplicable variations of nature. Climate change has added severe concerns for developing countries specifically in line with agriculture and Pakistan is not alone to experience terrific social, economic and environmental shocks. Such tremendous climatic impacts on agriculture have received high considerations in Pakistan. Since the phenomenon of climate change is primarily linked to food security, poverty and health. Thus the country's position as a developing country is very much dependent on agriculture sector which makes it extremely vulnerable to the threats of climate change. Agriculture sector alone is contributing 21 per cent to GDP and occupying a considerable portion (44 %) of the total labor force. Country's exports are also highly dependent on agriculture sector which contributes about 65 per cent of foreign exchange. More than two third of the total population of the country lives in rural areas and their livelihood primarily depend on agriculture and agro-based activities (Government of Pakistan, 2009).

Contribution of agriculture sector in GDP, exports and employment level of the country has remarkably decreased. With other reasons of loss in agricultural productivity, climatic variations have been marked as main contributors. Government of Pakistan, 2009 draws attention to the fact that agriculture sector has shown a poor performance in the year 2007-08. It grew at 1.5 per cent in opposition to the target of 4 per cent. In May 2007 agriculture sector had suffered from varied reasons specifically heavy precipitation level, high temperature during August and September, 2007 while scarcity of water throughout the irrigation season.

The study area to engage with is the Punjab province of Pakistan. Punjab is the second biggest and densely populated province of Pakistan. Agriculture is the main stream economic activity in Punjab province. A major portion of land about (57.2 per cent) in Punjab is dominated by agriculture sector. It also contributes about (53 percent) in total Pakistan's agricultural gross domestic product (GDP) (Government of Punjab, 2009). According to Punjab Development Statistics, 2009, during the year 2007-08 Punjab's contribution in the country's agricultural production of major crops was rice 59.1 per cent, wheat 74.5 per cent, and sugarcane 63.1 per cent, maize 74.5 per cent while cotton contributes 77.8 per cent. Similarly, in case of major fruits, Punjab contributes a significant portion in the overall country's production. In terms of production, the percentage share of Punjab was citrus 96.7 per cent, mango 78.3 per cent guava 78.3 per cent (Government of Punjab, 2009). During the recent past decade there have been few attempts to investigate the capacity of adaptability of Punjab agricultural sector to changing climate but the study in hand is pioneer to investigate the problem using the methodology more compatible to the topic of adaptability. Thus by taking into account the results and policy implication, policy makers can develop policies for climate change and adaptability based on facts.

In this connection the study in hand primarily focuses on the following objectives:

1.2 OBJECTIVES OF THE STUDY

The overall objective of the study is to examine climatic abnormalities and their impact on the agricultural sector of Punjab. The specific objectives of the study are the following:

1. To quantify the impact of climatic abnormalities on the overall agricultural land values of province Punjab.

2. To check how the climatic variability affects the land values of individual districts in the province Punjab.
3. To help policy makers in formulating strategies on climate change events and their impact on agriculture sector.

1.3 OVERVIEW OF PAKISTAN AGRICULTURE: Present Status and Frailty

Pakistan's geographical area is 79.61 million hectares, excluding the Northern Areas of Pakistan. Out of total area, only 72 per cent area has been reported, indicating a major limitation that 28 per cent area is not so far surveyed for land use classification. The reported area is further categorized in to four classes: forest area which accounts for 4.02 million hectares (mha), area not available for cultivation is of 22.88 mha, cultivable waste is 8.12 mha while cultivated are of 22.05 mha. Out of total reported area, around 8.1 mha is available for future agriculture and other uses if there is enough water is available (Ahmad and Joyia, 2003). Agriculture and livestock have been the core sectors on which the whole economy lays its foundation. It adds about 22 per cent to the gross domestic product (GDP), which accounts for 60 per cent country's exports, endows livelihood to about 68 per cent of the country's population while provides 44 per cent employment of the total labor force. Its primary concern is to provide sufficient food for the growing population at about 2 per cent annually without altering frail ecosystem. Being vulnerable to inexplicable changes of nature, agricultural activities are very much prone to climate change. Variations in climatic patterns will have far reaching repercussion on food security of the country. This is mainly through decrease in crop output and awful impacts on livestock health (TFCC, 2010).

1.4 CLIMATE CHANGE IN PAKISTAN

The idea of green house gases (GHG) starts with the very beginning of the universe. The average temperature on earth is primarily the result of GHG emissions whereas precipitation patterns are highly correlated with vitiations in average temperature. Indecencies in temperature are normal phenomena but irregular and extreme variation in temperature and precipitation patterns have serious consequences for ecosystem on the planet Earth. Most of the time, these decencies are the result of anthropogenic activities. The industrial revolution in 18th century played an imperative role in mounting human activities specifically the use of fossil fuels for power generation and deforestation which result in increasing the concentration of GHGs in the atmosphere beyond its carrying capacity. As a result Earth's average temperature has been increased.

Pakistan is more exposed to climate change due to its geographical location. It is located in a region where the incidence of increase in temperature is predictably higher than the average global temperature. Most of the agricultural land area in Pakistan is arid or semi-arid. Meteorological data shows that about 60 per cent of the total area receives less than 250 mm precipitation annually while 24 per cent receives 250 to 500 mm. Indus River which is the main source of agricultural water is predominantly fed by the Karakorum, Himalayan and Hindu Kush glaciers. However, it is very much obvious from the recent studies that these glaciers are receding rapidly due to climate change. Being the agrarian economy, Pakistan's economy is highly sensitive to climate change. As a result of this sensitivity, there is an immense threat of variability in monsoon rains which result in droughts and floods as experienced in 2010. Therefore, considering these ground realities, it is very much evident that water availability, food security and power generation are in grave jeopardy (TFCC, 2010).

1.5 PAKISTAN'S SHARE IN GHG EMISSIONS

Pakistan's share in total world emissions in terms of per capita GHG emissions is very small. It is ranked as 135th among the countries of the world with total carbon dioxide emissions of 107.5 million tones which accounts for about 0.43 per cent of the total emissions of the world during the year 2002. But in the year 2008, Pakistan's total emissions raised to 309 million tons (mt) of carbon dioxide equivalent. The total GHG emissions consisting of about 54 percent CO_2, 36 per cent Methane, Nitrous Oxide 9 per cent while 1per cent other gases. In terms of contribution, energy sector is at the top with 50% share; follow by agriculture sector with 39% share, industry (6 per cent) and other activities have (5%) share ask Force on Climate Change, 2010).

In addition, in terms of CO_2 emissions, energy is the major sector with 74.3% contribution, industrial processes (16%) while land use and forestry (9.7%). On the other hand, the major emitters of Methane (CH4) are agriculture (74.4%), while energy is contributing (16.0%). The projected fraction of contribution to the emission of N_2O from energy sector is 0.4%, industrial processes 0.6% whereas agriculture and waste are contributing about 94.8% and 4.2% respectively (SUPARCO).

Table 1.1 Inventories of Green House Gases in 1994 and 2008			
Description	**1994**	**2008**	**AAGR (%)**
GHG emission from All Sectors			
Total GHG emission (Million tones of CO_2 equivalent)	181.7	309.4	3.9
Total GHG emission per capita (kilogram of CO_2 equivalent)	1541	1922	1.6
Total GHG emission per 1000 US$ of year 2008 (kilogram of CO_2 equivalent)	2209	1942	-0.9
GHG emission from Fuel Sector Only			
Total Emission GHG emission from Fuel Combustion Activities (million tons of CO_2 equivalent)	78.9	152.1	4.8
Total GHG emission per capita from Fuel Combustion Activities (kilogram of CO_2 equivalent)	669	945	2.5
Total GHG emission from Fuel combustion Activities per 1000 US$ of year 2008 (kilogram of CO_2 equivalent)	959	955	-
Population Growth and Gross Domestic Product (GDP)			
Population (Million)	117.9	161.0	2.2
GDP (Billion US$ in 2007-08 prices)	82.3	159.3	4.8

Source: Government of Pakistan, 2010

The sectoral division of GHG emissions for the two years 1994 and 2008 are as shown in the above Table 1.1.

The table 1.2 shows the beneficial temperature and precipitation level for different crops in the Punjab province. The cropping period of wheat starts from December and ends in April while for rice cropping period is from August to November.

