Impact of Climate Change on Select Agriculture Produce in Jammu and Kashmir

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CERTIFICATE

This is to certify that the dissertation entitled **'Impact of Climate Change on Select Agriculture Produce in Jammu and Kashmir'**, submitted to the Department of Economics, Central University of Haryana for the award of the degree of Master of Philosophy in Economics, appears as the record of original work done by Mr. Irfan Yousuf Ganie (Enrollment No. CUH/2017/ECO/002/10052), under my supervision and guidance. The matter presented in this dissertation has not been submitted in part or full, for any other award of any degree/diploma of this university or any other university/institution.

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DECLARATION

I hereby certify that the research work entitled, "**Impact of Climate Change on Select Agriculture Produce in Jammu and Kashmir"** is a novel piece of work carried under the supervision of Dr. Ajeet kumar Sahoo**,** Assistant Professor, Department of Economics, Central University of Haryana, and is submitted in partial fulfillment of the requirements for the award of the degree of Master of Philosophy in Economics. The research work Carried is a bonafide one. No portion of the thesis has been submitted for any other degree or diploma in this or other university. Maintenance of research ethics remains the prime motive throughout the thesis writing.

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TABLE OF CONTENTS

Sr. No.	Contents	Page No.
	Certificate	i
	Declaration	ii
	Acknowledgement	iii-iv
	List of Abbreviations	ix-xi
Chapter 1	**Introduction**	**1-27**
1.1	Evidences and Effects of Climate Change	3
1.2	Historical Background of Climate Change	6
1.3	Global Scenario of Climate Change	10
1.4	Indian Scenario of Climate Change	13
1.5	Jammu and Kashmir Scenario of Climate Change	17
1.6	Kashmir Climate Change and Agriculture	19
1.7	Rationale of the Study	23
1.8	Statement of the Problem	24
1.9	Objectives of the Study	25
1.10	Hypothesis of the Study	25
1.11	Chapterization	25
Chapter 2	**Review of Literature**	**28-45**
2.1	Review of Literature: Foreign Studies	28
2.2	Review of Literature: Indian Studies	34
2.3	Review of Literature: Studies at Jammu and Kashmir	40
2.4	Research Gap	45
Chapter 3	**Research Methodology**	**46-49**
3.1	Regression Models	47
3.1.1	Model 1: Rice Production	47
3.1.2	Model 2: Rice Productivity	48
3.1.3	Model 3: Apple Production	48
3.1.4	Model 4: Apple Productivity	48
3.2	Area and Period of the Study	49
3.3	Data and Data Sources	49
Chapter 4	**Data Analysis and Interpretation**	**50-65**
4.1	Trends in Area, Production and Productivity	50
4.1.1	Trends in Rice Crop	50
4.1.2	Trends in Apple Crop	53
4.2	Descriptive Statistics(1985-2015)	56
4.3	Stationarity and Unit Root	61

4.4	Results of Regression Models	62
Chapter 5	**Conclusion and Findings**	**66-70**
5.1	Conclusion	66
5.2	Findings of the Study	67
5.3	Policy Implications	69
5.4	Limitations and Future Scope of the Study	70
	Bibliography	**71-74**

List of Tables

Table No.	Table Description	Page No.
4.1.1	Trends in Area, Production and Productivity of Rice from 1985-86 to 2015-16	50
4.1.2	Trends in Area, Production and Productivity of Apple from 1985 to 2016	53
4.2.1	Area under Apple and Rice Crop 1985-86 to 2016-17	57
4.2.2	Production of Apple and Rice Crop 1985-86 to 2016-17	58
4.2.3	Productivity of Apple and Rice Crop 1985-86 to 2016-17	59
4.2.4	Descriptive Statistics of the Climate Variables for the Time Period 1985-2015	60
4.3.1	Results of Augmented Dickey-Fuller (ADF) unit root test	61
4.4.1	Regression between AP, RF and TR	62
4.4.2	Regression between APD, RF and TR	63
4.4.3	Regression between RP, RF and TR	64
4.4.4	Regression between RPD, RF and TR	65

List of Figures

Figure No.	Description of Figure	Page No.
4.1.1	Trends in Area and Production of Rice from 1985-86 to 2015-16 (in ‘000 hectares and ‘000 tons)	51
4.1.2	Trends in Area and Productivity of Rice from 1985-86 to 2015-16	52
4.2.1	Trends in production of Apple from 1985-86 to 2016-17 (in mt. tons)	54
4.2.2	Trends in Area of Apple from 1985-86 to 2016-17 (in hectares)	55
4.2.3	Trends in Area and Productivity of Apple from 1985-86 to 2016-17	56

List of Abbreviations

IPCC- Intergovernmental Panel on Climate Change

UNDP- United Nations Development Programme

IFPRI- International Food Policy Research Institute

FAO- Food and Agriculture Organization

ICAR- Indian Council of Agricultural Research

UNFCCC- United Nations Framework Convention on Climate Change

UNEP- United Nations Environment Programme

INCCA- Indian Network on Climate Change Assessment

TAR- Third Assessment Report

HFCs- Hydrofluorocarbons

CFCs- Chlorofluorocarbons

WG1- Working Group First

ENVIS- Environmental Information System

FGLS- Feasible Generalized Least Squares

HAC- Heteroskedasticity and Auto Correlation

CSE- Consistent Standard Error

OLS- Ordinary Least Squares

MQ- Median Quantile

QR- Quantile Regression

FE- Fixed Effects

VAR- Vector Auto Regression

$HadCM_3$- Hadley's Centre Global Circulate Model

CD- Cobb Douglas

HVC- High Value Crops

SKUAST-K- Shere-e-Kashmir University of Agricultural Science and Technology-Kashmir

MT- Metric Tons

ADF- Augmented Dickey Fuller

DES- Directorate of Economics and Statistics

IMD- Indian Meteorological Department

AA- Apple Area

AP- Apple Production

APD- Apple Productivity

RF- Rainfall

AT- Average Temperature

RA- Rice Area

RP- Rice Production

RPD- Rice Productivity

RBI- Reserve Bank of India

RDP- Rice Development Patna

CHAPTER-1

INTRODUCTION

"Tackling climate change is closely linked to poverty alleviation and economic development; I would call them different sides of the same coin."

- Paul Polman, CEO, Unilever

Any undesirable variation in the physical, chemical and biological factors of the climate is termed as the climate change. Climate change is the significant variation in the components of the climate that lasts for an enlarged period of time. Climate change includes variations regarding different climatic variables like temperature, precipitation, wind speed, wind direction, relative humidity, snowfall content and its pattern etc. which occur over decades or more and leave a significant impact on mankind in general and poor and unprotected people in particular. The challenge of climate change is the biggest challenge facing the world today. It is the biggest threat that poses serious environmental, economic, social and political problems and engulfs the whole mankind in its periphery. Thus climate change is a universal issue and hence demands a collective universal conscience to combat it, so that mankind can be freed from the serious implications of climate change.

Climate change is a global environmental issue concerned with atmosphere which is a common property resource and has engaged the whole world. The biggest problem with respect to climate change is that, it is difficult to predict and further it worsens the conditions of poor people most whose contribution towards the major causes of climate change is negligible. Various worldwide organizations (including governmental and non-

governmental) are addressing this issue wholeheartedly in order to tackle the serious repercussions of climate change. After the inception of industrial revolution, the earth's average surface temperature got increased and is opined to increase more which impacts biodiversity, tourism sector, agricultural production and productivity, horticulture production and productivity, water content, food security and livelihoods of masses at an alarming rate (IPCC).

As per UNDP estimates, climate change has the ability to retard the growth and development which was achieved over last few decades and its seriousness could add millions to the existing stock of poor. Pressure on resources, which leads to resource extinction, further leads to mass migration globally. The symptoms of climate change are evident in terms of temperature increase, glacier melting and rise in sea levels which are responsible for unbalancing the worldwide ecosystems. It is presumed that 20 - 30% plant and animal species are vulnerable to extinction if global average temperature excels 1.5°c – 2.5°c which is expected as per present scenario of climate change (IPCC,2007).Also the frequency of floods (six times) and other disasters (four times) has increased yearly in comparison to 1980s level.

Climate change impacts are evident from developing economies more as developing economies rely more on primary sector and this is the sector which is most impacted by the climate change. Due to climate change the existing gap between the developing and developed countries widens further because developing countries are wholly and solely dependent on natural resources which form the base of primary sector and this primary sector is more vulnerable to climate change impacts. Regarding this the UNDP estimates exhibit that more than 90% of the people yearly got affected by the climate catastrophes

in developing countries from 2000 – 2004.Various other researches also show concerns over the sensitivity of developing countries to climate change because of their dependence on agriculture sector (which is more prone to climate catastrophes) and their adaptation inability. As per IFPRI report, climate change diminishes the output of various major essential crops in developing regions.

Among the negative opinions about the implications of climate change there are positive opinions regarding climate change as well, but positive points are limited only to certain geographical areas. Research evidences reveal that tropical areas and low to mid-latitudes are more prone to climate change effects than temperate areas which get benefits from climate change due to the increase in growing period length.

Thus climate change is a global issue for its imperative ill effects on human beings in general. It leads to ecological imbalances and causes huge loss of the natural and man-made resources through various catastrophes like floods, typhoons, droughts, heat waves, tempests etc. It puts the existence of poor people on stake due to their adaptation inefficiency and resource deficiency with which they could resist. In this context worldwide attention and intervention is of prime importance in order to tackle and combat such imperative negative consequences of climate change so that mankind can be freed from the havoc of climate change.

1.1 Evidences and Effects of Climate Change

As per IPCC, the potential impacts of climate change on different areas will vary over time due Climate change is a burning issue of 21st century .Its symptoms got revealed

through variations in different dimensions of climate like global sea level rise, global temperature rise, erratic precipitation, extreme events etc. which are discussed below;

World sea level rose up to 17cm, (6.7 inches) since last century. However the rate since the last decade is double than the previous century rate. Oceans became warmer, snow and ice content got decreased. Since 1901 – 2010 mean sea level of the world got enhanced by 19cm as oceans stretch because of warming which leads to melting of ice.The ice content in the arctic sea belt has contracted with successive decades from 1979, with every decade loss accounting for 1.07 million km^2 (IPCC, 2007). Due to the rise in sea levels, people dwelling around coastal belts and river basins shift to upper altitudes. Prolonged dry spells compels the livestock farmers to migrate to safer and feasible places. This motion of people from one place to another place gave rise to battles between the migrants and existing communities for land water access, (Kurukshetra, March 2010, pp. 4-5).

As per FAO report, warming of oceans, incessant tropical cyclones, flash floods and prolonged dry spells are imperative to destroy the pacific island countries food production. The pacific island countries report on climate change and food security revealed that the disasters related to climate change have curbed the growth and development of these islands and gave rise to food insecurity, (Kurukshetra, March 2010, p. 4).

Global warming signals that the effects of climate change are more prone to agriculture and severely affects it, there by leading to hunger risks and deficiency of portable water due to variability enhancement and fast glacier melting. According to Indian Council of

Agricultural Research (ICAR), annual wheat yield may diminish by 4 – 5 million tons with every 1°c temperature increase, (Kurukshetra, March 2010, p.4-5). The 2005 Millennium Ecosystem Assessment report revealed that, with the culmination of this century biodiversity will vanish.

Global surface temperature reveals that earth has warmed since 1880s.Most warming occurs since 1970s with last 20 years warmer than previous years and last 10 much more warmer than previous ten years. From 1880 – 2012, global mean temperature extends by 0.85°c.Fluctuations in precipitation content increased everywhere. Wet regions become wetter, dry and arid regions become more drier and arid (IPCC, 2007).

Globally the frequency and number of extreme events has increased. Uneven variation in diurnal temperatures, rising intensity of cold waves, erratic rainfalls, snowstorms, cloudbursts, hailstorms, devastating floods, soil erosions, landslides are various climate catastrophes which occur frequently now. Surface water acidification has increased by about 30%. The absorption rate of carbon dioxide by oceans got increased by about 2 billion tons annually. For every 1 degree temperature increment, the grain output diminishes by about 5%. Significant decrease occurs in rice, maize and wheat outputs at the global level. Near about 40 megatons output of above specified crops got lost per year between 1981–2002 due to warmer climate. CO_2 emissions globally got enhanced by about 50% since 1990. Emissions pick rapid pace between 2000 –2010 than past three decades (UNFCCC).

The predicted future impacts of climate change include temperature rise, severe rainfalls, floods, wild fires, extended drought periods, storms, landslides, diseases etc. The

observable effects of climate change are already evident. Glaciers got shrunk; ice cover is breaking up earlier. The changes are depicted by plant and animal lives as well. Trees are flowering sooner before their specific time periods. Animal ranges got displaced. Shift in the migration of migratory birds, food deficiency and decrease in water table are the other new faces of climate change.

