Title:

Impacts of Climate Change on Various Sectors in Khyber Pakhtunkhwa Province of Pakistan; A Review

Authors:

1) Muhammad Aamir Munir

   MS Research Scholar, Department of Environmental Sciences, University of Peshawar.

   Email: aamirmunir17@gmail.com

   Twitter: @aamirmunir117

2) Kamran Munir

   BS Student; Department of Environmental Sciences, University of Peshawar

   Email: kamranmunir2001@gmail.com

   Twitter: @KamranM36735776

Statement by Authors:

This manuscript which is being submitted to "EarthArXiv" is a non-peer reviewed preprint. This has never been published nor submitted to any other journal before. Research supervision and support were provided by Pakistan Red Crescent Society under the research theme of "Changing Perception Towards Climate Change". We, both the authors, have no issues for publishing this manuscript as a preprint by EarthArXiv.

Abstract:

Introduction: Day to day atmospheric conditions of an area is referred to as weather, whereas, the statistical expression of weather events in an area over a period of minimum 30 years is called climate. Due to the global warming, weather across the globe has started changing from time to time. As a result, the climate change in different areas have taken rise. Pakistan is amongst the top ten countries that are likely to be affected by the climate change.

Study Objectives: This study focuses on highlighting the impacts of climate change on various sectors in Khyber Pakhtunkhwa (KP) province of Pakistan. The research objectives of this report are (1) to explain, in simple words, the concept of climate change and other associated phenomena. (2) To identify the possible impacts of climate change in Khyber Pakhtunkhwa (3) To highlight any possible adaptative and mitigatory measure that could minimize the impacts of climate change.

Methodology: To achieve the aforementioned objectives, a detailed literature review was carried out using the keywords; climate change, impacts of climate change on forests, humans, agriculture, and water, climate change in KP, Climate change in Pakistan. The manuscripts were studied and then paraphrased to avoid plagiarism. This study is entirely based on the secondary data as it is based on review of published articles.

Conclusion and Recommendation: Amongst the most noticeable impacts are the seasonal shift and extreme weather events in the entire country, particularly in the KP. As a result, the agricultural productivity will decline, forests elevation up to 500 mm will occur. The surface and ground water bodies will be deteriorated and human behavioral changes like anger will increase. Therefore, there is need to cope this challenge by adopting anticipated approaches to combat the adversities.

Introduction

The physical conditions in the environment and atmosphere such as precipitation, temperature, wind, pressure and humidity, which have direct or indirect consequences upon the biosphere, are termed as weather while the pattern of weather in a region over a period of time (minimum 30 years) is called climate (Le Treut et al., 2007).

In other words, climate is the statistical expression of daily weather events. The overall distribution of weather parameters defines the climatic variability of the place. Climates may change on different scales of time and in different ways, due to forcing factors (orbital, solar, volcanic) and to internal variability within the climate system. (Bradley, 2015).

To understand the "***Climate and Climate Change***", we must understand about the weather and its parameters as the climate of an area depends upon the record of weather conditions of that area. Thus, the weather can be defined as, "the state of the atmosphere, to the degree that it is hot or cold, wet or dry, calm or stormy, clear or cloudy, at a particular place and at a particular moment (Barry and Chorley, 2009). The climate is usually described in terms of three weather phenomena, which include atmospheric temperature, precipitation, and wind, over a period of time (Le Treut et al., 2007). To elaborate further, air temperature is a measure of how hot or cold the air is, whereas, the movement of air caused by differences in the air pressure within our atmosphere is called wind (Paulson, 1970). The greater the difference in pressure, the faster the air flows. Wind is described with direction and speed. The direction of the wind is expressed as the direction from which the wind is blowing. For example, easterly winds blow from east to west, while westerly winds blow from west to east. Winds have different levels of speed, such as "breeze" and "gale", depending on how fast they blow (University Corporation for Atmospheric Research [UCAR], 2003). Similarly, precipitation refers to any form of water that falls to the Earth's surface from the clouds; includes rain, snow, sleet, and hail (Minallah and Steiner, 2021).