Table 1.2 Optimal Temperature and Precipitation level for Different Crops Production in Punjab			
Crops	**Cultivation Time**	**Optimal Temperature Level**	**Optimal precipitation Level**
Wheat	December-April	14.14 ^{0}C	111 mm
Rice	August-November	20-25 ^{0}C	40 mm
Cotton	May-September	20-25 ^{0}C	40 mm
Sugarcane	February-December	20-32 ^{0}C	1250-2550 mm

Source: siddiqui et al., 2011

Likewise, the cropping period for cotton and Sugarcane is May-September and February-December respectively. The mean temperatures for major crops (Wheat, Rice, Cotton, Sugarcane) shown in Table 1.2 are 14.14 ^{0}C, 20-25 ^{0}C, 20-25 ^{0}C, 20-32 ^{0}C respectively. This means that increase in temperature beyond this certain level (Mean

Temperature) will positively affect the crop production. On the other hand, the precipitation level for the first stage of production is 111 mm which is the optimal limit for the crop production. It is evident from the above Table that further increase in precipitation level beyond this optimal level will affect adversely the crop production. Similarly, for rice and cotton, the optimal level of precipitation is 40mm while for Sugarcane it is 1250- 2500mm.

Table 1.3 Water Requirement by Crops

Crop	Net Water Requirement per Hectare (m^3)	Yield per Hectare (Kg)	Water Requirement (m3) for Producing 1 Kg
Wheat	4050	2388	1.70
Rice	10260	2013	5.10
Cotton	11810	47300	0.25
Sugarcane	6500	622	10.45

Source: agriculture Statistics of Pakistan, 2002-03

The above Table 1.3 depicts the water requirement for different major crops in the country. The total water condition for summer crops is normally good and it allows the cultivation of rice and cotton in Punjab. But climate change has been adversely affecting water regimes as precipitation patterns have gone through alterations. In case of Pakistan, to produce 1 kilogram of rice needs 5.10 cubic meters while cotton requires 10.45 cubic meters.

Land use pattern in Pakistan is divided into five different categories as shown in the Table 1.4 below. The major shifts in land use pattern are in cropped and forest area. The percentage change in cropped area is 55.89 percent in 1947-48 to 1999-2000 while the forest area has altered by 28.87 percent respectively. The total area under forest is about 3.66 million hectares.

Table 1.4 Land Use Pattern of Pakistan (million ha)			
Category	1947-48	1999-2000	% Change
Geographical Area	79.61	79.61	00.00
Reported Area	47.43	59.28	+24.98
Forest Area	2.84	3.66	+28.87
Cropped Area	14.60	22.76	+55.89
Cultivable Area	11.50	9.13	-20.60
Unreported Area	32.18	20.33	-35.82

Source: Several issues of Agriculture Statistics of Pakistan

During 1947-48 to 2000, forest area has been increased from 2.84 to 3.66 million hectares of the total geographical area. Similarly, a considerable portion of waste area has been converted to productive land as shown in the Table 1.4 above.

The study has been divided into six sections. First section of the study deals with a brief introduction of the issue following the fragile situation of agriculture and its share in the agricultural GDP of Pakistan. Review of recent literature has been done in section two. The following section (III) discusses the methodology of the study in general while theoretical frame work of the study and the functional form of the model are also readily available. Similarly, different tests have been carried out to test the individual effects. Chapter-(IV) of the study impounds the data and description of the study while the last two chapters (V and VI) discuss in detail the econometric estimation, conclusion and policy suggestions of the study. In the next chapter (II) the study will concentrate on different features of previously done literature on climate change and agriculture to justify the scope and significance of the issue. For this purpose at least twenty five previously done studies have been reviewed. All the reviewed articles are presented in descending order in chapter-II. The entire review of literature is concluded at the end of the chapter.

CHAPTER II

This section broadly draws attention to the studies done so far in the context of impact of climate change on agriculture. Review of these studies has been set forth in ascending order from the preceding studies to the current stuff. Each study is reviewed and evaluated. Finally, the overall conclusion of the literature review has been presented at the end of the chapter.

2 REVIEW OF LITERATURE

There is a little doubt that agriculture sector is extremely susceptible to exogenous pressures like climate change. Economists from all over the world have spent decades to quantify the impact of climate change on agriculture. In this line IPCC fourth assessment report sets out more clear than ever that the "Warming of climate system is unequivocal". Climate change has been emerged as an idiosyncratic problem around the globe especially for low income countries like Pakistan. It is because agriculture is a key sector in low income economies accounting for about 24% of GDP and 44% of labor utilization[1]. There is a growing consent that effects of climate change are very obvious and malicious for developing countries, where a large segment of world's poorest use to live. Pakistan is of those countries where agriculture sector has a substantial portion of GDP (about 24%). Therefore, it is needed to regard seriously its adaptation strategy. However, in order to determine an adequate adaptation policy, it is essential to analyze the threats climate change posses on agriculture sector. Therefore, to evaluate these

[1] Khan, Mahmood (2005), Agriculture in Pak: Change and Progress 1947-2005, Vanguard book, page 8.

abnormalities, many studies have been done (Mendelsohn et. al., 1994 and Seo et. al., 2005).

Huiliu et al., (2004) had opined that under most climate change incidents rising temperature and more precipitation have a positive impact in general on China's agriculture. It is evident from the study that climatic impacts on agriculture are uncertain in China. The results also suggest that climate change will have an overall positive impact on China's agriculture. Generally in most scenarios impacts are positive in the center and eastern counties of the country. With respect to seasonal impacts, the autumn impacts are predicted to be the most positive while the spring effects for the most part are negative.

In spite of broad studies and interest of environmental economists in computing economic impact of climate change globally, few efforts have been done in relation with Asia. In this regard Mendelsohn (2005) examined the idea of climate change on Southeast Asian agriculture using a Ricardian valuation technique. Three different climate scenarios (PCM, CCSR, and CCC)[2] are developed. The results of the study exhibit that climatic impact on agriculture depends on four factors and each factor predicts different outcomes. The response function factor estimates severe impacts for larger agricultural sectors. On the other hand climate scenarios show beneficial outcomes for mild regions whereas moderate and extreme scenarios yield slightly

[2] **PCM** is a combination of climate models consists of Atmospheric, Oceanic, Sea and land surface components, using quantitative methods to simulate the interaction among them.

CCSR is the Centre for Climate Systems Research which is unit of Earth Institute, Columbia University and was established in 1994 for the purpose of enhancing interdisciplinary Earth and Climate System research.

CCC is a division of Climate Research Branch of the Meteorological Service of Canada. Its purpose is to contribute to research in Climate Modeling and Climate Change.

damaging and considerable harsh outcomes. The analysis also draws attention to the agricultural loses by each country due to climate change in Southeast Asia. Under experimental response function china loses 14 percent of its agricultural GDP in **CCC (**Canadian Climate Center) while Indian GDP will drop to half and Thailand will lose the entire agricultural GDP. Similarly, there are number of other countries like Cambodia, Laos and Vietnam will lose all their agricultural GDP.

Seo et al., (2005) reinvestigate the phenomenon of climate change and agriculture in Sri- Lanka, using Ricardian valuation technique[3]. The results of the study reveal that the impact of rainfall increase is estimated to be favorable for the country as a whole in the five AOGCM. Similarly, increase in temperature is predicted to be harmful. However, nationally the impacts vary from -11 billion rupees (-20%) to 39 billion rupees (72%) depending on climate scenarios. The estimated regression results of five climate scenarios reveal that the scenarios with loss have overall harmful temperature impacts, with offsetting precipitation benefits. While the scenario with gains has harmful temperature offsets which were dominated by beneficial changes in rainfall.

In subsequent papers, Schlenker et al., (2005) explored several different econometric specifications. This study compares a four season specification to a two season specification while introducing climate interaction terms between temperature and precipitation. Thus, to analyze the impact of climate, both small house hold farms and large commercial farms are separated. This tests the assumption that small house hold

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[3] The Ricardian Valuation Technique is based on comparative static estimates of how equilibrium land rents will change when a one-time instantaneous climate change is introduced. It estimates the impact of climatic, socio-economic, and geophysical variables on land values and farm revenues on the basis that the production function for crops will shift as climate changes. It assumes that farmers first take climate as given then decide what to grow, with what inputs, and in what way, or decide to convert land to other uses entirely.

farms are more vulnerable than large commercial farms to climate change because they have fewer substitution options. Furthermore, country specific dummies are introduced to see whether there are hidden variables concerning each country that can affect the results. Thus these regressions assume that irrigation is exogenous.

In this connection Maddison et al., (2007) examine the key issue of climate change impact on African agriculture using the Ricardian approach. The primary objective of this study is to assess quantitatively the economic impacts of climate abnormalities. For this purpose the study uses a large data set containing information on farming activities of eleven African countries. The study found that climate change could have devastating impacts on agriculture in sub Saharan Africa but more modest impacts elsewhere. It is very much clear from the study that climate change has a negative impact on productivity of all 11- countries. It is concluded that countries like Burkina Faso and Niger are suffering greatest loss in productivity because these already have very hot climate. Instead countries like Ethiopia and South Africa have a cooler climate suffer relatively little.

