

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 km² (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. CO₂ 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 2nd 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 13th century reached to its peak in the 18th 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 19th 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) CO₂ emissions in atmosphere increased from 280 ppm to 368 ppm since 1950-2000.
- 2) CH₄ amounts got enhanced from 7000 ppb to 8750 ppb between 1950 -2000.
- 3) The NO₂ 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 $0.6\pm 0.2^{\circ}\text{C}$ 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 earth's 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 CO₂ 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 CO₂ on grain quality. Increasing trend of global warming will become more powerful than precipitation over the 20th 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 CO₂ 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 cons 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 (Kuruksheetra, 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, Zaskar 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. Later on Emperor Jahangir used the same phrase to praise the astonishing beauty of the valley Kashmir when he visited the valley in 17th 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.