As per IPCC, the potential impacts of climate change on different areas will vary overtime due to the advantage of ability and adaptive efficiency of certain regions than others with respect to climate change.

1.2 Historical Background of Climate Change

"The earth, the air, the land and the water are not an inheritance from our forefathers but on loan from our children. So we have to handover to them, at least, as it was handed over to us."

- Mahatma Gandhi

Among the basic necessities of mankind climate is of prime importance. It is one of the essential factors in physical environment of all living creatures. It is highly beneficial for all till it is in balance and any sort of variation in its balance leads to serious irresistible repercussions on whole planet in general and mankind in particular.

Climate change history is directly connected with the geological history of the earth. Rocks and fossils exhibit evidence about the evolution genesis and change in the earth's climate. Climate varies various times and will continue to vary with the passage of time, however in past it varies slowly and the variation was a natural one.

Climate became much hot and humid before 12000 years ago. However this effect doesn't last longer and got soon substituted by a cooling phase. Due to this climatic variation, the air temperature of Europe in summer varied by few degrees. After it hot and humid phase started around 5000 B.C and continental glaciations were wiped out in Europe and North America. In this period postglacial warming attained the peak. The mid-latitudes air temperature of northern hemisphere was about 1°c – 8°c more, than at present, between the time period 7000 – 8000 B.C. At this juncture atmospheric circulation got changed. The polar ice boundary shifts towards north wards was corresponded by the shift in high pressure sub-tropical belt to topper latitudes. This resulted in the formation and extension of arid areas in Europe, Asia and North America. Further in low latitudes of North America precipitation increased (Budyko, 1986).

The beginning of 2^{nd} millennium A.D was accompanied by a warming trend which leads to polar ice retreat thereby colonization of Greenland occurs and North America was discovered. With the elapse of time cooling trend occurred once again favoring ice which leads to Greenland extinction. The formation of cooling phase since 13^{th} century reached to its peak in the 18^{th} century beginning. In this phase extension of glaciers took place. That is why this phase is also termed as "little ice age". Latter on warming resumed again and glaciers start retreating.

The biggest climate change in the technological era occurred at the end of 19^{th} century. The period was accompanied by a steady rise in air temperatures in the Northern hemisphere. Warming was actually experienced at high latitudes in cold season, (Lamb, 1970). Even if the implications of modern climate change are less in southern hemisphere

in comparison to Northern hemisphere, still there are facts which reveal that warming also envelops the Southern hemisphere in the 20th century (Rubinstein, 1966).

So many research and scientific evidences revealed that there is a huge difference between the climates in past and their present scenarios. Even though past climates reveal certain amount of warming but increase in the amount of greenhouse gases was never felt. From this statement it can be concluded that, for the first time human intervention has reached to that extent where from his existence is now on stake, as climate is now playing a negative role towards mankind. Without any doubt global climate is now showing an anti-behavior to mankind. Majority of studies related to climate revealed that the global climate has changed and the effects depicted by this change are evident to naked eye now, which range from uneven temperature increase to rapid glacial retreat, intense cold waves to crop yield decrease, ozone layer depletion to the spreading of various diseases etc. Majority of the changes exist largely over the hemispheric scale. Regional effects of the climate change are yet dormant or minimum (Pant et al., 1993).

Reliable climate data with variables temperature and rainfall from India over the time period 1870 onwards till now revealed a little but significant warming trend in yearly average temperature, approximately accounting up to 0.4°c/100 years. It is concluded that climate change and global warming (Two sides of the same coin) is the cumulative effect of all human and developmental processes which took place after the industrial revolution.

The analysis report put forward by IPCC-TAR-2001 (Intergovernmental Panel on Climate Change-Third Assessment Report) revealed the following results;

1) CO_2 emissions in atmosphere increased from 280 ppm to 368 ppm since 1950-2000.
2) CH_4 amounts got enhanced from 7000 ppb to 8750 ppb between 1950 -2000.
3) The NO_2 concentrations increased from 270 ppb to 316 ppb between the time periods 1950-2000.
4) The atmospheric content of HFCs and CFCs got increased globally since last 150 years.

With respect to weather indicators IPCC-TAR (2001) exhibited that average surface temperature increased by 0.6±0.2°c in the 20th century. Surface areas become warmer than the oceans. The surface temperatures over the northern hemisphere increased drastically in the 20th century in contrast to any other century, since last 1000 years. Over land regions, Diurnal surface temperatures extent diminishes between the time periods 1950 – 2000.During the 20th century average number of warmer days got increased for all land areas. Average number of frost days got decreased during the above mentioned time period. Over the 20th century continental precipitation increased by 5% - 10% in the northern hemisphere, even though it diminishes in certain areas of North and West Africa with few areas belonging to mediterranean. In some areas of Africa and Asia, Severeness and frequency of droughts increased in last few decades.

The phenomena of climate change got the recognition from Biological and physical sides as well. As per IPCC-TAR (2001), increase in average global sea level occurred at an annual mean rate of 2mm in the 20th century. The ice content duration over rivers and lakes got diminished by about 14 days in Northern hemisphere. About 40% thickness

decrease occurred in arctic ice content. Retreat of non – polar glaciers occurred on a large scale in the 20th century. Snow content got decreased by 10% over the 20th century.

Growing periods got extended by 4 days/decade since last 40 years in the Northern hemisphere. Shift in plant and animal ranges occurred pole-wards. The warming of 20th century results in pre- flowering in plants, pre bird migration and pre breeding seasons in the Northern Hemisphere. Economic losses in the context of weather went up considerably since last 40 years (IPCC-TAR, 2001).

Projected change in the climate conditions exhibited that the 21st century is expected to encounter higher maximum temperature, much hotter days and intense heat waves globally. Frequency of minimum temperature, fewer cold days and frost days will increase. More over the precipitation intensity is also expected to increase in the 21st century. Chances of drought and floods are evident in various parts of the world as per the projection (WG1-TAR, 2001).

Keeping an eye on the above mentioned findings, it is the time right now to close the wait and watch chapter once for all. Scientific policy framework is the need of hour in order to combat the imperative climate catastrophe, days before until climate change brings such a havoc which will be both irreversible and irresistible.

1.3 Global Scenario of Climate Change

The existence of mankind with harmony is possible only when there exists a balance between food, water, energy, shelter and environment at present as well as for future races. But with the advent of industrial era anthropogenic activities break this existing balance between man and environment by burning fossil fuels and deforestation which

leads to increase in the earths mean surface temperature and there by the phenomena of global warming takes the identity. It is a fact that warming on the earth's surface originates from the anthropogenic activities. According to IPCC, 2007 report, global average surface temperature is predicted to range between 0.3 – 0.7°c for the time period 2016 – 2035. This temperature rise will be responsible for rise in sea levels, melting of the snow spreads and rainfall pattern variations. Thus global warming is considered as the prime factor responsible for bringing changes in the earth's climate.

Climate warming exists all over the world and the changes brought by this warming leave their impacts on both natural as well as human systems. Agriculture sector is the most vulnerable sector to climate change impacts. It is predicted that the temperature rise will depict overall negative impacts on agriculture sector globally. Generally in developing countries like India, productivity is assessed to diminish by 9 – 21% due to temperature surge**.** In China 2.4% decrease was reported in wheat production because of rising temperatures over previous two decades. Increase in global average surface temperature is likely to lead variations in the precipitation patterns. IPCC predicted that CO_2 amounts in atmosphere will increase more than the equilibrium rate by 2100 A.D. Research findings revealed that the increase in temperature from 2°c – 4°c had comparatively more impact than elevated CO_2 on grain quality. Increasing trend of global warming will become more powerful than precipitation over the 20^{th} century.

Climate change is one of the parameters affecting over whole world. According to IPCC various changes brought by the climate change are novel to mankind. Sea level rise is predicted to vary between 0.17 – 0.41 m by the year 2050. The rise in sea level rate is much more than the previous average rate which was prevailing in the past two millennia

till mid-19th century. According to IPCC, non-uniform variations in precipitation will occur with its extreme repercussions engulfing mid-latitude and wet tropical areas. Greater chances of floods became evident with the increasing tendency in precipitation levels. It is observed that the previous three decades on the earth's surface were constantly warmer in comparison to any other decade since 1850. Since the mid of 20th century, heat wave frequency has increased over most parts of Asia. Further, the amounts of greenhouse gases and CO_2 emissions tend to expand the temperature levels on earth. As per UNDP report, total amount of greenhouse gases that anthropogenic processes unveil will decide the warming rate of climate for 21st century.

The effects of climate change got discerned time to time throughout the globe. In 2005, Hurricane Katrina which strikes U.S is considered the most powerful catastrophe since last 100 years. It stretches over the gulf coast area and is estimated that huge production loss occurs because of this disaster. Earlier to this climate catastrophe significant loss in crops occurred due to prolonged drought period in mid-west portions. Haiti earth quake of 2010 and Pakistan earth quake of 2005 are the repercussions of climate change. Recently in September, 2014 floods destructed the major parts of Kashmir valley. The estimated property loss from floods accounted between 5000cr to 6000cr and scrapped more than 500 lives. Similarly Uttarakhand flash floods (2013), Leh cloud burst (2010), Indian Ocean Tsunami (2004), Gujarat earth quake (2001), Orissa super cyclone (1999) etc. are the other major catastrophes which are the outcomes of climate change. Such climate tendencies disrupted the world wide ecological balance.

Due to climate change crop output may increase or decrease depending upon the irrigation use and latitude of the region. Increment in temperature and changing

precipitation may reduce the productivity of crops in future. Among the two variables temperature could be the more effective parameter which will impact the crops worldwide. Hence studies related to the effects of temperature on different pros and cones of agriculture get more impetus as it helps the said sector to devise policies, programs and strategies in a best way so that the climate change prone sector could combat the unevenness of natural hazards to some extent and enhance the economy towards future generations with sustenance (Ruchita and Rohit, 2017).

1.4 Indian Scenario of Climate Change

According to world meteorological organization, climate change could severely impact the world environment, agriculture produce and productivity and the human life quality. Further, farmers will have to face hardships in carrying the farming in developing regions with the increase in temperatures. India being a developing country needs to address the climate change issue and should stress on establishing a congenial environment in order to better human life quality (Kurukshetra, March, 2010, p. 4).

IPCC addresses that the countries existing in the developing phase will be more prone to climate changes than developed ones. India falls in the developing countries zone which is more vulnerable to climate changes and hence the agriculture sector over these developing zones is severely affected by the climate change.

Like other nations, India also starts witnessing various climate tragedies. In India, it is found that average annual temperature increases at an alarming rate of 0.42°c.Predominantly being a monsoon dependent country India relies upon South- West and North- East monsoons. South-West monsoons contribute near about 80% to overall

precipitation in India. So any sort of variation in the above precipitation rate would impact the agricultural sector and would even lead to rise in the dry spells and floods at regional scale. An increasing tendency in precipitation got revealed over the West coast, Northern Andhra Pradesh and North-West of India while a diminishing tendency got evident in the parts of Gujarat, M.P and allied regions. Western disturbances impact the North Western area of India at a small scale as these disturbances leave impact only on the Rabi produce, only for just 20-30 days (Ruchita and Rohit, 2017).

The climate change impact assessment report put forward by the World Bank with reference to drought and flood prone areas of India indicates the chances of diminishing the output of major dry land crops in Andhra Pradesh, Maharashtra and Orissa. The sugarcane output got diminished by 30% in Maharashtra while the Rice yield diminished by 12% in flood sensitive areas of Orissa. The victims of the specified loss were poor and Marginal farmers who owe less than 1 acre of land on one side and on the other side bear the burden of huge population thereby enhancing their conditions from bad to worse (Kurukshetra, March, 2010, p. 5).

Temperature has also depicted its impact on agricultural production and productivity. Increasing temperature tendency got evident over southern part while a diminishing tendency got revealed in the Northern part of India. Research evidences revealed that with temperature increase, productivity of crops is likely to decrease in future. According to ICAR prediction, annual wheat yield may decline by about 4-5 million tons with every 1°c temperature rise. Thus there emerges a dire need to study the dependency of quality, suitability and stability of crop yield on temperature in order to boost the economy of nation properly through proper policies and precautions.

Research studies revealed that the increasing tendency in world surface temperature had imperative effects on the agriculture in India. Various climate factors which impact agricultural produce are heat waves, rising temperatures, prolonged downpour and intense cold periods. The above specified factors possess dual impact with respect to crop yield that is both positive and negative. Indian is prone to various weather related catastrophes every year due to the variations in above mentioned factors which diminish the crop output. The unevenness of these climate events affects the growth cycle of plants and their physiological processes. Near about 17% of years between 1901-2010 fall in the category of drought years, which have serious repercussions on several resources like agriculture, water, food security and economy of masses. The variability in temperature and precipitation beyond the limit value affects the photosynthesis and transpiration processes in crops, there by damage the crops physically. It is projected that the varying tendency in temperature and precipitation would continue to have notable effect upon the agriculture. An increment in temperature equivalent to 1-2°c in tropical areas would lead to significant decrement in crops (Khan et.al, 2009).