Deschenes and Greenstone (2007) evaluated the economic cost of climate change on US agricultural land. For this purpose they used year to year differences in temperature and precipitation to estimate the effects of climate change. "Hadley 2 model[4] "is used to predict long term climate changes. From climate prediction model it is evident that with change in climate will lead to a 1.3 billion dollars or 4.0 % increase in annual agricultural profits.

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[4] **Hadley** model was first developed in 1990 by George Hadley in the Hadley Centre for Climate Research and Prediction. The main purpose of this model is to monitor the natural inter-annual to decadal variability of climate.

Kurukulasuriya and Ahmad (2007) contributed to our knowledge in the application of the Ricardian technique to estimate the impact of climate change. From methodological perspective, the study uses a single cress-section of farm level data in a Ricardian framework. Outcomes of the study disclose that non climatic variables explain about half of the variation in net revenue. The paper elucidates that reduction in precipitation during key months can be disastrous. At the national level, a change in net revenues between -23 per cent and +22 per cent is likely depending on the climate change scenarios.

Fischer et al., (2007) examined impacts of climate change on crop yields and land values in U.S agriculture and comparing results with Deschenes and Greenstone (2007). The comparison of the two studies illustrates unique results. The estimates of the study clearly show that yield coefficients for Soybean and corn are significantly lower than the average price of these crops. For not storable crops like Strawberries and Oranges, the calculated price is not extensively different from the average prices. Thus it can be concluded that storage can affects storable commodities average price. Furthermore, it is evident from the overall results that, all estimates show strong negative shocks from climate change. The study also depicts that spatial pattern of temperature changes confirms strange degree of variability even among adjacent countries. Moreover, it is predicted that projected declines in crop yield are 30% with predicted warming in 35 years and about 80% over the next 90 years using more severe climate change scenario.

Seo and Mendelsohn (2007) analyzed the susceptibility of Latin American agriculture to climate change. Ricardian analysis is used to investigate both land values and net revenues of the Latin American farms using a sample size of 2200 farms. The study uses the entire crops in the region along with the value of live stock. The study primarily focuses on the sensitivity of small and large farms to climate change. Separate regressions have been estimated both for land values and annual net revenue. Land value regression reveals that many soil textures are beneficial but in case of net revenue regression few soils are significant. Both regressions hold technology as significant. It is very much clear from Temperature regression coefficients that net farm revenues are highly susceptible especially to summer temperature. It is further revealed that large farms responsiveness to summer temperature is quite different from small farms. Precipitation results show that rainfall has minor effects on net farm revenues than temperature. It is further added that in case of small and large farms precipitation responses similar results. In terms of loses 111 USD and 78USD are lost by 1 ^{0}C annual warming both in case of large and small farms respectively. The study also suggests that small farms are more sensitive to warming than large farms.

Fleischer et al., (2008) conducted a study in Israel testing the relationship between climate change and annual net revenues while focusing on irrigation water available for each farmer. A Ricardian technique is used to test the relationship. Two types of models are estimated; one without including irrigation water quota, the second model, includes irrigation water in a linear form. In most of the previous Ricardian analyses irrigation water was omitted which affects the consistency of these studies. The study finds that soil type has a significant positive effect on farm profit level. As age of a farmer reflects experience thus profits increase with increase in age of the farmer. The results further confirm that an increase in annual irrigation water quota leads to an increase in the annual profits per hectare. The model with irrigation water quota reveals that inclusion of water quota in the model leads to decrease in the level of significance magnitudes of the two temperature coefficients. In case of precipitation, the marginal effects of average precipitation level are positive however more precipitation above the average level reduces profits.

In the same line Seo and Mendelsohn (2008a) examined the impact of climate change on American farmlands. This study highlights the significance of climate change anomalies taking into account the very idea of adaptation. Ricardian approach is used to expound the effects of global warming on land values. It is evident from the results that farm land value decreases with increase in temperature. Trends for rainfall increase except for the irrigated land. In addition, most of the climatic variables in the whole sample analysis are significant. On the whole, results reveal that small households are slightly more susceptible to higher temperature than large commercial farms. Likely, increase in precipitation is also predicted to be harmful.

Afterward Seo and Mendelsohn (2008b) provide a new energy to the idea of climate change keeping in view the role of farm type in explaining climate impacts. They examined how climate plays an inimitable role in depreciating American farm land values. The upshots of the study unveil that warmer temperatures and heavy precipitations are harmful that result in reduce in farm value immediately. Statistics show that increase in seasonal precipitation during monsoon season is more harmful than beneficial precipitation during dry seasons. Climate variables are mostly significant except for livestock-only farms. Both temperature and rainfall coefficients vary a great deal across the farm type. Mixed farms are slightly more temperature sensitive than crop-only farms. Inversely, livestock-only farms are far more sensitive than either of crop farms.

In line with the above discussion the next study is giving a new stimulus to the idea of climate change. Seo et al., (2009) tried to compute the climate change impacts across agro-ecological zones in Africa. This study primarily focuses on how climate affects the farm land net revenues in different agro-ecological zones. OLS technique is used to estimate the Ricardian model. The whole analysis is divided into four regressions. In all regressions climate coefficients are mostly significant except for the model with four seasons. The net revenue responses to the summer temperature are all concave while for the winters it is convex. For soil most of the coefficients are negative. This shows that soil is severely exposed to climate abnormalities. It is evident from the first two specifications of the study that rain is generally beneficial but the last two specifications imply that rainfall is generally harmful. The study also reveals that AEZs do not receive benefits from increased rain due to high elevation or already humid conditions.

As the forgone considerations reveal that climate change has become a challenging concern for human society because of its potential deleterious impact world-wide. It poses serious threats especially to agriculture.

In this regard Lippert et al., (2009) assessed the impact of climate change on German agriculture using Ricardian method. To overcome the unbiased marginal effects a spatial error model is obtained. The cross sectional analysis yields an increase of land rent along with both rising mean temperature and declining spring precipitation except the eastern part of the country. Besides the calculated overall rent increases corresponds to approximately 5-6% of the net German agriculture income.

Likewise Wang et al., (2009) examined how expected variability in climate is likely to affect agriculture in China. For this purpose a cross-sectional data set of both rain fed and irrigated farms is used to analyze the effects of temperature and precipitation on net crop revenues. The results suggest that higher annual temperature slightly reduces the net revenues (-10USD/) per hectors in China. On the whole, temperature elasticity is -0.09. In spring season, high temperatures are detrimental while temperate summer and especially winter temperatures are beneficial. Higher annual precipitation increases net farm revenue (+15 USD/mm/hec). The overall precipitation elasticity is +0.8%. Though, the average effect of temperature is harmful while marginal effects of precipitation play a positive. But the effects are somewhat diverse for different regions of the country. Results for regional impacts reveal that with irrigated farms, warmer temperatures are more beneficial in the South East and South West regions of China (128-255 USD/hec/C^0). However farms in the central part of the country are enjoying additional benefits from warming. All irrigated farms enjoy small benefits from increased rain.

In line with Lippert et al., (2009), (Aurbacher et al., 2010) reassessed the correlation of climate change and agriculture in different German districts using Ricardian approach. The results of the study illustrate a significant relationship among climatic variables and land rents except for the eastern part of the Germany. Further, grassland share is predicted to be negative with land rents.

Ward et al., (2010) examined agricultural productivity and anticipated climate change in Sub-Saharan Africa using a spatial sample selection model. It aims to use simulated climate change shocks to predict the extent to which yields in Sub-Saharan Africa exposed to specific aspects of projected climate change including increases in temperature and changes in precipitation patterns. It is very much clear from the study that there is highly significant spatial dependence in the unobserved error terms in both the selection equation and response equation. The correlation of the spatial correlation is roughly 0.83 which is likely so high because of geographic scale involved. Even after controlling the effects of temperature precipitation and soil chemistry the country specific factor does contribute significantly to predict cereal yields. The study finally concludes that the coefficients of all country dummy variables are highly significant which suggests a great deal of spatial heterogeneity across Sub-Saharan Africa dependent of geographical and environmental factors.

Similarly, Thapa and Joshi (2010) examined a relationship between net farm revenue and climatic variables in Nepal. This paper applies Ricardian approach to estimate the effect of climate change on crop production. The main findings of the study reveal that there is a positive impact of high temperature and low precipitation on net farm income during fall and spring seasons. High temperature in summer season causes to decrease net farm income while high precipitation level results in increase in net farm income.