To maintain a suitable temperature on earth for the survival of living organisms, a natural phenomenon called "Greenhouse Effect" plays a vital role. This is the process due to which we have suitable weather conditions on planet earth. This phenomenon plays a pivotal role in maintaining a survivable global average temperature (Cline, 1991).

Greenhouse Effect

Greenhouse Effect is a natural process due to which the lower layer of the atmosphere; troposphere, is kept warm and favorable for living. Sun is the major source of energy for planet earth. Solar radiations, having heat energy, when reaches the earth's atmosphere, some of them are reflected by the gases present in the upper atmosphere. Similarly, stratospheric ozone also traps the dangerous ultraviolet radiations and prevent them from reaching the earth. The remaining sunlight and radiations (visible light) reach the earth surface which are released from the earth surface, after being absorbed, in the form of infrared radiations. These infrared radiations, unlike the visible light, are absorbed by the gases present in the troposphere which are known as "Greenhouse Gases". The absorption of radiations by the greenhouse gases results in trapping the heat inside the troposphere which results in maintaining an average global temperature of 33 °C on the earth (Stępniewska and Kuźniar, 2013). The greenhouse gases include carbon dioxide, methane, nitrous oxide, tropospheric ozone, water vapors and chlorofluorocarbons (El-Fadel and Massoud, 2001).

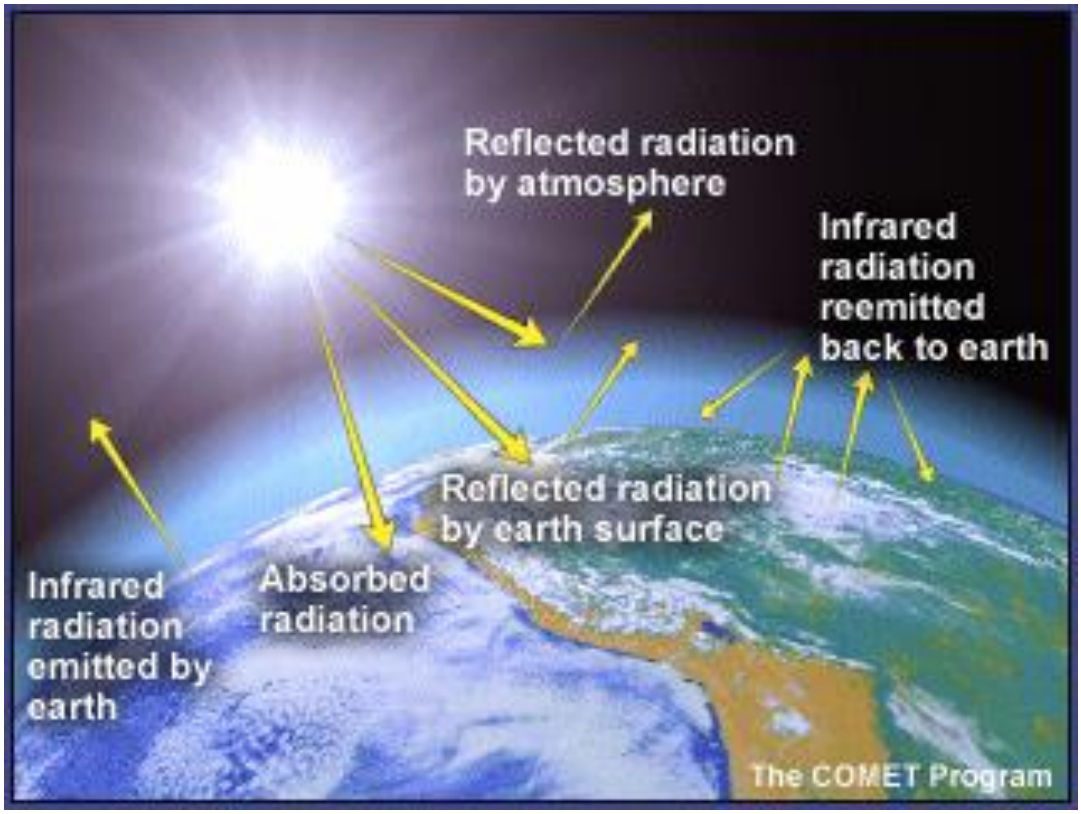

Figure 1. Graphical presentation of the Greenhouse effect (Kweku et al. 2017)