Based on the monsoons, agriculture in India is separated in to two periods: Kharif and Rabi. Temperature increase is predicted to be more in Rabi period (winter) as compared to Kharif period (Rainy). Further it is estimated that average temperature in India would increase by 0.4-2°c in Kharif period and 1.1- 4.5°c in Rabi period by 2070. Decrease in agriculture produce leads to inflate prices of food nationwide. Thus temperature is considered as one of the impactful parameter responsible for bringing agricultural instability in India (Jain et.al 2012).

The impacts of global warming got revealed since 1990s over India as the mean annual temperature start exhibiting rising tendency. The highest temperature of 25.2°c got revealed during 1996. This rising temperature tendency helps certain crops to grow rapidly but impacts various other crops negatively. Research evidences imply that with every 1°c temperature rise during the growing period of wheat in India, its production will be diminished by 4 – 5 million tons, although carbon fertilization will be included. The production of rice will diminish by 10% with every 1°c increment in minimum temperature throughout the growing season. Thus we can conclude that, the consistent variability of temperature affects both the production and productivity of crops throughout the country (Arora et.al, 2009).

The burning issue of climate change has left its impact on almost everything and everywhere in one way or the other but till now mankind is able to detect its effects on only few sectors. The various other notable spheres affected by the climate change are listed below.

1) As per Indian Council of Agricultural Research (ICAR), uneven weather events like cold waves, heat waves and heavy rainfalls were noticed in some parts of India. In Agra it was perceived that wheat output diminished because of cold waves in 2002 -2003 as compared to previous year levels. Similarly these waves captures Bihar and Assam were effect got deciphered through the loss in maize seed setting and decrement in the Boro rice produce.
2) The data pertaining to sea level shows an elevated variation through coast line with an increment through Gulf of Kutch and West Bengal and decrement over Karnataka coast. The studies revealed a long term average increment of 1mm

yearly in sea level and the prediction of increase in sea level between the range of 46 -59cm with the culmination of 21st century.

3) Heavy infrastructure public properties utilizing huge costs are prone to devastating weather episodes like typhoons, landslides and floods, thereby increasing the burden on exchequer.
4) Vegetation in India is likely to be least adapted to the existing climate due to the prevailing unfavorable environmental conditions. Extinction of Biodiversity is also predicted in the presence of existing climate conditions (Kurukshetra, March, 2010. 41).

1.5 Jammu and Kashmir Scenario of Climate Change

The Himalayan mountain range is considered as one of the most essential mountain systems throughout the world and is also pronounced as the "Third pole" and Water tower of Asia" due to its huge snow and ice cover. Stretching over the Northern hem of the Indian sub-continent, with the Indus river in the North west and Brahmaputra river in the east, the Himalayas affect the lives and livelihoods of more than 300 million people falling in its range. The Ganga, the Brahmaputra and the Indus are the three precious gifts of Himalayas.

The state of Jammu and Kashmir lies in the North-Western range of this mountain structure and forms the Northern part of the Indian sub-continent, sharing its borders with Pakistan, Tibet and China and exhibits the unique strategic position throughout country. The state is a natural reservoir of resources and is globally known for its Natural beauty, Biological richness, Biodiversity, socio-cultural diversity, ecological wealth etc. A huge

population portion of the state is directly or indirectly dependent upon these natural resources for their livelihoods. The state also receives the huge tourist inflow from entire world throughout the year which is one of the biggest income generating sources for the people (Envis newsletter, December, 2015).

In the context of Jammu and Kashmir, the climate change symptoms are apparent now with their immediate severe effects on Agriculture, Horticulture, Water resources, Tourism, Biodiversity, Habitats, Forests, wild life and livelihoods of millions in the region. UNEP in its report states that various parts of the state are highly prone to climate changes. According to INCCA, there will be an increment in the number of rainy days over the Himalayan region by 2030s. The increment will be of 5- 10 days at an average with eastern part of the state expected to receive more than 15 rainy days, in comparison to the previous levels. The rainfall tendency is likely to rise by 1- 2mm per day and will brutally affect the various horticulture crops. Variations which occurred in temperature, precipitation and cold waves, lead to the significant down fall of the agriculture sector.

The studies conducted by the National Institute of Hydrology, Roorkee from the past three decades revealed that Ladakh, Zanskar and the Himalayas are losing the glacial content to a huge extent with major glaciers showing the decrement between 17%- 25% respectively. It is reported that, deficit in the glacial content occurs due to the variations in winter precipitation, climate warming and various climate sensitive anthropogenic activities. The Indus water level is expected to rise by 5%- 20% with few parts extending up to 50% in comparison to 1970s level (Ram Krishan, 2016).

The climate profile document of Jammu and Kashmir reported that temperature (average) in Jammu and Kashmir got increased, with Kashmir valley depicting the increase equivalent to 1.45°c and Jammu division revealed the surge in temperature by 2.34°c since last two decades. The document further revealed that maximum temperature in Kashmir valley got increased by 0.05°c per year while in Jammu division it got enhanced by 0.08°c per year over the last two decades.

Food production deficiency is at peak in Jammu and Kashmir. With varying rainfall and diminishing snowfall, agriculture and horticulture sectors produce at a diminishing rate. Both the production and productivity of apples got diminished with a question mark on quality also due to continuous uneven fluctuations in weather conditions. Climate change lays its impact on human health also. The spread of various infectious and viral diseases are the outcomes of climate change. Climate change serves as a medium in enhancing the spread of viruses, bacteria, fungus and various other diseases etc. which take a huge toll on human health (Envis Newsletter, December, 2015).

1.6 Kashmir Climate Change and Agriculture

"If there is a paradise upon earth, it is here, it is here, it is here".

- Amir Khusru

This quote was quoted by a great Persian poet "Amir Khusru" who termed Kashmir as the paradise upon earth. Latter on Emperor Jahangir used the same phrase to praise the astonishing beauty of the valley Kashmir when he visited the valley in 17^{th} century.

Among all the valleys of Jammu and Kashmir, Kashmir valley occupies the prominent place due to its pristine glory and rich cultural past. This beautiful valley falls between the laps of Pir Panjal range from the South-West side and Himalayan range on the North-East side. The valley spreads over an area of about 15,948sq.kms and stretches between (32°22 -34°43 N) latitude to (73°52 -75°42 E) longitude. The height of mountain ranges range between 5550m in the North- East to 2770m in the South. The altitude of the valley is about 1730m from the sea level (Husain, 1987).

The climate of Kashmir is extremely distinctive in character due to its unique geographical position and mountain systems which accustom it with certain different climate peculiarities than other states and the rest of world. Due to continuous annual variations in the climate of Kashmir it is the most hectic task to categorize it any particular type of the climate hence the best method to categorize it, is to call it an "irregular type" of the climate with no specified consistency as compared to other climates of the world. In the context of rainfall distribution, Kashmir valley depicts Sub-Mediterranean pattern of climate (Mehor- Homji, 1971).

The climate in Kashmir valley is a fluctuating moderate one due to its geographical position and is determined by altitude, thermic fever and the rainfall content. The mean altitude of the valley is about 1545m. Normal yearly mean annual precipitation in the valley accounts for 823.9mm with mean rainfall accounting for 84cm. The temperature range of the valley extends from -9°c to 30°c from winter to summer. Mean maximum temperature of the valley is 19.27°c, with mean minimum temperature equivalent to 7.29°c respectively. The valley is experiencing a surge in temperature and precipitation levels from the last two decades (Husain, 1987).

Kashmir valley like the other parts of the country and rest of the world is now a days facing the serious implications of climate change which are multifaceted in nature and show their impacts on almost every sector in general and primary sector in particular , with severe impacts on the agriculture and horticulture sector. The various impacts over the years depicted by the agriculture and horticulture sector due to climate change are listed below.

1) The production of rice, wheat and mustard got diminished by 6%, 4% and 4% respectively in the valley since 2001.
2) Near about 40% reduction in the production of food occurred in the valley. Vegetable production got diminished by 30% while the oil seeds production reduce by 69% putting the food security of the valley on stake.
3) Due to consistent variation in the precipitation levels, number of weeds in crop lands got increased which reduce the production potential of the land and crops concerned.
4) Frequency of pests got enhanced with the surge in temperatures which reduced the yield on onside and on the other side puts the quality of the yield on stake.
5) Due to water deficiency, shift in the cultivation of crops occurred from rice to apple. The evidence of such shift is depicted by the increment in the area of rain fed crops (like apples) in various districts like Anantnag, Baramulla, Bandipora, Badgam, Pulwama, Kulgam and Shopian. Although the area under apples got enhanced but the output/hectare has remarkably diminished since last two decades. (J&k Envis Newsletter, December 2015).

The repercussions of climate change alter the habitats, ecosystems, wildlife, water resources, fisheries etc. throughout the valley. About 20% of the wetland biodiversity is on the verge to vanish. Agricultural land becomes more prone to climate changes. Drastic change in the precipitation levels impact the rain fed agriculture on one side and on the other side reduces the production of apples throughout the valley (Parvaze et.al, 2017).

The various other facets of climate change with respect to the Kashmir valley are revealed below;

1) Precipitation levels in Kashmir valley diminished from 1000- 1200mm in 1999 to 600- 800mm in 2015 which leads to delay in flower germination.
2) Frequency of hailstorms has increased over the said time period due to the oscillations in temperature levels which cause a huge damage to flowers there by resulting in crop loss.
3) Due to climate change pests, fungi, Pathogens, insects, bacteria and viruses got enhanced which directly damage the crops. Multiple number of sprays are now needed in order to combat this enhancement. The frequency of sprays has increased from 4/year- 11/year since 1980s till now. Due to the existing climate conditions, diseases like red mite and scab are on boom throughout the valley which impact the apple production directly both in quantity and quality.
4) Climate change is responsible for inhibiting the pollination as due to temperature fluctuations flowering is delayed which mismatches the timing between flowering and bees. Also uneven heavy rains flush out the pollens from flowers which reduce the pollination capacity of plants with bees and there by leads to the downfall in output.

5) The chilling hours insufficiency is the another facet of climate change in the valley. Lack of proper chilling hours at required timing inhibits the proper flowering and leads to the variations in fruit dimensions/structure.

Climate change impacts are vivid in the Kashmir valley more than the rest of the country. A huge portion of land covered under apples in various south Kashmir districts got defunct. More than 14.25 billion rupees got lost due to the floods of 2014. Saffron output start diminishing at an increasing rate. Due to the fluctuations in temperature and precipitation levels bacteria, fungus, pests etc. got enhanced which impact the quality of fruits and eventually lead to the reduction in fruit prices (Wani et.al, 2017).

Recently IMD predicted that Kashmir will experience heavy rainfall from June-September 2018 with July predicted to be the wettest month of this year (Greater Kashmir, 31st May 2018).

1.7 Rationale of the Study

Climate change is a worldwide issue and is termed as the "problem of commons" as it impacts the resources which are common to all. The impacts of climate change vary between the sectors with agriculture being more vulnerable, thereby putting its future on stake. The state of Jammu and Kashmir is an agriculture dominant state and is more prone to climate changes than the rest of the country. The impacts of climate changes got evident everywhere with agriculture and allied sectors being most hit leading to decrease in the production, productivity and the area.

The present study undertaken deserves great attention in order to maintain the ecological balance between man and environment keeping in view the sustainability of agriculture

sector. The study will serve as a precautionary principal to tackle and combat the serious imperative negative impacts of climate change which are totally neglected in the state. Besides the impact assessment, the study depicts the various trends in respects of area, production and productivity which provide a clearer picture of the impacts in the concerned area. As the study is a research deficient area, the present study will thus serve as an alarm for dormant policy makers and stakeholders of the Jammu and Kashmir state to wake up and cope up with the problem otherwise it will turn once again in any catastrophe like the recent flood catastrophe of 2014.

1.8 Statement of the Problem

Climate change is the major hurdle experiencing the world today. It has compromised with the resources on which the existence of man depends. These resources are diminishing at an alarming rate and hence put the existence of man on stake. Habitat extinction, temperature rise, rainfall fluctuations, glacier melting, sea level rise, decrease in production and productivity, area succumbing are the different other facets of the climate change. The balance between man and environment defuncts which leads to ecological imbalance. The future existence of the man is predictable only when this ecological balance is struck back. The government, the stakeholders, worldwide forums and other concerned institutions need to come up with solid strategies which could tackle and combat the imperative negative impacts of the climate change otherwise, as usual, it will play a detrimental game with the lives and livelihoods of masses in general.

1.9 Objectives of the Study

The present study captures the climate change with variables Temperature and Rainfall and depicts their impacts on agriculture production and productivity of Rice and apple. Also the area, production and productivity trend is exhibited in the study so as to reveal the fluctuations which occurred over the time in rice and apple crop. Keeping the above context in view the objectives of the study are as follows:-

1) To examine the trends in area, production and productivity of rice and apple.
2) To assess the impact of climate variables on select agriculture produce.