The phenomenon of economic impact of climate change on agriculture is investigated for Pakistan (Ahmed and Schmitz, 2011). It is one of the few studies which highlight how Pakistan's agricultural sector is prone to climate change. This study primarily focuses on the major crops in the country using the production function approach. The analysis shows that fertilizer has a key role in improving food crop yield. Thus it can be suggested that to overcome the impact of climate change on productivity, farmers should be provided with easy access to fertilizer. Another important variable is agricultural credit. The study shows that one unit increase in agricultural credit per hectare raises food crop yield about 1100kg per hectare. The study depicts that privately owned tube wells have significant positive effect on productivity. In the case of temperature the model proves a significant negative impact. One degree increase in temperature decrease about 44 kilos per hectare.

Finally, it can be wrapped up from the above debate that the incident of climate change is becoming very crucial for the Asian economies, especially for the developing countries. The principle challenge of this century is to provide adequate groceries to the rising inhabitants on the earth. So in the absence of a sufficient amount of agricultural output, it is not feasible to congregate these challenges. Agricultural activities are very much vulnerable to inexplicable changes of climate. These changes have widespread implications on agricultural output. It is obvious from the literature that maximum temperature is likely to be harmful in hot region like Sub Saharan Africa while beneficial in eastern frosty counties of china. Furthermore, in case of Germany, a significant relationship among climatic variables and land values is predicted to be negative. In the same line from the experience of ecological zones of Africa, it is evident that soil texture and soil fertility are rigorously exposed to climate abnormalities. Major part of the literature reviewed above reveals that both temperature and precipitation have a two prong impact on agricultural values. Consequently, temperature has a negative relation with land value in the hot counties of a region like in Sub Saharan Africa while it has a positive impact in freezing regions because it improves soil texture and fertility for those crops for which previously the temperature was not conducive. This results in increase in agricultural activities in that region. Similarly, precipitation plays a positive role in rain fed areas whereas in arid and semi arid regions, excessive amount of rainfall affects negatively. Likewise during summer season precipitation plays an important role to increase net form incomes.

CHAPTER III

3 METHODOLOGY

This section deals with the theoretical framework and methodology of the study, primarily focusing on the basic idea of the theory of rent. Furthermore, the following clauses of this chapter will give details of Ricardo's definition of the land rent and the law of diminishing returns in relation with the theory of rent. Assumptions of the Ricardian method are also presented in this chapter. The functional form of the study is illustrated in detail.

To check the individual effects, relevant tests have been carried out and results have been presented in tables. Appropriate tests have been conducted and presented in tables to apply a suitable econometric technique. The decision of fixed effects and random effects is based on the results of Hausman test. The test results are presented in a table below.

3.1 THEORETICAL FRAMEWORK OF THE STUDY

3.1.1 Ricardian Theory of Land Rent

Majority of economists subsist in a two-factor world (just labor and capital) disregarding land particularly vital for conventional political economy and ingested into capital and labor and departed (Gaffney, 2008). David Ricardo one of the leading classical economists propounded the theory of rent. He appeared first time in the field of economics in 1799, took an inspiration from the work of Adam Smith, "Wealth of Nations". Later on he continued his journey in the field of economics for 10 years with increasing interest. In the beginning of 19th century (1810), he came up with his first published work, "The High price of Bullion, a proof of the Depreciation of Bank Notes."

In response to the Corn Laws controversy[5] in 1815, Ricardo emerged with a new idea and published an essay on, "The influence of a low price of corn on the profits of stock." Dealing with the issues raised by the Corn Law controversy, Ricardo and eminent friends of him like Thomas Malthus and Torrens devised a remarkable principle of diminishing returns which afterwards became a milestone in the theory of rent (Deak, 1985).

Ricardo instigated the theory of rent from two fundamental conjectures regarding agricultural production. The first inevitable supposition of diminishing returns which is very much linked to the existing situation of production on piece terrain whereas the second assumption of marginal returns which is quite controversial practically, related to farmer's preferences preceding to the presence of rent.

3.1.2 The Principle of Diminishing Return

> *According to the law of diminishing return, "if a factor of production is steadily increased keeping other factors constant, the rate of increase in total product will eventually diminish" (Deak, 1985)*

Ricardo in his theory of rent assumes that the coefficients of production for land and labor are fixed in terms of technology. In other words, he assumes a fixed size of land for which an amount of labor and capital are added. Here he comes out with a conclusion that returns will start to diminish soon. As a result the marginal product of second unit of labor and capital would be less than the marginal product of first. Moreover, he was of opine that increase in population will lead to increase in demand

[5] In 1815, a controversy arose over the Corn Law in Europe. They were of the view that falling Wheat prices had led parliament, under the Lord Liverpool, to raise the tariff on the imported wheat.

for corn and thus to meet this demand a new piece of marginal land would be brought under cultivation in worsening conditions of production. This result in mounting regulating price of production of corn, which in turn would raise wages, thus leading to diminishing profit rate and the economy would eventually become stagnant (Deak, 1985). Further, he was of the view that the cause of tendency to fall in profits is due to the increase in the price of agricultural produce.

3.1.3 Ricardo's Differential Rent

The theory of rent instigated by David Ricardo is the concept of differential rent. He opined that land rent arises because of the variation in the fertility of the land. For him some lands are rich in productivity while some are less productive. So rents arise for land with high productivity while there would be no rent for low-grade land. Moreover, he says that if an excess amount of fertile land is available in a country, there will be no rent. But in reality the fertile land is not unlimited. Ricardo in his discussion of land rent restricted the idea of land rent/value to agriculture because for him the amount of land available was fixed, with a vertical supply curve and that law of diminishing returns hold best in agriculture sector.

Ricardo defined land rent as:

> *"That portion of the produce of the earth, which is paid to the landlord for the use of the original and indestructible powers of the soil."*

Ricardo (1821) underlined four key propositions about rent: for him land rent can be regarded as the indestructible powers of the soil, rents are not equal to profits. He also opines that land is heterogeneous in fertility while price of the commodities is not determined by the rent but the way other round. According to Ricardo, "whenever I speak of the rent of land, I wish to be understood as speaking of that compensation which is paid to the owner of land for use of its original and indestructible powers" (Ricardo, 1821:34). His argument is based on the idea that all other feature of the land exhaust over time except novel and unyielding powers. Therefore, he was of the view that all replacement cost must be subtracted from the rent. The second key proposition Ricardo talked about rent was that rent is not equal to profits. Furthermore, he says that the factors that control the rent to rise are quite different from that of profits and hardly ever move in the same trend.

3.1.4 Assumptions of Ricardian Method

The Ricardian model of climate change is anchored with the assumptions as under (Uzma et al., 2010).

- The theory assumes that there is a perfect competition among the farmers and they abide same cost of cultivation of land.
- It is implied that in the long run land values attain equilibrium in relation with each region's climate.
- Market for agricultural lands is also assumed to be uniform.
- Land is assumed as fixed or limited.
- The theory is primarily based on the assumption of diminishing returns.

Here perfect competition means that farmers are fully aware of all market information and this information is freely accessible to each farmer. Furthermore, it is also assumed that all farmers are rational and consistent, while adjust themselves with climatic variations using that information. That allows each farmer equal opportunities of adaptation.

3.2 Functional Form of the Model

The very assumption of perfect competition in Ricardian model allows free entry and exits and this notion of free entry-exit guarantees that additional profits are driven to zero. As a result, land rents will be similar as the net income per hectare (Ricardo, 1817). This indicates that land values are the mirror image of the present value of net farm income. It is very obvious that any agricultural farm that is located to a city has more chances to be employed other non-farm activities like construction of buildings, shopping malls, roads etc, this can also affect directly or indirectly the land value. Thus it is imperative to deem very carefully such characteristics while measuring farmland values near cities using Ricardian approach.

The Ricardian approach was initially developed with the purpose to predict the cost of impairment from climate change (Mendelsohn et al., 1994, 2001, 2005 and Mendelsohn and Neumann, 1999). It is evident from several studies that land value per hectare is sensitive to climatic variables like precipitator and temperature (Mendelsohn et al., 2005, 2007, Mendelsohn and Dinar, 2003 and Kurukulasuriya et al., 2006). Previous empirical work reveals that there is a certain level of precipitation and temperature which is conducive for many crops. So, the temperature and precipitation beyond that certain level reduces productivity and that results in decrease in land values. This approach is more practical in a sense that it not only incorporates the direct effects of climate change but also regard adaptation as a response from farmers to their native climate. Thus literature suggests that there should be a hill-shaped relationship among land values and climatic variables. As the response of land values to climatic variables is not linear, thus a quadratic functional form has been used in the study. Therefore, the standard model of quadratic form is given as:

$$LV_{it} = \alpha_{it} + b_{it} F_{it} + c_{it} F^2_{it} + d_{it} Z_{it} + \epsilon_{it} \ldots\ldots\ldots\ldots \qquad (3.1)$$

Where:

LV_{it} = Shows land value per hectare in Pak rupees in i_{th} district for time period t.

α_{it} = Constant term in the equation.