Enhanced Greenhouse Effect

Due to the industrial revolution and mechanization, excessive use of fossil fuels, air conditioners, fridges, and brick kilns emissions have caused an increased in the concentration of greenhouse gases in the troposphere due to which more heat is trapped by the greenhouse gases. This phenomenon is called enhanced greenhouse effect (Intergovernmental Panel on Climate Change [IPCC], 2001). As a result of enhanced greenhouse effect, more head is trapped, as a result the earth is getting warmer day by day which has initiated the process of "Global Warming". The global average temperature has increased 0.2 °C per decade since 1970 (IPCC, 2007).

Due to the continuous rise in the global average temperature (global warming) for a long period of time, the weather conditions had been facing variations which has resulted in the climate change because climate is the record of the weather conditions of an area (Farooqi et al., 2005).

Literature Review

In order to throw light on the research work carried out globally about the climate change, the following studies were reviewed and were added to represent the complete picture climate change taking place globally. The studies are summarized and presented in proper order where the first few represents the global perspective followed by regional, national and then local studies. The research papers relevant to different regions were found out using the keywords "global, Asia, Pakistan, Khyber Pakhtunkhwa, and Peshawar" at the end of each searching statement.

In order to do the literature review, the research papers from the websites; science direct, PubMed, and Google scholar, were downloaded. For searching the relevant literature, keywords were used which include: climate change in Khyber Pakhtunkhwa, impacts of climate change on crops, forests, humans' life, and weather, people's perception about climate change in KPK, adaptations and mitigations of climate change in KPK-Pakistan. Reports published by Ministry of Climate Change, Pakistan, were also used as reference.

Global Climate Change Research Studies

Global average temperature has increased 0.2 °C per decade since 1970 and global average precipitation has increased 2 % in the last 100 years. Moreover, climate changes are spatially

heterogeneous. Some locations, such as the Arctic experience much large change than global means, while others are exposed to secondary effects like sea level rise. (IPCC, 2007)

Jones et al., (1999) reviewed the surface air temperature record of the past 150 years, considering the homogeneity of the basic data and the standard errors of estimation of the average hemispheric and global estimates. They presented global fields of surface temperature change over the two 20-year periods of greatest warming the 20th century, 1925–1944 and 1978–1997. Over these periods, global temperatures rose by 0.37° and 0.32°C, respectively. The twentieth-century warming has been accompanied by a decrease in those areas of the world affected by exceptionally cool temperatures and to a lesser extent by increases in areas affected by exceptionally warm temperatures. In recent decades, there have been much greater increases in night minimum temperatures than in day maximum temperatures, so that over 1950–1993 the diurnal temperature range has decreased by 0.08°C per decade.

Mao et al., (2016) proposed a new method to calculate global mean surface temperature based on remote sensing data from MODIS satellite. Because Global surface temperature change is one of the most important aspects in global climate change research. They found that (1) the global mean surface temperature was close to 14.35 °C from 2001 to 2012, and the warmest and coldest surface temperatures of the globe in the recent twelve years occurred in 2005 and 2008, respectively; (2) the warmest and coldest surface temperatures on the global land surface occurred in 2005 and 2001, respectively, and on the global ocean surface in 2010 and 2008, respectively; and (3) in recent twelve years, although most regions (especially the Southern Hemisphere) are warming, global warming is yet controversial because it is cooling in the central and eastern regions of Pacific Ocean, northern regions of the Atlantic Ocean, northern regions of China, Mongolia, southern regions of Russia, western regions of Canada and America, the eastern and northern regions of Australia, and the southern tip of Africa.