1.10 Hypothesis of the Study

Climate change is being suspected as a key cause of change in production and productivity of the crops today and in recent future. It has engulfed each and every sphere in its periphery with serious imperative impressions on the primary sector more than other sectors. The developing economies are more prone to these climate impressions because of their high dependence on the primary sector. Keeping the above points in view, the hypothesis of the present study therefore is as follows:-

Hypothesis 1: Climate change significantly impacts agriculture produce in Jammu and Kashmir.

1.11 Chapterization

Chapterization gives the brief overview of the various chapters on which the study is based. Present study is based upon five main chapters which are briefly described below;

Chapter: 1 Introduction

This chapter gives the detailed over view of climate change and its impacts on different sectors of the economy. Firstly, description of climate change is given followed by the evidences and effects content. Next historical perspective of the climate change is addressed followed by the global scenario of climate change. After assessing the global state of climate change it is then explained in the Indian context followed by the Jammu and Kashmir scenario of climate change. Lastly in introduction part of the present study impacts of climate change are explained with respect to the agriculture of Jammu and Kashmir. The various other contents which are included in the introductory part are; rationale of the study, statement of the problem, objectives of the study and its hypothesis.

Chapter: 2 Review of literature

It constitutes the second chapter in the present study. It provides the detailed over view of the amount of work done in the past and reveals the area which is not yet researched. The review of literature is given in three main contexts viz, international, national and state level (related to concerned research area i.e. Jammu and Kashmir). Research gap which gets revealed is also included in this chapter.

Chapter: 3 Research Methodology

This chapter deals with the methodology which is adopted in the study in order to achieve the objectives. Also it gives the detail about the various data sources, variables of the study and the various methods which were incorporated in the study so as to achieve the established target i.e. objectives.

Chapter: 4 Data Analysis and Interpretation

This chapter deals with various rice and apple trends in the respects of area, production and productivity over the time period 1985- 15. Comparative analysis of trends is done which helps in understanding the actual status regarding area, production and productivity of the crop concerned. In this chapter analysis of data is carried with different methods and methodologies. Discussion of results and interpretation is done in this chapter.

Chapter: 5 Conclusion, Findings, Policy Implications, Limitations and Future Scope of the Study

This is the concluding portion of the research work in which theme of the work done is recapitulated, major findings of the study are highlighted, limitations of the study are provided, future scope for researchers is determined and Various policy suggestions are put forth for the government, stake holders and reformers so as to increase the welfare of the said sector.

CHAPTER 2

REVIEW OF LITERATURE

Review of literature provides a detailed account about the stock of knowledge existing in the research area. It is just a revision about what has already been researched time to time in any specified area. Thus literature review is an informative process which helps us to understand the level of research work done previously in any area. It also helps us to know and understand the different types of methods and methodologies which are incorporated in different studies so as to get the required results.

In the present study review of literature is broadly divided into three parts:

(1) Global level literature review (2) National/ All India level literature review and (3) State specific review of literature (J&K state). All the three categories provide a detailed account about the amount of work done in the research area, methods and methodologies incorporated, results found and policy suggestions put forth by the studies.

2.1 Review of Literature: Foreign Studies

Ali et. al. (2017) conducted a study in which they evaluated the climate change effects on major crops of Pakistan viz. wheat, rice, maize and sugarcane taking temperature, rainfall, relative humidity and sunshine as climate variables. Secondary source time series data from 1989 – 2017 is used in the study. Feasible generalized least square (FGLS), heteroskedasticity and auto correlation (HAC) consistent standard error methods were executed in the study in order to attain the objectives concerned. It was found that some climatic variables negatively and significantly affect the crop yield while others are

insignificant. In the wheat crop production the most influential climatic variables observed were maximum temperature, rainfall and relative humidity. The results revealed that maximum temperature is significant and negatively affects the wheat yield, while rainfall and relative humidity are both insignificant and negatively influenced the wheat yield. Maximum temperature was found significant for the rice yield. Regarding maize yield it was found that maximum temperature and minimum temperature are positive and non-significant, while relative humidity depicts significant contribution towards maize yield. Both temperature and relative humidity exhibited positive relation with sugarcane yield. The overall results show that climate change has adversely impacted the yield of major food crops in Pakistan. The policy suggestions of the study towards the government stressed upon to tackle, combat and mitigate the adverse impacts of climate change. Also it is implied that heat and drought resistant high-yielding varieties of seeds need to be used in order to ensure food security in the country.

Zhang et.al. (2016) studied the climate change impacts on agriculture using different climate variables other than temperature and precipitation. Agriculture data of rice, wheat and corn from 1980-2010 of China was employed in the study with respect to humidity, wind speed, sunshine duration and evaporation. The study highlights the contributions made by the variables relative humidity, wind speed, sunshine duration and evaporation. Regression model was incorporated in the study in order to assess the impacts of climate change on crop yields. The future predictions were established using other climate models like PCM, ECHAM, CGCM and CCSM.

The results revealed that the additional climate variables have economically as well as statistically significant effects on crop yields. Humidity is beneficial for all crops. The

study revealed that a 1% increase in average humidity during the growing season enhances rice, wheat and corn yields by 0.75%, 0.96% and 0.61% respectively. Also it was found that wind speed has a significant impact on crop growth, especially for rice and wheat. The results exhibited that if average wind speed increases by 1 meter/second, rice and wheat yields diminish by 14.51% and 13.91% respectively. Positive effects of sunshine duration were found on rice and corn crops. As per point estimates rice and corn yields increased by 6.10% and 3.84% respectively, when average sunshine duration extends by one hour during the growing season. No significant effects for evaporation were found in general.

Amin et.al. (2015) investigated the climate change impacts such as maximum temperature, minimum temperature, rainfall, humidity and sun shine on the yield and cropping area of major four crops (aus rice, aman rice, boro rice and wheat) in Bangladesh using country level time series data from 1972-2010. The methodology incorporated in the given study was heteroskedasticity and auto correlation consistent standard error (HAC) and feasible generalized least squares (FGLS).Major findings of the study show that the climate variables contributed significantly both to the yield and cropping area with differential impacts. Maximum temperature except for aus rice had significant impacts upon the yields of all food crops. It also insignificantly impacted area under cropping of all the crops concerned. In the domain of minimum temperature the results revealed that aman rice was impacted insignificantly but had a positive impact on the other three crop yields and cropping area. With respect to rainfall aus rice cropping area gets positive boost but had a significant impact on both the yield and cropping area of aman rice. Humidity gives positive contribution to the yield of aman and aus rice but

negatively impacted the cropping area of aus rice. Sunshine proved itself beneficial only for the yield of boro rice. The overall results show that the maximum temperature had detrimental effects upon the yield and cropping area of the crops concerned and rainfall seriously impacted aman rice only. The policy implications highlight the concerns of climate change to food security and hence impressed upon the concerned authorities for generation and development of drought and flood resistant varieties of crops particularly aman rice.

Sarker et.al. (2012) carried out time series analysis in order to assess the impacts of climate change for three major rice crops, aus, aman and boro with respect to three major climate variables, maximum temperature, minimum temperature and rainfall in Bangladesh at an aggregate level using the country level data from 1972 – 2009. Ordinary least squares (OLS) and Median quantile (MQ) regression methods were incorporated in the in the study for climate change assessment. The findings of the study revealed that there exists a significant relationship between climate change variables and agricultural productivity, but this significant relationship varies between the three rice crops. Maximum temperature depicts significant results for all the three kinds of rice with positive effects on aus and aman yield but a negative effect on boro rice yield. Minimum temperature shows significant results in case of aman and boro rice with negative effects on aman and positive effects on the boro rice respectively. Rainfall depicts significant results only for aus and aman rice varieties with positive effects on both kinds of rice yields respectively. The policy suggestions address the policy makers to fund for the research and development of temperature tolerant varieties of rice with a special focus on aman and boro rice verities respectively.

Braun and Muller (2012) studied the impact of climate change on production and productivity among apple trees, in the state of Hesse, Germany. They reported that due to climate change there are numerous possible threats to production and productivity of fruits. The threats involve spring frost, diseases and pests, hailstorm, water scarcity and variable precipitation with longer drought periods. The results of the study revealed that climate variables are critical to fruit crops than any other variable. They argued that the initial flowering and full flowering stages are the two crucial stages of crop growth with reference to mentioned climate variables such as precipitation and drought.

Iqbal and Siddique (2010) worked on the paper impact of climate change on agricultural productivity in Bangladesh with reference to time period 1975 – 2008 for 23 regions. The study explores descriptive statistics with maps in order to know the long term changes both at country as well as local level in climate variables like temperature, rainfall, humidity and sunshine. In addition, the study utilizes regression models OLS and FE to estimate the climate change impacts on the productivity of agriculture viz., Aus, Aman and Boro rice. The study is different from previous works as it uses regional fixed effect (in order to neutralize the regional differences) to estimate the effect of long term changes in climate variables on agricultural productivity. The results revealed that long term changes in means as well as in standard deviations of climate variables have different impacts on the rice productivity. More over the results vary significantly with the option of weather variables employed. The policy suggestions of the study impressed upon concerned policy framers and researchers for the robust estimates of the climate change impacts on productivity of agriculture under different climatic prognoses.

Haim et.al. (2007) conducted a study in which they estimate the climate change impacts on wheat and cotton in Israel. Production function approach was incorporated in the study in order to explore the economic aspects of agricultural production under projected climate change scenarios. In this study projections were generated for 2070-2100 temperatures and precipitations for two scenarios of climate change utilizing global climate model (Hadley's Centre global circulate model, $HadCM_3$).As per the results wheat revealed variation between the two climate scenarios .Net revenues turn negative under severe scenarios (varies from -145 to -273%) but they might increase under the moderate scenarios (-43 to +35%) depending upon the nitrogen application to the crop. Rain distribution plays a key role in yields .In contrast to it cotton depicts a decrease in output with significant losses (-240 and -173%) both in A2 and B2 scenarios respectively. The policy implications as per results suggest the researchers to include technological developments on one side and on the other side impresses upon the government and private corporations to provide insurance for the research projects which will boost the research in the concerned area.

Ching and Chang (2002) studied the impacts of climate change on the agriculture of Taiwan using the country level data from 1977 – 1996 with respect to average yields of 60 crops from 15 sub regions. Multiple regression model was adopted for crop yields that merge the physical and social determinants of yield. In order to simulate the welfare impacts regarding output changes under different scenarios of climate change, a price endogenous spatial equilibrium model (TASM) was used. The empirical results revealed that the two variables of climate (temperature and precipitation) had a significant impact on crop yields. The results regarding welfare impacts of different scenarios of climate

change depict that the impacts of climate change on welfare are mostly positive. The results further revealed that the temperature rise is not bad for the farmers and might be even fruitful when adaptive measures are taken, however the right ward shift in precipitation could wipe out the farmers welfare.

2.2 Review of Literature: Indian Studies

Japneet Kaur (2017) studied the impact of climate change on agricultural productivity and food security resulting in poverty in India .The researcher incorporated state level data of 4 major crops viz, rice, wheat, cotton, sugarcane and climate variables annual rainfall, maximum temperature, minimum temperature, gross irrigated area, fertilizer consumption, agriculture workers, number of tractors, total forest area, farm harvest price over the time span 2004 – 2013 in the study. Seven agricultural states with different climates belonging to tropical and subtropical zones were taken into consideration. The methodology of the present study relies upon Cobb Douglas production function. The climate change and agricultural productivity relation is assessed by an econometric model utilizing panel regression. The results of the study revealed that agriculture in India is sensitive to climate changes and varying precipitation levels. Rice and sugarcane are most impacted by climate variations. Results further revealed that the detrimental impacts on agriculture productivity due to climate change have led to food shortage in India. Regarding policy suggestions the study stressed upon adaptations and mitigation strategies in order to combat the detrimental impacts of climate change on agricultural productivity and food security.

Farook and Kannan (2015) studied the impact of climate change on rice yield in India by evaluating the relation between the output of two rice crops namely kharif and rabi and main three climate variables maximum temperature, minimum temperature and rainfall with reference to the time period 1974 – 2011.The study is based on secondary sources of data and the required data is taken from IMD Pune, Directorate of rice development, Patna etc. Comprehensive methodology was incorporated in the study based on Vector Auto regression (VAR) model with the application of Granger causality test, Impulse response function and Variance decomposition technique. The results of the study revealed that the average temperature both (maximum, minimum) significantly affect the kharif yields while rainfall depicts negative effects on kharif rice. Detrimental effects were shown on rabi rice in relation to average maximum temperature and rainfall but positive impacts were found on rabi yield due to average minimum temperature. The policy implications of the study stressed for appropriate adaptive techniques in order to overcome this alarming issue of climate change on rice production.