F_{it} = Represents the vector of climatic variables (temperature, Rainfall and humidity) in i_{th} district of Punjab for the period t while,

F^2_{it} = It is the quadratic form of vector of climatic variables.

Z_{it} = Vector used for non-climatic variables (population density) for i_{th} district in time period t and,

ϵ_{it} = Error term in the model.

Here, symbols F_{it} and F^2_{it} show single and multidimensional effects of climatic variables (average temperature, precipitation and humidity) employed in the equation. The quadratic form of climatic variables in the equation represents the non linear relationship among land values and climatic variables. Different models have been estimated to test the robustness of the model. For this purpose five models have been tested and in each model one extra variable is introduced[6]. We have also included interactive district dummies to capture district wise impact of climate change.

[6] In our analysis we have estimated five different models to check the robustness of the model. The first model is estimated with five key variables (Max.tempt, Max.tempt square, Min.tempt, Min.tempt Square and average rainfall) with constant term. In the later models, Average rainfall square, Humidity, Humidity square and population Density are brought in one by one respectively.

3.3 Selection of the Dependent Variable

For our analysis we can use either the land rent or the land value as a dependent variable. Hence, land value is used as a dependent variable in the study in hand. Moreover, land value or assets price is the value of holding title of assets to perpetuity (Deacon and Kolstad, 2000). On the other hand land rent is the price of a piece of land for a short time span. The reasoning for choosing land value as a dependent variable is that land value is the direct variable used in most of the Ricardian analyses (Uzma et al., 2010, Seo and Mendelsohn, 2008). But in case of developing countries, data on land value is not so easily available. Consequently, net farm income or revenue has been used as a proxy for land value.

3.4 Nature of the Data Used in the Model

Numerous studies that measure the climate change impact on agricultural sector have been using Cobb Douglas production function or Hedonic price model, mostly carried out on a single year's data (Mendelsohn et al., 2001, Mendelsohn, 2005, and Seo and Mendelsohn, 2008). But the study to play with is using a panel data with cross sectional units (districts) over a particular time period. The spirit of panel data is that it helps to estimate district wise climate sensitivities and temporal changes. Data on dependent and independent variables was collected from different sources as presented in data description table. Annually data on cropland value for the selected districts (twenty districts) of Punjab over a given time period (2005-2008) has been collected from Punjab Economics Research Institute (PERI), Lahore while for each climatic variable annually average data for thirty year have been taken from Pakistan Meteorological Department, Islamabad. Then we got a single value for each variable by taking thirty years average. The purpose of taking thirty years average was to fulfill the preliminary condition of climate change phenomenon. In other words, to capture climate change phenomenon it is imperative to consider a minimum span of three to six decades.

3.5 Tests for Individual Effects

District specific effects are excluded under the pooled ordinary least square estimation. In this a case, if the unobservable individual specific effects are associated with the regressors, then OLS estimates will be biased (Cheng Hsiao, 2003). Revisit equation 3.1,

$$PCM_{it} = \alpha_0 + \mu_i + \lambda_t + \beta X_{ijt} + \varepsilon_{it} \text{.......... ....}(3.2)$$

To check the individual effects, following three types of restrictions can be imposed on the above unrestricted specification of the model

$$PCM_{it} = \alpha_0 + \lambda_t + \beta\ X_{ijt} + \varepsilon_{it} \text{.......... ...}(3.3)$$

Specifically, to reckon only the time specific effects and consider that there are no cross-section specific effects, then test the following hypothesis

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \text{......} = \mu_N = 0$$

"Under H_0 the residual sum of squares (RSS_R) of the restricted model (3.9) divided by the variance (δ_ε^2) follow chi-square distribution with $NT-(2K+1)$ degrees of freedom, and the residual sum of squares (RSS_U) of the unrestricted model (3.8) divided by the variance follow chi-square distribution with $N(T-1)-2K$ degrees of freedom. $\frac{RSS_U}{\delta_\varepsilon^2}$ is independent of $\frac{RSS_R - RSS_U}{\delta_\varepsilon^2}$ which follow chi-square distribution with $N-1$ degrees of freedom. The F-test under H_0 is"

$$F = \frac{(RSS_R - RSS_U)/(N-1)}{RSS_U /[N(T-1)-2K]} \text{.......... .....}(3.4)$$

If F-test with $N-1$ and $N(T-1)-2K$ degrees of freedom is significant, the null hypothesis will be rejected and we will have to estimate a model with cross-section specific terms. The second restriction that can be imposed is to treat the time specific effects equal to zero and consider a model with cross-section effects only

$$PCM_{it} = \alpha_0 + \mu_i + \beta X_{ijt} + \varepsilon_{it} \text{.......... ....}(3.5)$$

And then test the following hypothesis

$$H_0 : \lambda_1 = \lambda_2 = \lambda_3 = ... = \lambda_T = 0$$

By using the following F-test

$$F = \frac{(RSS_R - RSS_U)/(T-1)}{RSS_U \ /[N(T-1)-2K]} \text{.......... ....}(3.6)$$

If F-test with $T-1$ and $N(T-1)-2K$ degrees of freedom is significant, the null hypothesis will be rejected and we will have to consider the time specific effects in our estimation model. But if the F-statistic turns out to be insignificant then we can ignore the time specific effects. The final restriction is to treat the model as common effects model with no time and cross-section specific effects.

$$PCM_{it} = \alpha_0 + \beta \ X_{ijt} + \varepsilon_{it} \text{.......... ....}(3.7)$$

And then test the following hypothesis

$$H_0 : \mu_1 = \mu_2 = \mu_3 = ... = \mu_N = 0, \lambda_1 = \lambda_2 = \lambda_3 = ... = \lambda_T = 0$$

By using the following F-test

$$F = \frac{(RSS_R - RSS_U)/(N-1)+(T-1)}{RSS_U \ /[N(T-1)-2K]} \text{.......... .....}(3.8)$$

If F-test with $(N-1)+(T-1)$ and $N(T-1)-2K$ degrees of freedom is significant, the null hypotheses are rejected and common effects model will be the incorrect choice.

To test for the individual effects in E-Views, the unrestricted specification of the model, with two-way fixed effects, is estimated first. When we perform the fixed effects test in E-views, E-views give us three restricted specifications as outline above, period specific effects only, cross-section specific effects only and estimation with common intercept.

Table 3.1 Individual Effects Test

Effects Test	Statistic	d.f.	Prob.	Conclusion
Cross-section F-Statistic	7.743722	(19,67)	0.0000	Reject H_0 of redundancy
Cross-section Chi-Square	116.189405	19	0.0000	Reject H_0 of redundant effects
Period F-Statistic	0.350235	(4,67)	0.8430	Fail to reject H_0 of redundancy
Period Chi-Square	2.069396	4	0.74	Fail to reject H_0 of redundancy
Cross-Section/PeriodF	6.581480	(23,67)	0.0000	Reject H_0 of redundancy
Cross-Section/Period Chi-square	118.151673	23	0.0000	Reject H_0 of redundant effects

The results of the redundant fixed effects are presented in table 3.1above. Both of the F-test and the Likelihood function (Chi-Square test) indicates the presence of cross-section fixed effects but the presence of period effects are not indicated by both of the tests. After that we conduct separate tests. In one case our unrestricted model is the one with cross-section fixed effects only and in second case our unrestricted model is with period effects only. Our E-views results have strongly recommended a model with a cross-section fixed effects only. So we have proceeded with a model that has cross-section specific but no period specific effects.

3.6 Fixed Effects- versus -Random Effects-Hausman Test

After deciding to estimate a model with cross-section specific unobservable effects, our next task is to determine that whether these unobservable effects are fixed constant correlated with the other explanatory variables (Fixed Effects Model) or randomly distributed independent of the explanatory variables (Random Effects Model). Whether to treat the effects as fixed or random makes no difference when time span is large, because both the Least Square Dummy Variable and Generalized Least Square estimators become the same (Cheng Hsiao, 2003). But when time period is finite and cross-section unites are large, whether to treat the effects as fixed or random, can make a surprising amount of difference in the estimates of the parameters. In our case cross-sectional unites are very large compared to the time period, so care is taken upon deciding between Fixed Effects and Random Effects Models.