Regional Climate Change Research Studies

Occurrence of temperature anomaly has greatly affected natural cycles of water resources in Lancang River basin in China, which is the upper reach of Mekong River. The study indicated that the temperature increased significantly over the period of 1960 to 2009 at annual and seasonal scales, particularly over 1990s. At the same time, the most significant rising occurred in winter

and the least in summer. Moreover, a west–east inverse phase pattern of temperature variations was a distinct feature in most of the basin. Temporal trend indicated that the increasing trend in the west region was slightly stronger than that in the east. This was particularly the case of edge areas almost vertical juncture with monsoons. (FeifeiWu et al., 2012)

Twentieth-century warming could lead to increases in the moisture-holding capacity of the atmosphere, altering the hydrological cycle and the characteristics of precipitation. An annually resolved oxygen isotope record from tree-rings, providing a millennial-scale reconstruction of precipitation variability in the high mountains of northern Pakistan including Karakoram and Himalaya was presented. The climatic signal originates mainly from winter precipitation, and is robust over ecologically different sites. Centennial-scale variations reveal dry conditions at the beginning of the past millennium and through the eighteenth and early nineteenth centuries, with precipitation increasing during the late nineteenth and the twentieth centuries to yield the wettest conditions of the past 1,000 years. (Treydte, et al., 2006)

National Climate Change Research Studies

Over the last century, an average annual increase in surface air temperature of about 2.9°C has been observed in boreal Asia. Asiatic region has been historically vulnerable to fluctuations in the monsoons, the El Nino Southern Oscillations and tropical cyclones. In Pakistan, for computing the past climatic changes, climatic data for the last 50 years (1951-2000) was analyzed using Global Climate Models and Regional Climate Models. The study revealed that in Pakistan, annual mean surface temperature has a consistent rising trend since the beginning of 20th century. Rise in mean temperature of 0.6-1.0°C in arid coastal areas, arid mountains and hyper arid plains, 10-15% decrease in both winter and summer rainfall in coastal belt and hyper arid plains, 18-32% increase in rainfall in monsoon zone especially the sub- humid and humid areas is observed. There is 5% decrease in relative humidity in Baluchistan, 0.5 to 0.7% Increase in solar radiation over southern half of country. There is 3-5% decrease in cloud cover in central Pakistan with increase in sunshine hours. There is 5% Increase in net irrigation water requirement with no change in rainfall. (Farooqi et al., 2005)

Sheikh et al., (2009) in their report clearly illustrate that precipitation in both Northern and Southern Pakistan, is likely to increase in summer and decrease in winter with no significant change in annual precipitation.

A study conducted in Pakistan to assess the rainfall trend in different climate zones of Pakistan over the past three decades from 1976-2005, show significant decreasing trend all over the country and attributed to relatively drier period in country from 1998 to 2001, in which country faced severe drought mainly in the southern and central parts. The results obtained from the analysis of rainfall data indicate 3.55mm decrease in the whole country in two-time intervals from 1976-1990 to 1991-2005, whereas a decrease of 1.18mm per decade has been observed during the entire study period. It was concluded that change in rainfall pattern and prolonged droughts will pose severe risk to agriculture and water management sectors. (Salma et al., 2012)

Sajjad et al., (2009) used the time series data of mean minimum temperature (MMiT), mean maximum temperature (MMxT) and mean annual temperature (MAT) from 1947 to 2005 to find out the possible changes in temperature of the mega city of Karachi, Pakistan. In the research conducted, the observed change in temperature was positive which had clear increasing trends in MMxT and MAT but MMiT had constant but little bit decreasing trends over the last 59 years. During 1947 to 2005, the observed increase in MMxT was about 4.6 °C that is 0.78°C increase per decade. The observed data also made it clear that the MMiT of Karachi show an increase of 1.2°C during 1975–2005 and overall, from 1947–2005, it was reduced −0.1°C. Overall results showed that MAT increased about 2.25°C during the whole study period.