Sharma et.al. (2013) studied the climate change effects on apple production in Shimla district of Himachal Pradesh .The study stretches over the time period 2001 – 2009.The climate variables considered for depicting the effect were temperature, rainfall and Snowfall and the required data sets for climate variables were taken from Kotkhai horticulture research station. The data related to the apple production was taken from Directorate of horticulture, Himachal Pradesh. Data revealed that annual minimum temperature slowly increased from 8.65°c – 12.70°c from 2001 – 2009. Correlation analysis was incorporated in the methodology in order to study the effects of climate change on apple production. Also coefficient of Variation was computed in the study to

know the year to year variability in climate variables. Coefficient of Variation was also used to check out the stage to stage variation in different weather variables.

The various results of the study are listed below;

1) Minimum temperature shows positive and significant impact on apple production. Yearly minimum temperature also shows significant and positive connection with the apple produce were, r = 0.685.
2) Maximum temperature revealed significant but negative impact on apple produce. Also yearly maximum and mean temperatures were significant and negative corresponding to the r – values - 0.813 and – 0.733.
3) No relationship was found between rainfall and apple produce. However between annual rainfall and annual apple produce non-significant positive correlation was found.
4) Annual snowfall shows non-significant and negative relation with annual apple produce.

The policy suggestions address the issue of poor apple production by tackling seasonal shift and combating the variability in climate conditions in order to boost the sustainability in the apple produce.

Banday and Aneja (2014) studied the impact of climate change on the agricultural productivity in Haryana over the time period 2000 – 2012 .The impact was studied on wheat with respect to two climate variables annual rainfall and average temperature. The study is based on secondary sources of data. The analysis of data was done through descriptive and inferential statistics. In descriptive statistics analysis was depicted

through maps, tables, flow charts and figures while inferential statistical analysis was made through percentages, averages, correlation etc. Multiple regression tests were carried to know the impact of climate change on wheat production. The results revealed that the agriculture sector is highly impacted by climate change than any other sector. The model further reveals that the decrease in rainfall negatively impacted the agricultural production in Haryana. If there occurs 1% decrease in rainfall it leads to 1.25% decrease in production. The model doesn't depict any significant impact of temperature on the production of wheat in Haryana, because wheat is cultivated in winters and during that time period temperature remains below 10°c which was found favorable for the wheat production. Regarding policy implications the study suggests a two way approach based on adaptation and mitigation. For climate variability crop insurance is necessary to overcome the losses and hence gets full stress. Stress was also given for the production and use of new varieties of certified seeds that would be least affected by rainfall variability. Crop diversification should be adopted to combat the negative impacts of climate change.

Sharma (2011) analyzed the impact of climate change on different crops in Himachal Pradesh. The results of the study revealed that there occurred slow but predictable variation in climate conditions which are fatal for the production of high value crops (HVC).The results further revealed that there occurred a shift in apple cultivation since last 20 years due to the variability in precipitation periods, affecting the required chilling period for the crops. These creeping fluctuations in weather variables turn wild with the passage of time and take a huge toll on apple output and there by incurring the growers in huge financial losses.

Aggarwal et.al. (2010) carried out the simulation analysis in selective 11 districts of Uttar Pradesh and Uttarakhand by incorporating infocrop-rice and infocrop-wheat models in their study. The results of the study revealed that the Rice and Wheat yields are likely to be impacted by climate change.

Singh et.al. (2008) studied the structural changes in horticulture sector of India for the 11^{th} five year plan, 2007 – 2012.As per the study decline was witnessed in agricultural sector from 3.7% to 2.5% during ninth and tenth five year plans per year in comparison to earlier periods 1991 – 97, while GDP growth rate got enhanced to 6.6% from earlier 5.7% per year during the specified time periods. In methodology Markov chain model was incorporated in order to reveal the land holding structural changes, land use, farm structure and market structure. The results pertaining to the study revealed that high value crops (HVC) contributed significantly to total agriculture exports. The results further revealed that substantial growth took place in the respects of area, production and output of major horticulture sub sectors between the time period 1991 – 2006. The policy implications of the study stressed upon the specific policy measures based on area constraints.

Birthal (2008) analyzed the trends of production and productivity in horticulture crops with respect to agriculture growth and diversification. The study was carried over the time period 1995 – 2005.The study revealed that the gross value of vegetables and fruits grew at 5.6% per annum during 1995 – 96 to 2004 – 05.Growth rate of agriculture decreased significantly from 3.2 to 1.9% during the above mentioned periods and would have diminished further if robust growth in vegetables and fruits wouldn't have taken place. Vegetable and fruit contribution to overall agriculture production was 64% during

the specified time period, three times more share than the earlier periods. The methodology of the study is primarily based upon Cobb Douglas production function approach. Cost benefit analysis was also incorporated in the study in order to compare the crop diversification costs. The main finding of the study revealed that the agriculture diversification towards horticulture crops enhances and accelerates agriculture growth. Also this diversification gives a chance to small farmers to boost their incomes.

Guiteras (2007) carried out a study titled, the impact of climate change on Indian agriculture. Panel data approach was applied in the study by using the panels of more than 200 districts covering the time period 1960 – 1999.Yearly district level major agricultural yields were regressed with respect to yearly climate variables (temperature and precipitation) and district fixed effects. The results of the study revealed that the projected climate change over the time period 2010 – 2039 decreases crop yields between 4.5 – 9%.The long term effect (2070 – 2099) decreases the yields by 25% and more if not tackled by proper adaptation. The policy implications of the study revealed that suitable and proper policy measures and strategies need to be incorporated quickly in order to overcome the imperative imposition of significant costs on the Indian economy.

Prashar et.al. (2006) evaluated the supply function of apples in Himachal Pradesh. Data pertaining to various variables viz. area, production, subsidies, climate variables etc. of secondary sources was incorporated in the study under the time period 1969 – 2000.Various equations for the yield and new planting responses were introduced in the model. The results exhibited that there occurs an increment in apple production from 50524 tons in 1969 to 376720 tonnes in 2000 with respect to 6.02% compound annual growth rate. The selected model results revealed that chilling hours are crucial factors

impacting the apple yield. The study reveals that due to the extension of certain facilities particularly road infrastructure, the acreage under apples increases in the long run.

Krishna et.al. (2004) identified the climate crop relations in India. They incorporated correlational analysis in their study in order to examine this realationship.Time series data with respect to both climate variables and yields was used by regression modeling. The results of the study revealed that there exists a significant relationship between Rainfall and crops with respect to their production.

2.3 Review of Literature: Studies at Jammu and Kashmir

Wani and Bhatt (2017) attempted to study the effects of climate change on horticulture sector of Jammu and Kashmir State. It is a descriptive study and gives the detailed overview of the various fluctuations that occurred in the respective sector with respect to production and productivity since1990s to 2016.The study revealed that climate change shows its impact in wide range of natural calamities like floods of 2014, dry weather of 2016, unpredicted hailstorm and untimely rain and snowfall. The various findings (with respect to climate impacts on horticulture crops) of the study are listed below:-

1) The 2014 floods account for the loss of 14.25 billion rupees.
2) Hailstorm that occurred in 2012, 13, 15 and 2016 causes the loss of 2 billion rupees.
3) Saffron production starts diminishing below average from last few years.
4) Fruit diseases like scab, red mite etc. are the outcomes of less or erratic precipitation and high temperatures.

5) High temperature and humidity favors the growth of bacteria, fungus and algae which are responsible for fruit falling. The number of sprays increased from 3 per year in 1980s to 12-15 per year today.
6) Low rainfall hinders growth and color which ultimately lowers the taste and price of the fruits.
7) Rainfall decreased from 1000 – 1200mm in 1999- 2000 to 600-800 mm in 2016, which is responsible for delayed sprouting.

The policy suggestions of the study stressed upon the government to inform the farmers via news bulletins regarding various precautions and procedures needed to be followed in respective crop cultivations. Government should supply the farmers with chemicals and fertilizers on subsidies in order to combat the pathogens, pests and diseases and to enhance the quality crop yields.

Lone and Guroo (2017) carried out a research work entitled effects of climate change on Agri-Horti sector in district Baramulla of J&K.The study relies on primary as well as on secondary sources of the data. The methodology employed in the study is based upon exploratory research design. Ten villages were selected randomly from Baramulla district and interview method was employed to collect the required data. The results of the study revealed that there is a general perception among the respondents that climate change effects agri-horti production and productivity to a great extent. The results further revealed that shift in cropping pattern is the outcome of climate change and this shift at present is the only available solution to combat the ill effects of climate change. The policy suggestions of the study insisted government intervention as the prime

requirement in order to tackle and combat the severeness of climate change which takes a huge toll on the backbone of the states economy.

Wani et.al. (2015) studied the changing scenario of Kashmir climate and its impact on different pros and cones of agriculture like production, productivity, area under cultivation, crop diversification, cropping intensity, gross farm income, women involvement, mitigation measures etc. The study is based upon primary as well as on secondary data. The required Primary data was collected from farmers perception and the secondary data related to climate variables (temp., rainfall) since 1980–2011 was collected from meteorological section of SKUAST-K, Shalimar. 270 respondents belonging to different age groups were interviewed over the time period 2013–14 and 2014–15 stretching over North, Central and South Kashmir. The survey was based on group discussions carried with the concerned persons like farmers, scientists and agricultural experts over the period 2013-14 and 2014-15. In order to analyze the data averages and percentages were calculated. The results of the study revealed that temperature rise helped the temperate mountain farming favoring increased cropping intensity. The average annual rainfall per day decreased to -19.44% and annual average number of rainy days per month also diminishes to -24.10% during the specified time period. The various climate changes perceived by the farmers are increased temperatures, long summers, short winters, less snowfall and highly uncertain weather conditions which got revealed in late 1990s. The results further depicted a negative change in net cultivated area over the specified time period. Cropping pattern shift was the major change occurred over the time period 1980-2011. Positive changes occurred in the cropping intensity as witnessed by the farmers. Increment in growing period length was

also experienced by the concerned farmers. Livestock sector also becomes the victim of climate change as due to inefficient snowfall pasture lands lose moisture which leads to poor growth of the grass and there by lessens the feeding options for the said sector. The policy suggestions put forward by the study implied and insisted upon researchers to conduct empirical research work which is lacking in the area in order to know the actual impact condition. It also stressed upon adaptive measures so as to combat the negative impacts of climate change through a proper policy framework. Stress was also given on technological development which can predict various climate uncertainties. Setting up financial institutions was the need of hour for the farmers as they have no financial source which supports them at the time of calamity.

Muslim (2012) predicted and assessed the climate change and its impact on paddy crop in Kashmir valley over the time period 1980-2010.The study utilizes a general approach combining data base of crop, soil, farm management and climate for baseline and future climate, utilizing GEPIC agro climate model. Base line climate data for the year 1980-2010 were taken from IMD, Pune. The various results of the study are listed below:

1) Maximum and Minimum temperature increased by 1.43% over the specified time period.
2) Annual precipitation increased from 909.23mm to 1225.58mm over the said time period.
3) The future results revealed that the Maximum and Minimum temperature is predicted to increase by 5.39°c over the years 2011-2090.

4) Precipitation is likely to vary between 3094.72mm to 2578.53mm over the time period 2011-2090.Predicted precipitation is expected to decrease by about 16.67% in the year 2090.
5) Other than climate results the impact results revealed that rice production for the base line would decrease by 6.6% by the 2040 and 29% by the year 2090.

The present study addresses an important alarming issue about the severe climate changes and their deteriorating impacts on agriculture sector. So the policy implications as per the study stressed upon integrated mitigation and adaptive measures in order to combat the imperative negative impacts of climate change on agriculture.

Masoodi (2003) studied the apple production and productivity in J&K state. The study revealed that area covered under apples in J&K was 90.08 thousand hectares in (2002) with annual production of about 9.09 lakh tonnes at an average yield 10.09 tonnes per hectare. Although the area increased from 86.65 thousand hectares to 90.08 thousand hectares but both production and productivity got decreased .The justification for this decrease is the prevailing drought like situations over the entire state.

Farooqi (2003) carried a study related to the future market of apples produced in the J&K state. The study revealed apple as the main principal fruit which constitutes 60 – 65% of the total area covered by all fruits in general. Approximately 9,00,000 MT was the yearly apple production in the state. As per present production status of apples, only one apple meets per person yearly which states that there is 1:1 equation between total apples produced and total population of the country. The results hence revealed prospect future market for apples in the country.

2.4 Research Gap

The study undertaken is a research deficit area and because of this deficiency and dormancy it becomes a serious issue as Jammu and Kashmir is becoming rapidly warmer than rest of the country which takes a huge toll on the states pearl resources. From the empirical point of view nothing noteworthy is done in the said area. Meager portion of work has been done like climate change and its impacts on fish fauna, horticulture, saffron sustainability of Jammu and Kashmir, while the impacts of climate change on agriculture and its allied sectors is not addressed properly and hence becomes a big and demanding research gap for the research.