We have used Hausman (1978) test to determine between Fixed Effects and Random Effects Models. Fixed effect estimators are consistent if the cross-sections specific effects are correlated with the explanatory variables and the random effects are inconsistent and biased. But the random effects are consistent and fixed effects are inconsistent if the individual specific effects are independently and randomly distributed of the explanatory variables. Thus the key factor to consider is to check that whether the individual effects are correlated with the explanatory variables or not. Hausman test is based on the difference between the fixed effects and random effects estimates. A significant difference between fixed and random effects is interpreted as evidence against random effects model. The null hypothesis of Hausman test state that there is no significant difference between the coefficients of fixed and random effects estimators. The chi-square test for the difference in estimates is

$$\chi^2_{df} = \left(\hat{\beta}_{FE} - \hat{\beta}_{RE} \right)' \left[\text{var}(\hat{\beta}_{FE}) - \text{var}(\hat{\beta}_{RE}) \right]^{-1} \left(\hat{\beta}_{FE} - \hat{\beta}_{RE} \right) \quad \ldots\ldots\ldots\ldots(3.9)$$

The fixed effects estimators are consistent under both the null and the alternative hypothesis. The random effects estimators are more efficient under the null hypothesis but inconsistent under the alternatives. The rejection of the null hypothesis implies that at least some of the explanatory variables are correlated with the individual specific effects. In such a situation if we used random effects model our results will be biased.

As we have extended our estimated model in three steps, at each stage we will check whether to use fixed or random effects model. Here we present the result of the check for the final model only. To perform Hausman test in E-views first a random effects specification is estimated. Then the null hypotheses of independent individual effects are tested using Chi-square Statistics. The results of our test are presented in Table 3.2.

Table 3.2 Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	15.06478	9	0.1118

As is clear from the above table, the null of independent individual effects is rejected by using Hausman test.

CHAPTER IV

4 DATA AND DISCRIPTION OF VARIABLES

Counties used in the study are given away in this section. Moreover, the topography of the study area and the agricultural share of the Punjab province are presented in detail. The variables used in the study and the data sources are presented in a tabulated form. Similarly, each fraction of variables is explained and justified. For further confirmation of requisite data, descriptive statistics are presented.

4.1 Study Area

Punjab province stands first in the race of agricultural GDP share in Pakistan's agricultural GDP. Punjab is the most densely populated province in Pakistan[7]. The total population of Punjab province is around 93 million people but it also contributes about 62.02 per cent to the total GDP of Pakistan. Being the major contributor and self sufficient in food crops and livestock, it is usually known as the granary of Pakistan (government of Punjab, 2010).

In terms of area, Punjab is the second largest province in Pakistan. The total area of the province is approximately 205344km^2 which is about 26 percent of the total area of Pakistan. The total farm area of Punjab is about 12.51 million hectares and it about 67 percent of the total cultivated area. Table 5.1 shows a detail summary of the agricultural share of Punjab province in the agricultural GDP of Pakistan.

[7] According to the Census Report (1998), the total population of Punjab province is 73621290. The province's population density was 359 persons per sq.km the urban population was 31.3 percent and the rural population was 68.7% with an average household size of 6.9 persons.

Figure4.1 Study Area Map

Table 4.1 Agricultural Share of Punjab in Agricultural GDP of Pakistan							
S. NO	Agricultural Production Sector	2008-2009			2009-2010		
		Pakistan	Punjab	% Share	Pakistan	Punjab	% Share
1	Major Crops	1195031	635444	53.2	1218873	646281	53.0
2	Minor Crops	136601	287347	59.7	135008	84641	62.7
3	Live Stock	622531	260344	41.8	648106	268327	41.4
4	Fishing	21319	5003	23.5	21626	5044	23.3
5	Forestry	14094	1202	8.5	14404	1484	10.3

Source: Punjab Development Statistics, 2010

The total share of major crops according to the Punjab development statistics, 2010 was roughly 53 per cent while minor crops contributed around 63 per cent of the total share during the period 2009-210. In terms of individual share of major crops, gram has the highest share of 81.7 per cent. Citrus is the main contributor with 96.7 per cent share in case of major fruits. The interlinked irrigation system which liked triple canals Jhelum, Chenab and Ravi was innovated initially in 1907-1915.

Table 4.2 Districts of Punjab Province			
1.	Bahawalpur	11.	Multan
2.	Bhakkar	12.	Nankana
3/	Chakwal	13.	Okara
4.	D.G Khan	14.	R.Y Khan
5.	Faisalabad	15.	Rawalpindi
6.	Hafizabad	16.	Sahiwal
7.	Jhang	17.	Sarghodha
8.	Khushab	18.	Shiekhupura
9.	Khanewal	19.	Sialkot
10.	Layyah	20.	Vehari

The main purpose of this project was to manage the surplus water to fulfill the existing demand. Thus the main rivers that contribute a major portion of irrigation water in Punjab are Jhelum, Chenab and the Indus with its tributaries.

To execute the study, twenty districts of Punjab have been selected. Districts have been selected on the basis of the accessibility of climate observatory stations. The list of the selected districts is given in Table 4.2.

4.2 Definition of Variables

Districts of Punjab are selected as cross sections in the study. Similarly, five points in time have been chosen on the basis of the availability of data. Variables used in the study are categorized in to climatic and non-climatic variables. The dependent and independent variables along with their definitions are presented in Table 4.3

4.3 Dependent Variable

The dependent variable inhabited in the study is the average land price per acre (market sale price of the land per acre). It is very evident from the literature that the use of agricultural land price as a dependent variable is consistent with other Ricardian approach analyses (Mendelsohn et al, 2001, Seo and Mendelsohn, 2007, Seo and Mendelsohn, 2008). It is clearly mentioned in final report of task force on climate change, 2010 that computing the upshots of climate change on different sectors of the economy is of crucial importance to devise a pragmatic procedure to develop country's development plans in the finest way and confine them within the limited available resources. In this connection the study in hand is a breakthrough to figure out the issue of impact of climate change on agriculture sector. For this purpose twenty districts from the province Punjab were selected. Data on agricultural land price was collected from Punjab agricultural research institute since 2005 to 2008.

Table 4.3 Description of Variables			
Variable	**Title**	**Definition**	**Source of data**
Dependent variable	LV	Annual average price of agricultural land at district level (PAK .RS/acre)	Punjab Economic Research Institute (PERI) (2004-2008)
Independent variable	**Climatic- variables**		
	MAX_TMP	Average annual maximum temperature (Degree Celsius $=^{0}C$) at district level	Pakistan Meteorological Department (1978-2008)
	MIN_TMP	Average annual minimum temperature (Degree Celsius $=^{0}C$) at district level	Pakistan Meteorological Department (1978-2008)
	RAIN_AVG	Average annual precipitation (millimeters= mm) at district level	Pakistan Meteorological Department (1978-2008)
	HUMID_AVG	Annual average humidity (percent= %) at district level	Pakistan Meteorological Department (1978-2008)
Independent variables	**Non- climatic**		
Population density	PDNS	The number of people living per kilometer square at district level	Punjab Development Statistics (2004-2008)

4.4 Independent Variable (Non-Climatic)

The current study divides the independent variables into two categories i.e. climatic and non- climatic variables. Only one non-climatic variable is used in the study and that is population density measured in terms of persons per km^2 (P_density). The intention of using this variable is to capture the magnitude of off farm usages of the agricultural land. So far four population censuses have been conducted in Pakistan. The last census was conducted in 1998 which is the most recent available census report. But to fulfill the data requirement of the study, data on population density for the year 2005-2008 were collected from the Punjab Bureau of Statistics, Lahore[8].

4.5 Independent Variable (Climatic)

Climatic variables are the second group of independent variables in the study. Yearly average data from 2007 to 2008 is used to capture the climate change impact. The standard minimum stretch of time consists of thirty years in order to address climate change phenomenon.

Maximum and minimum average temperatures are measured in degree Celsius (^{0}C), whereas square terms of both minimum and maximum temperature are also included in the regression. Another climate variable which is very crucial for the land value assessment is the annual average rainfall. It is measured in millimeters (mm). Relative humidity is also introduced as a climatic variable in the study. It is the relative amount of water contents in the air at a certain temperature and pressure (Vaisala, 2012). In addition, it has two prong effects on the way in which the water reacts with plants and the growth of leaf. It also affects the process of photosynthesis which results in raise the incidence of diseases. It is further confirmed from the results of the study in hand that the average humidity level has a positive relation but the square term of the variable has a devastating impact on agricultural land. The data on all climatic variables is collected

[8] The Punjab Statistical Bureau is the centre for the statistical data collection in the whole province and is responsible for the reliable data compilation and distribution of statistical data throughout the province.

from Pakistan Meteorological Department Islamabad. Some districts in the study area had no climate observatory stations. Thus to overcome this issue adjacent districts were chosen to collect the required data.