Local/Provincial Level Climate Change Research Studies

Research investigated precipitation variability across 15 stations in the Swat River basin, Pakistan, over a 51-year study period (1961–2011). The results highlighted a mix of positive (increasing) and negative (decreasing) trends in monthly, seasonal, and annual precipitation. One station in particular, the Saidu Sharif station, showed the maximum number of significant monthly precipitation events, followed by Abazai, Khairabad, and Malakand. On the seasonal time scale, precipitation trends changed from the summer to the autumn season. The Saidu Sharif station revealed the highest positive trend (7.48 mm/year) in annual precipitation. In the entire Swat River basin, statistically insignificant trends were found in the sub basins for the annual precipitation

series; however, the Lower Swat sub basin showed the maximum quantitative increase in the precipitation at a rate of 2.18 mm/year. (Ahmad et al., 2015)

Bukhari and Bajwa (2008) observed that the climate is changing in Peshawar with increased temperature and decreased rainfall. Their result has shown 0.85°C (0.77°C – 0.92 °C) increase in the temperature during the study period 1985-2009 in Peshawar apart from vertical increase in temperature, there are horizontal changes in temperature causing considerable shifting in seasons. The spring season started 15.6 days earlier as well as the spring season was shortened by 17.8 days. The summer season was extended and spread over seven months (April- October) having mean maximum temperature greater than 30°C. There was 30% decrease in rainfall during study period. The climate was shifted towards dry tropical with 8 months receiving <25 mm rainfall. The rainfall was reduced drastically in spring and late summer season. Evaporation and wind increased 1.59 times and 1.40 times, respectively. The results indicated a significant feedback mechanism among temperature, rainfall and evaporation. Present finding forecast a likely increase of 4.13°C in maximum temperature by the end of 21st century.

Bouma et al. (1996) while analyzing the impacts of climate in the spread of *Plasmodium falciparum*, determined that in Northwest Frontier Province (now known as Khyber Pakhtunkhwa) of Pakistan, the climatologic records since 1876 show an increase in mean November and December temperatures by 2°C and 1.5°C, respectively, and in October rainfall whereas mean humidity in December has also been increasing since 1950.

Shah, et al., (2012) conducted a study with the objective to investigate the recent trends and variability of annual minimum, maximum and mean temperatures, relative humidity and rainfall of Peshawar. Annual meteorological parameters for 30-years (1981-2010) of Peshawar observatory have been analyzed to determine indications of variations from long-term averages. Different statistical methods were used to analyze the data. For this purpose, Mann-Kendall test was applied to Meteorological data of Peshawar (1981-2010) to study any trend, which were revealed to be in a mixture. The final results show that rainfall is decreasing, minimum temperature, mean temperature and relative humidity are increasing and maximum temperature has no change.

Iqbal & Quamar in 2011 conducted a research to measures the variability of annual surface air temperature of five major cities of Pakistan (Lahore, Peshawar, Quetta, Hyderabad and Karachi) for the period from 1882 to 2003. They performed an exploratory analysis which showed that the annual landmass air temperature series of five relatively more important climate stations of Pakistan obey the normal distribution. A subsequent trend analysis showed that the temperature has been increasing in the twentieth century for the five (major) cities of Pakistan, the increase being 0.3°C to 1.0°C (Iqbal and Quamar, 2011).

Shah, et al., (2010) studied changes in the rainfall activity, minimum, maximum and mean temperatures on monthly as well as on seasonal basis during the pre-monsoon season (April-June) 2009 in the province of NWFP now known as Khyber Pakhtunkhwa. The data was collected from 11 meteorological observatories located in NWFP. By comparing with the climatic normal values of 1971-2000, it was found that the rainfall was largely above normal during April, slightly below normal during May and normal in June. As a whole, it remained slightly above normal during the pre-monsoon season across the region. The minimum temperature remained slightly below normal during April and June and normal during May throughout the region. As a whole, it remained normal during the season in the area. The maximum temperature remained slightly below normal during April and normal during the months of May and June respectively. As a whole, it remained normal throughout the season across the region. As a result, the mean temperature remained normal during the study period across the region.