CHAPTER- 3

RESEARCH METHODOLOGY

Research methodology is the systematic layout for carrying and conducting the research towards its desired end. Different types of methodologies were used by various researchers at national as well as at international level while assessing the climate change, depending on the nature of the objectives concerned. In the present study, there are two objectives which address the two different things.

The first objective covers the trends in area, production and productivity of rice and apple between the years 1985-2015 which are discussed in the chapter 4^{th} of the present study. Firstly trends of rice with respect to production, area and productivity are discussed in detail followed by the trends of apple in same spheres viz. production, area and productivity. These trends help in the comparative analysis of both the crops.

The second objective which is the main objective of the present study assesses the impact of climate variables (average temperature and rainfall) on rice and apple production using the time series data from 1985-2015. For accomplishing the second objective multi-variate regression analysis has been used to identify the extent of impact on the production and productivity of rice and apple crop respectively. Augmented Dickey Fuller (ADF) test is used to check the Stationarity in the data before employing the regression model. A multi linear regression model is used to examine the relation between independent and dependent variables. The rice and apple production data is regressed upon the climatic variables in order to estimate the effects of climate variables on the production and productivity of rice and apple crop respectively.

Following Sarker et.al (2012), two climatic variables (average temperature and rainfall) are used as independent variables with rice and apple (production and productivity) as dependent variables. Like Lobell and field (2007), only growing period data is used in order to capture the net effect of climatic variables upon the rice and apple production and productivity. In this study temperature is pronounced as the average temperature while rainfall is used as the total rainfall like in the previous studies of Granger and Chang in 1980 and 2002. Following Amin et.al (2015) Augmented Dickey Fuller (ADF) test is used to check the stationarity in the data. In the present study there are two dependent variables (rice and apple), whose production and productivity is assessed by four simultaneous regression equations which are discussed below.

ADF Equation without constant and trend:

$$\Delta_{Y_t} = \gamma_{Y-1} + \sum_{s=1}^{m} \partial_s \Delta_{Y_{t-s}} + V_t$$

3.1 Regression Models

3.1.1 Model 1: Rice production

$$W\ (Rice_p)_t = \alpha_o + \alpha_1 avg.temp_t + \alpha_2 train_t + \mu_t \text{ ---------- } 1$$

Where, W $(Rice_p)_t$ is the production of rice (in thousand tons), avg.temp. is the average temperature in (°c), train is the total rainfall (mm), α_1 measures the variations in W with respect to average temperature and α_2 measures the change in W with respect to the total rainfall. μ_t is the error term which we pronounce as the disturbance term because we can't capture the influence of each and every variable and t denotes time (i.e., 1 year).

3.1.2 Model 2: Rice productivity

$$X\,(Rice_{pd})_t = \beta_o + \beta_1 avg.temp_t + \beta_2 train_t + \mu_t \text{----------} 2$$

In the regression equation 2, $X\,(Rice_{pd})_t$ denotes the productivity of rice (in Qtls. /Hectare), avg.temp. is the average temperature in (°c), train is the total rainfall (mm), β_1 measures the variations in X with respect to average temperature and β_2 measures the change in X with respect to the total rainfall. μ_t is the error term which we also call as disturbance term. Error term denotes that we can't reveal the impact of each and every variable on the dependent variable. T is the notion for time (i.e., 1 year).

3.1.3 Model 3: Apple Production

$$Y\,(Apple_p)_t = \gamma_o + \gamma_1 avg.temp_t + \gamma_2 train_t + \mu_t \text{----------} 3$$

Where, $Y\,(Apple_p)_t$ is the apple production (in metric tons), avg.temp. is the average temperature in (°c), train is the total rainfall (mm), γ_1 quantifies the variations in Y in response to average temperature, γ_2 calculates the variations in Y with respect to the total rainfall, μ_t is the error term and t represents the time (i.e., 1 year).

3.1.4 Model 4: Apple Productivity

$$Z\,(Apple_{pd})_t = \theta_o + \theta_1 avg.temp_t + \theta_2 train_t + \mu_t \text{----------} 4$$

In this regression model, $Z\,(Apple_{pd})_t$ depicts the apple productivity (in kg/hectare), avg.temp. is the average temperature in (°c), train is the total rainfall (mm), θ_1 exhibits the variations in Z with respect to average temperature, θ_2 calculates the variations in Z in response to the total rainfall, μ_t is the disturbance term and t mentions the time (i.e., 1 year).

3.2 Area and Period of the Study

Kashmir valley which comprises of 10 districts is selected as the study area and the period of the study stretches over 1985-2015.

3.3 Data and Data sources

The present study is based on the secondary sources of data and the data related to Rice and Apple is collected from Directorate of Statistics and Economics (Srinagar), Annual Statistical Digests of Jammu and Kashmir, Directorate of Horticulture (Srinagar), Directorate of Rice Development (Patna) and Reserve Bank of India, while the data related to climate variables (Average temperature and rainfall) is collected from the Indian Meteorological department (Srinagar).

CHAPTER- 4

DATA ANALYSIS AND INTERPRETATION

The first part of this chapter fulfills the first objective of this study by analyzing the trends of area, production and productivity of agriculture produce – rice and apple. In the second part of this chapter, multi-variate regression analysis is done with the application of four regression models.

4.1 Trends in Area, Production and Productivity

4.1.1 Trends in Rice Crop

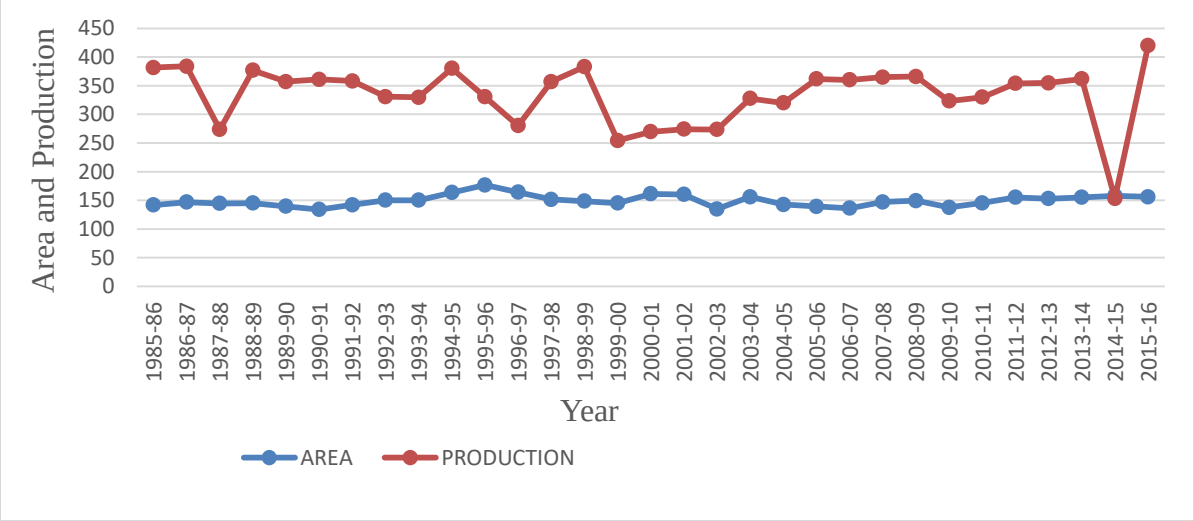
Table 4.1.1: Trends in Area, Production and Productivity of Rice from 1985-86 to 2015-16

Year	Area ('000 Hect.)	Production ('000 Tons)	Productivity Qtls./Hect.
1985-86	141.9	381.6	26.9
1986-87	147	383.8	26.1
1987-88	144.7	273.5	18.9
1988-89	145.2	376.7	25.9
1989-90	139.7	356.9	25.6
1990-91	134.1	360.8	26.9
1991-92	142.2	358	25.2
1992-93	150.2	330.7	22
1993-94	150.1	329.6	22
1994-95	163.5	380.1	23.2
1995-96	176.8	330.5	18.7
1996-97	164.2	280.4	17.1
1997-98	151.6	357	23.5
1998-99	148.5	382.9	25.8
1999-00	145.3	254.2	17.5
2000-01	161.5	269.7	16.7
2001-02	160.4	274.2	17.1
2002-03	134.8	273.7	20.3
2003-04	156	327.7	21
2004-05	142.8	319.9	22.4
2005-06	139.2	361.9	26
2006-07	136.4	360.1	26.4
2007-08	147.1	364.8	24.8
2008-09	149.4	366	24.5

2009-10	137.6	323.3	23.5
2010-11	145.4	330	22.7
2011-12	155.3	354	22.8
2012-13	153	354.9	23.2
2013-14	155.3	361.8	23.3
2014-15	158	153.3	9.7
2015-16	156.2	420.2	26.9

Source: Author's calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

Figure: 4.1.1 Trends in Area and Production of Rice from 1985-86 to 2015-16 (in '000 hectares and '000 tons)

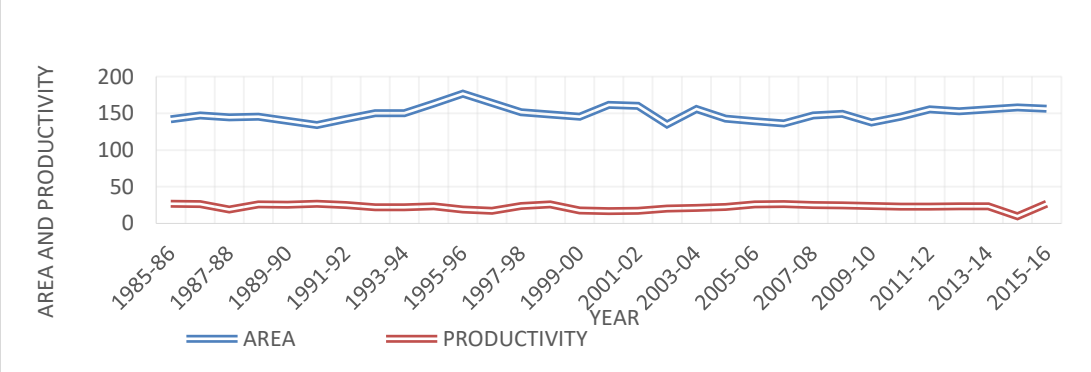


Source: Author's calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

The above given graph shows the area and production trend of rice over the time period 1985- 15. The production trend of rice depicts continuous fluctuations with least consistency. From the beginning i.e. 1985, production trend exhibits continuous troughs and crusts till 2015. Various reasons are responsible for this non-linear production trend like droughts, floods and continuous cropping pattern shifts etc. In contrast to the production trend area trend depicts minimal fluctuations. It is depicted by the graph that the variations in area trend didn't match the production trend and vice versa. At certain

points both the trends show positive correlation while overall there exists no unanimity between the two trends in general. The production trend reveals that there is no relevance between the fluctuations in production curve and area under the rice crop. Thus it can be concluded from here that production is least affected by the area than other factors. The other factors that may be responsible for these uneven fluctuations are variations in climate variables, droughts, floods, cropping pattern shifts etc. The production trend falls to the highest ever figure in 2014- 15 because over this time period floods washout the production of various crops particularly rice and apple throughout the valley.

Figure: 4.1.2 Trends in Area and Productivity of Rice from 1985-86 to 2015-16



Source: Author's calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

The above given graph compares the area and productivity trend of rice over the specified time period 1985- 2015. The figure reveals that over the time period 1985- 2015 area trend depicts various ups and downs. These ups and downs in the area trend occur due to the continuous shifts in cropping pattern over the specified time period in order to combat the various climate changes like droughts, water scarcity and various other changes which farmers consider production inhibiting for a certain crop. In comparison to area trend, productivity trend is smooth which reveals that area has least impacted the

productivity of rice and there are other changes which impact the productivity like in 2014 -2015, productivity falls to the highest ever figure due to the floods.