4.6 Descriptive statistics

Table 4 .4 Descriptive Statistics

Sr. NO	Variables	Mean	Standard Deviation	Min	Max	Observ-ations	Cross Sections
1	LV	423725.4	349953.9	64062.50	1678333.	100	20
2	Max_tmp	31.36994	1.129183	28.12326	33.37226	100	20
3	Max_tmpsq	985.3688	70.03190	790.9177	1113.708	100	20
4	Min_tmp	17.86295	1.106120	13.98763	19.81895	100	20
5	Min_tmpsq	321.5177	38.52184	195.6539	392.7909	100	20
6	Rain_avg	1.530830	0.572833	0.457936	2.929819	100	20
7	Rainsq_avg	2.668298	1.953205	0.209706	8.583842	100	20
8	Humid_avg	60.69702	3.687411	54.36909	77.41149	100	20
9	Humidsq_avg	3697.589	465.4343	2955.998	5992.538	100	20
10	Pop_density	522.3700	270.3329	117.0000	1058.000	100	20

CHAPTER V

5. ECONOMETRIC ESTIMATION

Empirical investigation using an econometric technique is an essential apparatus for researchers to find out a relationship among some controlled variables and a response variable. The fundamental problem is that there is always a possibility of multi-colinearity among the climatic variable and their square terms. E.views software package is used to estimate the regression. To deal with the problem of multi-colinearity, cross section white covariance method is used in the model.

Estimated Generalized Least Square technique has been used to contend with the panel regression model. The potency of the model can be judged from the characteristics of the model. In this relation the overall fit of the model is predicted from the values of F-Statistics while the relationship among the response variable and the regressors can be judged from the R-Square value. Similarly, it can also be assessed from the direction of the relationship between the dependent variable and the individual explanatory variables.

5.1 Results and Discussion

The study has a broad scope considering five points in time and twenty districts from the province Punjab. Results of the study have been wrapped up using Estimated Generalized Least Square (EGLS) with white cross section standard error technique. The EGLS (White cross-section) model results shown in Table 5.1 depict a quadratic relationship between the dependent variable (Land Value) and some climatic and non-climatic variables. Furthermore, some relevant statistics is also presented in the table. To check out the asperity and irregularities, quadratic forms of climate variables are also introduced along with linear form in the equation. Using quadratic form is logical and quite consistent with the previous literature (Seo and Mendelsohn, 2007, Schlenker et al., 200, Fisher et al., 2007, Uzma et al., 2010). The rationale of quadratic forms of climate variables is to capture the possible climatic abnormalities and sensitivities. The linear form in the equation shows the marginal impact of climate change on land values while the square terms represent how much land values are responsive to severity of climate. The quadratic relationship shows the direction and nature of the correlation among climatic variables and land values. Sign of the coefficients depicts the U-shape or hill-shape of the relationship. The negative sign confirms a U-shape relationship amid land values and climatic variables. In the same way a positive sign indicates the hill shaped relationship (∩) among the dependent (Land Value) and independent variables (climatic Variables). A U-shaped relationship concludes that value of land will decrease with increase in climatic variables up to a certain point, that is the bottom of the of the U-shape, then after this point land values will start to increase with climate variables. In case of hill-shaped relationship (∩), it reveals that land value will increase up to a certain point (maximum of inverted U-shape); from this point land values will start to decline as increase in climate variables.

Table 5.1 Ricardian Panel Estimation Results	
Variables	**Model**
Constant	-3667379 (-0.36)
Rain_avg	-650214.7 (-8.532)***
Rainsq_avg	241411.9 (13.641)***
Pop_density	806.1 (3.806)**
Humid_avg	302798.7 (3.367)**
Humidsq_avg	-2132.7 (-3.029)**
Min_tmp	495678.1 (3.544)**
Min_tmpsq	-14061.9 (-4.389)***
Max_tmp	-772058.4 (-1.430)
Max_tmpsq	13613.9 (1.584)
R-Square F-Stat	0.391 6.43

***, **, * denotes 1, 5 and 10 percent level of significance respectively.
The dependent variable is land value in Pak RS per hectare of land in 2004-2008**.**

5.2 Climatic Variables

Average rainfall has been a very important and significant role in Punjab's agricultural sector. Agricultural land values in Punjab region are explicitly dependent on average rainfall because almost 68% of the total geographical region comes under annual rain fall of 250 to 500mm while there is only 8% of the area where rainfall exceeds the limit of 500mm (Alam, 2000). In our analysis average rainfall has a highly significant U-shaped relationship with agricultural land values. It implies that 1mm increase in rainfall will result in decrease in agricultural land values by 650214 Pak rupees per hectare.

Average precipitation is highly statistically significant at 1 percent of significance level. The rationale behind this relationship is that current magnitude of rainfall is not sufficient for the agricultural lands in Punjab. In other words land value will decrease to a certain (minimum of U) and after that point both rainfall and land value will start to increase.

On the other hand, the square term of average precipitation shows a positive and highly significant relationship which confirms the hill-shaped relationship among land values and climatic variables. The relationship is significant at 1 per cent significance level. This again concludes that the present level of precipitation is inadequate for the agricultural land which results in departure of land value downward. From this end of analysis, it is confirmed that increase in rainfall above average level has a positive and optimistic impact on agricultural land values.

In case of humidity, the linear relationship between land value and humidity is positive and statistically significant at 5 per cent level of significance. It predicts that if humidity increases by 1 per cent it results in increase in land value by 302798 Pak rupees per hectare. But the quadratic term of humidity foretells a statistically significant negative relationship which again verifies the U-shaped relationship. Hence with higher level of humidity, land values are extremely sensitive and will start to decline sharply.

Minimum temperature has a hill- shape (∩) positive impact on land values. It implies that there is a direct relationship between mean minimum temperature and agricultural land values. This illustrates that 1^0C increase in minimum temperature will raise the land values by 495678 Pak rupees per hectare. Both the land value and mean minimum temperature shows an increasing trend up to the maximum point of (∩) and then departure from this point means that both the agricultural land value and minimum temperature are decreasing simultaneously. Mean minimum temperature is significant at 5 percent level of significance.

Minimum temperature square has an inverse relationship with land values. The relationship becomes U-shape which means if minimum temperature square increases, agricultural land values tend to decrease. The underlying principle is that if the variation in minimum temperature would too high, it would be less beneficial for the land values but if the change is normal, it will affect agricultural productivity positively hence land values.

Maximum temperature and maximum temperature square have U-shape (U) and hill-shape (∩) relationship respectively. But this relationship is not established to be statistically significant. The reason is that farmer's decisions about agricultural land value are not so attached with maximum temperature as compare to other factors in case of Pakistan. They do care of factors like access to road; access to market soil quality and precipitation level etc. It is also evident that in Punjab maximum temperature has been not increased significantly during 1960-2008 (Rasul et al, 2009). Thus this validates the consistency of our results from the recent literature. Similarly, the expected signs and the direction of relationships are in line with the expectations.

5.3 Non Climatic Variables

It is imperative to be acquainted that land value is not the only factor that reflects the agricultural land price but there are some other regional variations might be non climatic or geographical like irrigation, soil fertility, population etc, that might influence the land values directly or indirectly as well. In the same line the study has introduced a diverse variable that is the population density (persons/km2) at district level. The rationale for introducing this variable is that if population increases this result in increase in persons per kilometer square. Thus, to accommodate the more persons, we need to supply additional amount of land that shorten the availability of land for agricultural purposes. Consequently, the demand supply effect will give rise to agricultural land prices. From the analysis it can be concluded that there is positive and strongly significant relationship between land values and population density. It predicts that one unit increase in population density will cause to increase land prices by Pak Rs 801. It is statistically significant at 5 per cent level of significance. From this we can conclude that land is a fixed factor of production, as population density increases, demand for agricultural land also increases.

5.4 Estimation of Interactive Dummies for Rainfall

To see the district wise effects of rainfall, we have included nineteen dummies as interactive terms in our earlier estimated equation. This means that we have allowed slop coefficient for rainfall to vary from district to district. Vehari is taken as the base category in our analysis. Our result shows that the highest positive effects of rainfall are in district Rawalpindi where one millimeter increase in average rainfall lead to increase the land value by more than a half million of Pak rupees.