4.1.2 Trends in Apple Crop

Table 4.1.2: Trends in Area, Production and Productivity of Apple from 1985 to 2016

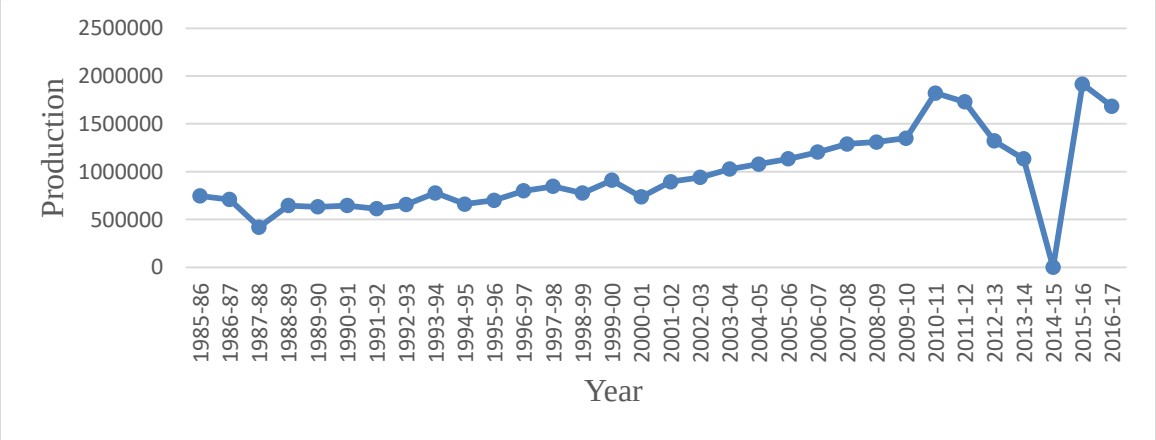
Year	Area.(Hectares)	Production.(M.Tons)	Yield (Kg/Hect.)
1985-86	57416	745452	12983
1986-87	60328	709349	11758
1987-88	60716	418522	6893
1988-89	61012	645090	10573
1989-90	61381	631918	10295
1990-91	61851	645002	10428
1991-92	62537	611980	9785
1992-93	63327	655875	10356
1993-94	65793	776895	11808
1994-95	67491	660565	9787
1995-96	70206	700537	9978
1996-97	72324	799729	11057
1997-98	74320	846842	11394
1998-99	75002	775752	10343
1999-00	77986	910442	11674
2000-01	79334	736284	9280
2001-02	81115	894019	11021
2002-03	85758	939657	10957
2003-04	91397	1027526	11242
2004-05	98234	1078730	10981
2005-06	101038	1134472	11228
2006-07	107177	1204011	11233
2007-08	115235	1289551	11190
2008-09	119730	1310362	10944
2009-10	123322	1349672	10944

2010-11	125788	1822058	14485
2011-12	137891	1730609	12550
2012-13	139017	1321317	9504
2013-14	143472	1134637	7908
2014-15	143472	0	0
2015-16	142501	1915448	13441

Source: Author's calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

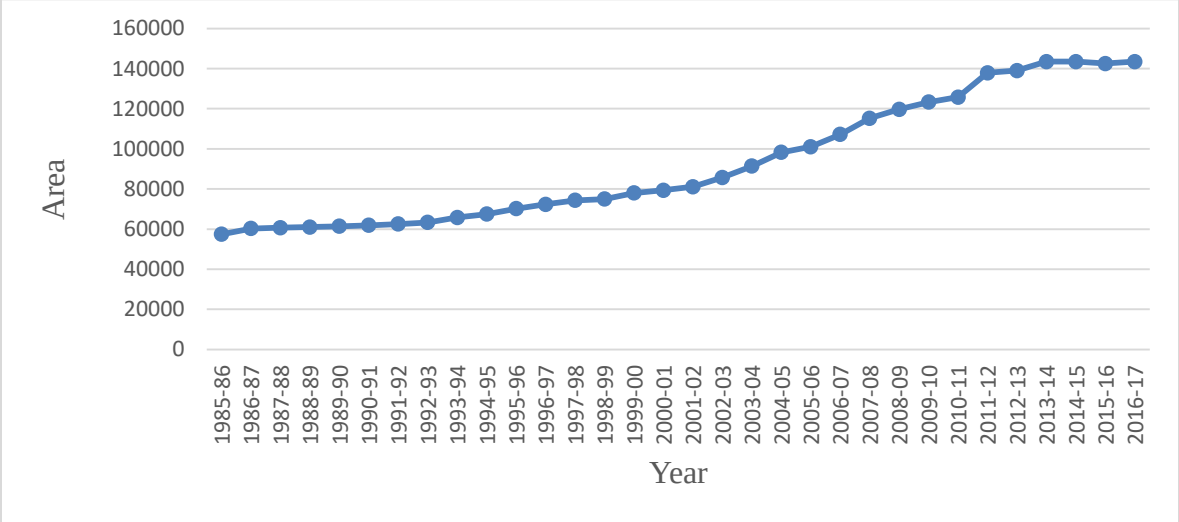
The below given two graphs depict the production and area trends of apple. The graphical trend reveals that the apple production exhibits little but continuous fluctuations in the preliminary phase (from 1985 up to 2001), after which it increases continuously for a decade and then again diminishes between 2011-2015 but soon attains recovery and touches the highest ever production level in 2015. In contrast to it area trend reveals increasing tendency since the beginning and continuously goes on increasing till a dip occurred in 2014-15.The comparative analysis of both the graphs is given below.

Figure: 4.2.1 Trends in production of Apple from 1985-86 to 2016-17 (in mt. tons)



Source: Author's calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

Figure: 4.2.2 Trends in Area of Apple from 1985-86 to 2016-17 (in hectares)

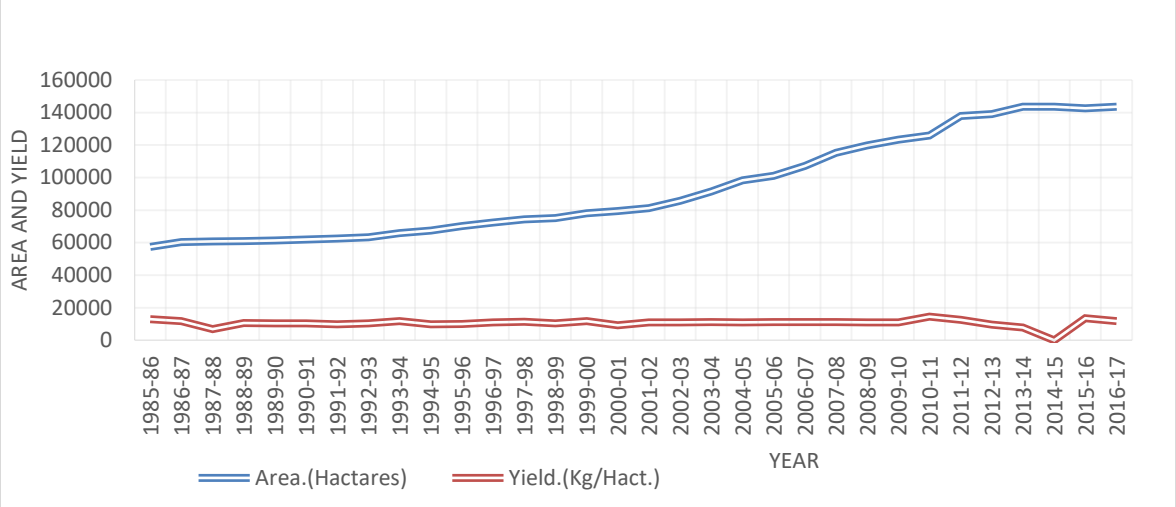


Source: Author's calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

In the above graph apple production trend is depicted with respect to the time series data 1985-2015. The figure reveals that since 1985 – 2000, apple production depicts short term fluctuations and after the year 2000 production continuously sustains the increasing trend till 2010-2011 after which production falls continuously and fell to the highest ever value (0) in 2014 -15 due to the floods. After 2014- 15 production once again attains the increasing trend and reaches to the highest ever point since 1985 and then falls again in 2016- 17. The main reason behind these fluctuations between the time periods 1985 – 2001 was the lack in technical knows how about the methods of apple production, lack of production enhancing fertilisers, equipment deficiency and lack of hybrid plants. Also area was almost stagnant up to this point which is another cause of these short term fluctuations and supports the law of diminishing returns. The logic behind the increasing trend between the time period 2000- 2010 is that during this decade area under apples got increased. When we compare the above two graphs it gets revealed that with increase in

area, production also increases and vice versa. This shows that the production has a direct correlation with the area which means that an increase in the area leads to the increase in production of apples and vice versa.

Figure: 4.2.3 Trends in Area and Productivity of Apple from 1985-86 to 2016-17



Source: Author's calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

The above given graph related to the area and productivity of apples reveals that with the continuous increase in area productivity didn't increase, however it shows the consistency in slope except in 1987-88 and 2014 -15 when a dip occurred in productivity due to drought and floods respectively. It can be here concluded that the consistency in productivity will sustain till area increases continuously and vice versa.

4.2: Descriptive Statistics (1985-2015)

As said earlier the second part of this chapter deals with the multiple regression of which descriptive and inferential results with interpretations are given below. The descriptive statistics portrays the basic properties of all concerned variables. The first table delineates the basic characteristics of area occupied under Apple and Rice production with second

table describing the overall production characteristics. Table third portrays the descriptive figures of Average yield over the 31 years in both Apple and Rice crop while the Table fourth, the last one exhibits the basic features of two climate variables viz., Rainfall (mms) and Average temperature (°c).

Table: 4.2.1: Area under Apple and Rice Crop 1985-86 to 2016-17

Statistics	Variables	
	Apple (Hectares)	Rice('000 hectares)
Mean	91166.8	149.5
Std. Deviation	29926.1	9.794
Maximum	143472	176.8
Minimum	57416	134.1
Skewness	0.625	0.64
Kurtosis	-1.118	0.53
Observations	31	31

Source: Author's calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

The above table delineates the descriptive properties of Apple and Rice with respect to the area covered under them. The mean area under apples over 31 years is 91166.8 hectares, with Maximum and Minimum values equal to 143472 hectares and 57416 hectares respectively. The increment in area from thousand hectares (57416 hectares) to lakh hectares (143472 hectares) within 31 years depicts the shift in cropping pattern at a rapid pace.

On the other hand, the mean value of area under rice is 149.5 thousand hectares over 31 years with Maximum value 176.8 thousand hectares and Minimum value 134.1 thousand hectares. Even though the area under Rice increased as gets revealed from the Minimum

and Maximum value, yet the increasing pace of area is too slow as compared to the Apple area.

Table: 4.2.2: Production of Apple and Rice Crop 1985-86 to 2016-17

Statistics	Variables	
	Apple(Metric Tons)	Rice((‘000) Tons)
Mean	949107	333.94
Std. Deviation	410796	52.67
Maximum	1915448	420.2
Minimum	0	153.3
Skewness	0.53	-1.49
Kurtosis	0.77	3.319
Observations	31	31

Source: Author’s calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

The apple results for 31 observations in the above table show that the maximum and minimum production values have very high difference with respect to the mean value. Maximum value is 1915448 metric tons while the minimum value is 0. The main reason behind the minimum value being zero (0) is the floods of September, 2014 which devastated the whole apple production. For better comparisons we will take here second minimum value from the data which is 418522 metric tons. When we compare maximum apple production value and second minimum apple production value they still differ hugely. This means that within 31 observations production has increased from 418522 metric tons to 1915448 metric tons, which is the indication of rapidly increasing production.

In rice production, mean value is 333.94 thousand tons, minimum value is 153.3 thousand tons and maximum value is 420.2 thousand tons. The given statistics regarding

rice didn't reveal any certainty about the production trend and thus to assess the production on such statistics will be absurd.

Table: 4.2.3: Productivity of Apple and Rice Crop 1985-86 to 2016-17

Statistics	Variables	
	Apple(Yield (kg per hectare)	Rice Yield (Qtls. Per hectare)
Mean	10517	22.47
Std. Deviation	2434	3.94
Maximum	14485	26.9
Minimum	0	9.7
Skewness	-2.75	-1.3
Kurtosis	11.57	2.15
Observations	31	31

Source: Author's calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

The above given table reveals the descriptive characteristics of apple and rice with respect to their productivity. The mean productivity of apple is 10517 kgs/hectare with maximum productivity equal to 14485 kgs/hectare and minimum productivity equal to zero (0). Minimum productivity equal to zero (0) accrue in the year 2014 when whole apple production in Kashmir got devastated by the floods.

The average value of Rice over the 31 years is 22.47 quintals/hectare, with maximum and minimum values equivalent to 26.9 and 9.7 quintals per hectare respectively. The minimum value equivalent to 9.7 quintals per hectare exhibits the flood impact of 2014 on production.

Table: 4.2.4: Descriptive Statistics of the Climate Variables for the Time Period 1985-2015

Statistics	Variables	
	Rainfall (mms)	Average Temperature (°c)
Mean	6775.4	20.32
Std. Deviation	1366.7	1.012
Maximum	9264	22
Minimum	4350	18
Skewness	-0.013	-0.096
Kurtosis	-0.69	-0.303
Observations	31	31

Source: Author's calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice Development Patna, RBI, IMD Srinagar.

In the above table, minimum value of rainfall is 4350 mms, mean rainfall value is 6775.4 mms, and the maximum value of rainfall is 9264 mms. The increase in the total rainfall from 4350 mms to 9264 mms in the span of just 31 observations reveals high fluctuation and is the indication of changing climate. Average temperature (°c) over the 31 observations increases from 18 °c to 22 °c with mean 20.32 °c gives the evidence of changing climate.

The basic limitation with the descriptive statistics is that we can't justify to which extent independent variable impacts the dependent variable, we can only make a comparison with descriptive results and thus to conclude results with only descriptive figures will be absurd. Thus for clear impact assessment we move on to the multi- variate regression model results which are shown below;

4.3: Stationarity and Unit Root

As the present data set contains more than 20 observations, therefore it becomes mandatory to verify the Stationarity in the series before applying the regression. For doing this a very famous method namely Augmented Dickey Fuller (ADF) test is used. Hence, Augmented Dickey Fuller (ADF) test is applied so as to test the presence of unit roots in the series. The results of the Augmented Dickey Fuller test (ADF) are given in the following table;

Table: 4.3.1: Results of Augmented Dickey-Fuller (ADF) unit root test

Series	t statistic	ADF at 1% Level	ADF at 5% Level
AA	1.259	-3.661	-2.960
ΔAA	-3.914	-3.670	-2.963
AP	0.011	-3.699	-2.976
ΔAP	-6.670	-3.699	-2.976
APD	**-4.073***	-3.689	-2.971
ΔAPD	-5.366	-3.699	-2.976
RF	**-2.992***	-3.670	-2.963
ΔRF	-8.237	-3.679	-2.976
AT	**-4.516***	-3.670	-2.963
ΔAT	-9.107	-3.679	-2.967
RA	**-3.131***	-3.670	-2.963
ΔRA	-6.507	-3.679	-2.967
RP	**-5.551***	-3.661	-2.96
ΔRP	-6.68	-3.679	-2.967
RPD	**-4.734***	-3.661	-2.960
ΔRPD	-5.928	-3.679	-2.967

Source: Authors calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice development Patna, RBI, IMD Srinagar.

Note: The "*" defines variables are stationary at level.

AA= Apple Area, AP= Apple Production, APD= Apple Productivity.

RF= Rainfall.

AT= Average Temperature.

RA= Rice Area, RP= Rice Production, RPD= Rice Productivity.

Above table 1 depicts the results of Stationarity test for the selected variables in the present study. For checking the stationary ADF has been selected at 5% level as well as at 1% level. If t-statistics is greater than ADF critical value, the null hypothesis is then accepted, i.e., unit root exists which means that the data is non-stationary. If t-statistics is less than the ADF critical value, we reject the null hypothesis, i.e., unit root does not exist which means that the data is stationary. So the results of above table reveal that the six variables out of eight variables are stationary at 5% level of significance. The t-statistic values of APD, RF, AT, RA, RP RPD are lesser than the ADF critical value. So we reject the null hypothesis and data is stationary at 5% level.

4.4: Results of Regression Models

Table: 4.4.1: Regression between AP, RF and TR

AP	**Coef**	**Std. Err**	**P**	**t**	**R^2**	**Obs**
RF	2.183841	42.7736	0.960	0.05	0.881	31
TR	71103.17[a]	21288.67	0.002	3.34		

Source: Authors calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice development Patna, RBI, IMD Srinagar.

Note*:* *Superscripts "a" denote 5% level of significance.*

In the above table, AP stands for the Apple production, RF stands for the Rainfall and TR stands for the Average temperature. The table shows the multi-variate regression results between these three variables in Kashmir over the time period 1985- 2015. Here Apple production is regressed upon the two climate variables Rainfall and Average temperature. Regression analysis generates a statistical relationship between one or more predictor variables and the response variable. The above table exhibits the relationship between the

variables. The results of the model explained that there is a positive relationship between the variables. P-value of TR indicates that the relationships are statistically significant at 5% level; P-value 0.002 is less than 0.05. It means that we fail to accept the null hypothesis. But the p-value of RF is 0.960 which greater than the 0.05, so in this case we fail to reject the null hypothesis. R^2 value means that 88% of the variations of w-values around the mean are explained by the α-values. In other words, 88% of the values fit the model. Among the two climate variables Rainfall doesn't impacts Apple production. The reason behind this is that the Apple production is totally independent of the Rains and is thus least affected by this climate variable.

In contrast to this Average temperature is affecting the Apple production significantly. The basic fact behind this is that the Average temperature plays a crucial role throughout the growth and development stages of the Apple. It plays a key role at the time of flower sprouting to color picking stage of the Apple.

Table: 4.4.2: Regression between APD, RF and TR

APD	**Coef**	**Std. Err**	**P**	**t**	**R^2**	**Obs**
RF	0.0124648	0.2586989	0.962	0.05	0.957	31
TR	515.5876a	88.41596	0.000	5.83		

Source: Authors calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice development Patna, RBI, IMD Srinagar.

Note*:* *Superscripts "a" denote 5% level of significance.*

Here APD means Apple productivity, RF means Rainfall and TR means Average temperature. The above given table 2 shows the relationship between the APD, RF and TR. The results of the model explained that there is a positive relationship between the variables. P-value of TR indicates that the relationship is statistically significant at 5%

level. P-value 0.000 is less than 0.05. Here null hypothesis gets rejected. The p-value of RF is 0.962 which is greater than 0.05, so in this case we have fail to reject the null hypothesis. R^2 value means that 95% of the variations of x-values around the mean are explained by the β-values. In other words, 95% of the values fit the model.

Table: 4.4.3: Regression between RP, RF and TR

RP	Coef	Std. Err	P	t	R^2	Obs
RF	.0126714	.0062684	0.053	2.02	0.976	31
TR	17.87001a	3.119829	0.000	5.73		

Source: Authors calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice development Patna, RBI, IMD Srinagar.

In the above given table, RP denotes the Rice production, RF the Rainfall and TR the Average temperature. The above table denotes the multi-variate regression results between these variables in Kashmir over the time period 1985-2015. Rice production is regressed upon the climate variables; Rainfall and Average temperature. Results revealed that the Rainfall and Average temperature are able to show variations in the Rice production. The results of the model explained that there is a positive relationship between the variables. P-value 0.000 of TR, which is less than 0.05, indicates the relationship is statistically significant at 5% level and here null hypothesis is rejected. On the other hand, the p-value of RF is 0.053 which is almost equivalent to 0.05, so in this case we fail to reject the null hypothesis. R^2 value means that 97% of the variations of y-values around the mean are explained by the γ-values. In other words, 97% of the values fit the model.

Table: 4.4.4: Regression between RPD, RF and TR

RPD	Coef	Std. Err	P	t	R^2	Obs
RF	.0005093	.0004199	0.235	1.21	0.975	31
TR	.9367942[a]	.1435159	0.000	6.53		

Source: Authors calculation, using the data of DES of J&K, Directorate of Horticulture Srinagar, Directorate of Rice development Patna, RBI, IMD Srinagar.

Note*: Superscripts "a" denote 5% level of significance.*

In the above table RPD stands for Rice productivity, RF for the Rainfall and TR for the Average temperature. The results of the model explained that there exists a positive relationship between the variables. P-value of TR indicates that the relationship is statistically significant at 5% level. Here P-value of TR is 0.000 which is less than 0.05. In this case null hypothesis is rejected, but the p-value of RF is 0.235 which is greater than 0.05. So in this case we fail to reject the null hypothesis. Furthermore, R^2 value means that 97% of the variations of z-values around the mean are explained by the θ-values. In other words, 97% of the values fit the model.

CHAPTER: 5

CONCLUSION AND FINDINGS

5.1 Conclusion

Climate change is a universally recognized issue and concern of 21st century. Globally nations strive coherently to combat the imperative fatal repercussions of climate change. It has put the existence of man on stake. The worldwide forums, climate bodies and other organizations are putting their heart and soul out to devise strategies which could cover and cope up serious impacts of climate change. The tragedy with the climate change is that it affects the developing countries (like, India) most whose contribution towards it goes least. Similarly in every nation poor people are more affected by climate change rather than rich people because rich people possess various means to stand and tackle all the negative impressions of climate change to a huge extent.

Climate change depicts itself in different facets like surge in temperatures, decrease in glacier content, increase in sea levels, uneven fluctuations in precipitation levels, increase in crop diseases, decrease in production and productivity of crops, shift in agricultural practices, habitat extinction etc. The impacts of climate change vary between the sectors with agriculture being more prone to its impacts than the other sectors. This leads to the deficit in agricultural production and productivity and puts the food security at risk. The pattern of monsoons is now a day's unpredictable which force the farmers to make a shift in their agricultural practices from one crop to another. The frequency of extreme weather events like pro- longed dry spells and floods has increased. As per the official estimates, major loss is predicted in Rabi crops as compared to the kharif crops. The farmers with small holdings are more vulnerable and prone to climate change impacts which put their

lives and livelihoods on stake. This forces the farmers to migrate from resource deficient to resource efficient places which further leads to resource crisis.

The impacts of Climate change are evident in Kashmir valley more as compared to rest of the country. According to UNEP report, most parts of the state are highly prone to climate changes. As per INCCA, the number of rainy days in Himalayan region will increase by 2030s. The climate report of Jammu and Kashmir highlighted that the temperature (average) in the state got increased, with Kashmir valley delineated the increase equal to 1.45°c while Jammu division revealed this increase equal to 2.34°c since last two decades. The document further revealed that the maximum temperature in Kashmir valley gets enhanced by 0.05°c per year while Jammu division is experiencing this rate equal to 0.08°c per year since last two decades. As per the latest report put forth by IMD, heavy rains will occur from June- September 2018 with July predicted to be the wettest month of this year.

5.2 Findings of the Study

The aim of the present study was to assess the connection between the production and productivity of rice and apple crops with respect to climate variables average temperature and rainfall. For this multi-variate regression model was incorporated in the study. The results of the study revealed that the two climatic variables had notable impact on the production and productivity of rice and apple respectively. The major findings of the study are listed below;

1) Rainfall and average temperature were found statistically significant for the rice production and productivity. The reason is that the rice crop is dependent on water

more at its initial stages of growth and in the late stages it heavily depends upon the average temperature which is also supported by Sarker et.al (2012). That is why rainfall and average temperature had significant positive impacts on the production and productivity of rice.

2) Overall, the impact of two climatic variables viz., rainfall and average temperature on the production and productivity of rice was found to be significant. The fact is supported by the R^2 value which explains that the 97% variation in the rice production and productivity is the outcome of these two variables.
3) Rainfall was found insignificant and doesn't impact the apple production. The reason behind this fact is that the apple production is least affected by rains in the context of increase or decrease in the production and productivity. This fact is also supported by Wani et.al. (2015).
4) Average temperature was found significant and impacts both, the apple production and productivity. The logic behind this is that the apple production and productivity highly depend upon the average temperature while in the stages of flower sprouting to color picking, as is also highlighted by Braun and Muller (2012).
5) Over all the composite impact of two climatic variables on the apple production and productivity was found positively significant. This is indicated by the R^2 value which explains that the variations in apple production and productivity equivalent to 88% and 95% were brought about by these two climate variables rainfall and average temperature.

5.3 Policy Implications

The findings of the present study are of great utility in devising various policy measures which would prove welfare boosting in the agriculture and its allied sectors and will help policy makers, stakeholders, research persons, students and other agencies in focusing on basic problems before they will turn into certain complicated issues. The various policy implications implied by the present study are listed below;

1) There is the dearth of research in the concerned area due to the deficiency of research resources. It is thus implied upon the policy makers to provide funds for research and development in the said area, so that the actual assessment of prevailing conditions can be understood broadly.
2) Temperature tolerant verities of rice should be supplemented to the farmers so that they could combat the low productivity effects.
3) Funds should be provided for the research and development of various fertilizers, fungicides, insecticides which will boost the production on one side and on the other side counter the various uneven climatic fluctuations.
4) Government should focus on providing hybrid apple trees which will increase the productivity of apples.
5) Credit facilities at low interest rates must be provided to the farmers which will help them to overcome various climatic uncertainties and keeps their interest sustained in basic primary activities.
6) Timely climate bulletins via media are of prime importance in order to cover the various environmental risks.

5.4 Limitations and Future Scope of the Study

The scope of the present study is limited to Kashmir valley only. Although the study in near future will prove its significance for the policy makers, stake holders and various other agencies, yet it has a limitation regarding its scope as it is limited to a single division (only Kashmir valley), leaving the other parts of the state (Jammu division and Leh- ladakh areas) untouched. Moreover, the study is expected to yield much better results if it is carried out at inter- district level, which is another limitation of the present study. Also increase in the number of variables will provide clearer picture than the present study, so that more better and fruitful policies can be adopted which will enrich the welfare of the said sector.

In the context of future scope of the present study, the study bears a wide research range which can be opted by the researchers. A state level study can be undertaken which will help in understanding the status of the state in comparison to the other states of the country. Also inter-district and inter-division comparisons will unveil the areas which are more impacted by the climate change. Comprehensive study can be undertaken with the addition of more climatic variables and crops. Also time series data can be extended to more than 31 years which will reveal the years from were climate changes become evident.

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