Table 5.2 Estimation for Rainfall with Interactive Dummies	
Variables	**Model**
Constant	-476869.9 (-3.77)
Rain_avg	382398.1 (1.81)
Rainsq_avg	-172082.5 (-1.89)
Pop_density	2089.410 (4.99)**
Humid_avg	127868.9 (1.90)
Humidsq_avg	-773.5264 (-1.75)
Min_tmp	-1218663. (-4.09)**
Min_tmpsq	28315.14 (3.58)
Max_tmp	-328232.0 (-3.68)**
Max_tmpsq	49822.77 (3.84)**
Rain_avg *Bahawalpur Dummy	-69654.65 (-1.84)
Rain_avg *Bhakkar dummy	300493.6 (1.67)
Rain_avg *Chakwal Dummy	717129.1 (1.811)
Rain_avg *D.G Khan Dummy	- 116222. (-1.55)
Rain_avg *Faisalabad Dummy	-298806.7 (-1.694)
Rain_avg *Hafizabad Dummy	-186798.8 (-6.11)***
Rain_avg *Jhang Dummy	-709481.7 (-1.83)
Rain_avg *Khushab Dummy	817877.1 (0.88)
Rain_avg *Khanewal Dummy	-45290.25 (-1.71)
Rain_avg *Layyah Dummy	-31128.58 (-1.43)
Rain_avg *Multan Dummy	-232738.1 (-0.86)

Continue…… Table6. 1 Estimation for Rainfall with Interactive Dummies	
Rain_avg *Nankana Dummy	41605.50 (0.760)
Rain_avg *Okara Dummy	19839.10 (1.36)
Rain_avg *R.Y khan Dummy	-87672.27 (-1.81)
Rain_avg *Rawalpindi Dummy	391733.1 (2.90)*
Rain_avg *Sahiwal Dummy	205331.1 (3.25)**
Rain_avg *Sarghodha Dummy	-106411.5 (-0.895)
Rain_avg *Shiekhupura Dummy	169345.8 (3.0)*
Rain_avg *Sialkot Dummy	131041.0 (3.66)**
R-Square	0.91
F-Stat	13.06

*****, **, *** denotes 1, 5 and 10 percent level of significance respectively.

Similarly, the highest negative effects are reported in district Hafizabad where one millimeter increase in average rainfall results in decrease in agricultural land value by two lakh Pak rupees approximately. In contrast, all the insignificant rainfall interactive dummies illustrate that the effects of rainfall in these districts are quite similar to the district (Vehari) taken as the base category.

5.5 Overall Results

To check the robustness of the model, different models have been tested and the best model is reported in table 6.1. Results of the study show that there is a significant value of R-Square with 0.391 which is pretty reasonable in panel data estimations. R-square value shows that 39 percent of the total variation in the response variable is due to the independent variables both climatic and non-climatic variables. F- Statistic is also presented in the table which predicts the overall good fit of the model. It is the combine significance of explanatory variables (Climatic and Non-Climatic) on land values per hectare of the agricultural land. The Estimated Generalized Least Square method is applied to estimate the random effect model which is opted on the basis of the probability value of Chi-Square test. To avoid the problem of autocorrelation and mult-colinearity EGLS-technique is used.

5.6 Robustness Check and Sensitivity Analysis

To scrutinize the sturdiness of the model, robustness and sensitivity tests have been carried out by adding up new variables in the final model. For this purpose, we have estimated five different models using random effect method. In the first model, five key variables have been estimated. Maximum and minimum temperatures with their square terms show a U-shaped and hill-shaped relationship with the dependent variable respectively. Thus, the relationship is very much consistent with the expectations. From the results of second model it is confirmed that signs of the relationship are again consistent. In the same way rest of the variables have been introduced in the subsequent models and in spite of different specifications the direction of coefficients in all models remain consistent. This clearly proves the robustness of the results

Table 5.3 Robustness Check & Sensitivity Analysis					
Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Max_tmp	-945151.1 (-0.7252)	-53882.68 (-0.0428)	-396337.4 (-0.485)	-880415.0 (-0.8487)	-772058.4 (-1.0393)
Max_tmpsq	14415.74 (0.6999)	812.5262 (0.0411)	6550.365 (0.7176)	14192.38 (0.8752)	13613.85 (1.1847)
Min_tmp	412731.8 (3.2871)*	215227.6 (1.9734)*	196547.2 (2.3874)*	246987.8 (2.3712)*	495678.1 (3.5444)*
Min_tmpsq	-10508.2 (-5.9299)*	-5544.881 (-4.3108)	-4907.5 (-6.340)	-5692.1 (-2.7360)*	-14061.66 (-4.3897)*
Rain_avg	-11303.81 (-0.2807)	-581643.8 (-4.7746)*	-526996.4 (-3.543)*	-420856.9 (-5.223)*	-650214.7 (-8.5322)*
Rainsq_avg	—	216106.1 (5.3324)*	195901.2 (4.2068)*	153116.6 (6.813)*	241411.9 (13.6418)*
Humid_avg	—	—	23108..94 (1.1371)*	343737.7 (3.531)*	302798.7 (3.3679)*
Humidsq_avg	—	—	—	-2455.6 (-3.148)*	-2132.776 (-3.0294)
Pop_density	—	—	—	—	806.1216 (3.8065)
C	11856871 (0.5976)	-2219352 (-0.1165)	-3350597 (0.2160)	-72648.83 (-0.0438)	-3667379 (-0.2966)
R-Squared	0.010	0.056	0.125	0.212	0.391
F-statistic	0.203	0.931	1.884	3.070	6.432

***, **, * denotes 1, 5 and 10 percent level of significance respectively.

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CHAPTER VI

6. CONCLUSION AND POLICY SUGGESTIONS

The study in hand investigates empirically the impact of climate change on agricultural land values primarily focuses on the agricultural land of Punjab province. In this connection present study validates that the climate change influences extensively the productivity and the market value of a piece of agricultural land. The way round, ups and downs in agricultural land values are largely impinged by climatic anomalies.

Therefore, it is of dire need to address the issue of climate change and its impact on different segments of the economy specifically the agricultural sector to formulate a strategy for policy making. Consequently, consideration of environmental factors in any growth plan is fundamental for policymakers to utilize the available resources in a sustainable manner. Keeping this in mind, the current study is a good contribution to compute the impact of climate change on agricultural sector.

To collect the agricultural land values data at district level, twenty districts from province Punjab were selected. The choice of each district is based on the availability of data on land values for the concerned district. Annual Data on agricultural land values is collected from Punjab Economic Research Institute (PERI), Lahore for the year 2005-2008. Data on all climatic variables is collected from Pakistan Meteorological Department, Islamabad. Average precipitation has a significant negative impact but if we take the square of this current rain, it shows a positive relation. The rationale is that the current amount of rain is insufficient for the crop productivity and the soil fertility of the land rather there is a dire need of additional quantity of rainfall to compensate the demand of water for agricultural purposes. In case of maximum temperature and maximum temperature square, both are statistically insignificant for Pakistan. The reason is that apart from precipitation, people do not give much weight to temperature in their decision making. Another reason is that there are no extremely hot or cold regions in the study area so that temperature could affect their decision making. Thus its role in case of Pakistan is negligible. Our results are similar to (Uzma et al., 2010) in case of maximum temperature. They also found it insignificant in case of Pakistan. Population density is used as a control socio-economic variable which has a significant positive hill-shaped (∩) relationship. It is found from the results that one person per square meter increase in population density increases Pak Rs. 806 per acre of the agricultural land value. The minimum temperature has a significant positive impact on land values. In contrast, minimum temperature square has a significant negative impact on land values with a (U) shape relationship. It is further clear from the results that the current humidity level has a positive impact on agricultural land however if humidity exceeds from the current level, agricultural land values start to decline. This concludes that it is of great importance to consider the level of humidity and precipitation level which directly affect the agriculture land. The overall results indicate that both climatic and non-climatic control variables explain almost 40 per cent of the total variation across the region.

6.1 Policy Propositions

It is very much clear from the overall outcomes of the current study that excepted average maximum temperature and its square term rest of the climatic and non-climatic variables are highly statistically significant with agricultural land values. Therefore, it is confirmed that climate change is striking agricultural land values but at the same time it seems beneficial as well because of the adaptation. These benefits show the adaptation factor that allows farmers to adjust their farming activity with changing climate. Thus adaptation makes them capable to increase their revenues in the long run.

Consequently, policy makers should develop such policies that help in minimizing costs related to climate change and maximize agricultural benefits. For this purpose government should come up with new ideas and practices of research. For the awareness of the issue, government can conduct workshops and seminar for the farmers to equip them with new solutions and strategies. Government should also bring in both public and private institutions and encourage them to develop new varieties of crops that are capable of enduring extreme weather conditions like droughts etc. this will help do implement new adaptation tactics. Similarly; there should be flow of information related to climate change phenomenon for the concerned stakeholders at zero a rate. It can also be helpful if climate policies are enclosed with ground realities. Finally, planners should be pragmatic in their policy making and they should primarily focus on regional ground realities.

6.2 Study inadequacies

Proper understanding of the results needs the identification and presentation of constrains of the study. The first and foremost issue arrived during this study was the availability of the required data. Other than climatic variables, urbanization is a crucial variable to determined agricultural land values but this variable is not considered in the model because the data was not easily available at district level. Similarly, data on irrigation is also missing in the model as Irrigation Authority has not preserved the requisite data at district level.

District wise data on Agricultural land values was taken from Pakistan Agricultural Research Institute Lahore which is unpredictable. District wise surveys have been done in some selected regions of the study area for a short time period. This offers a data set which does not allow to including a large set of time series data that may affect the final results.

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