Impacts of Climate Change on Various Sectors

Agriculture

Pakistan is amongst the highly vulnerable countries due to the climate change, even though Pakistan contributes only 0.43 percent to the Greenhouse gasses emission. Due to the climate change, the agriculture sector in the Khyber Pakhtunkhwa will be highly affected as it will create many problems, for examples, excessive rain fall, high temperature, prolonged summers, droughts etc. As a consequence of the climate change, the agricultural productivity in KPK and all across Pakistan will be reduced. The decline in the agriculture sector productivity will affect about 2/3

percent population who are connected with agriculture (Ali and Iqbal, 2004). The increase in the temperature due to the climate change, the major crops like food grains, sugar cane and fruits will be adversely affected. The seasonal crops will experience difficulty in growth due to the seasonal shift and the characteristics and properties of soil may also get changed due to variation in the weathering process (Task Force for Climate Change [TFCC], 2010). It has been predicted that one-degree Celsius increase in the temperature will reduce the wheat productivity by 5.7% in Pakistan (Stefanski and Sivakumar, 2011). Whereas, in other crops, the high temperature results in early maturation of the plants, therefore, the productivity will also be reduced as it is predicted that by 2080, the growing season for crops will be shortened (Zhu, 2004).

As the Khyber Pakhtunkhwa also produces high quantity of corn, its productivity will also be declined as the yield of crops increases at moderate temperatures, whereas, the temperature higher than 30 degree Celsius reduces the corn yield (Schlenker and Roberts, 2006). So, KP will probably face a shortage of cereal crops in the nearby future as a consequence of climate change.

Generally, the increase in the warmth, as a result of climate change, the ratio of carbon and nitrogen in plants, growth of the plants' root and shoot, and nutrients uptake is affected. Thus, a non-significant change in the temperature will result is plants loss and may lead to desertification (Rashid, 2008). Further, the increase in temperature will also increase the pests and accelerates the spread of crop diseases which will affect the food security in Pakistan (Hussain et al., 2018).

The lower altitude areas of Khyber Pakhtunkhwa are likely to become unsuitable for agriculture as excessive flooding will cause salinity as well as soil erosion (International Fund for Agricultural Development [IFAD], 2013).Furthermore, due to the extreme climatic variations in Pakistan, in the upper region of the Indus basin, due to the deteriorated soil quality the agricultural land has reduced declining the livestock and agricultural productivity of the region (Hussain et al., 2016). Sugar cane, rice, cotton and wheat which are considered as the cash crops in Pakistan, have experienced a downfall in their productivity due to the climate change (Abid et al., 2015).

Forests

Majority of the forests in Pakistan are present in Khyber Pakhtunkhwa province. The forest cover in KP is 20.3%, however, the climate change will effect the forests. Environmental niches are

altered by the climate change due to which animal as well as plant species are compelled to change their habitat. It has been observed that due to the climate change, the species in forests change their habitat and rise to higher altitudes to cope with the extreme events. It has been suggested that when temperature increases by 3 C°, it can cause elevation shift of forests by 500 mm. So, the forests in KP which are mostly coniferous (1000-4000 m altitude) will grow in further higher altitudes (Siddiqui, 2001). Furthermore, 1 C° increase in the temperature may increase the possibility of wildfires by 30 times (Cruz et al., 2007).

Besides the impacts of climate change on the forests of Pakistan are further intensified due the over exploitation of fuel wood and over grazing. It has been estimated that the consumption of fuel food is 3 times more than the forest replenishing potential, whereas, the intensity of grazing is 6.5 times greater than the forage production capacity of the forest. The climate change and over exploitation, both together, will have severe impacts on the forest of Khyber Pakhtunkhwa (Khattack, 1992).

To cope with the adversities of climate change, certain actions need to be taken in order to make the forests survivable in Pakistan which include the selection of a tree species that can bear the harsh conditions resulting due to the climate change. The chir pine is highly adaptable and can be grown in various ecological regions. Similarly, fir and blue pine species are highly recommended to be planted in temperature region, whereas, in dry areas with high possibility of forest fire, the cold conifer trees must be grown. Furthermore, the use of wood as a fuel can be reduced by enhancing the quality of stoves and its utilization can also be reduced in construction if the roof tops are made by iron sheets rather than wood, in the hilly areas with inclined angle. Moreover, the man-made forest plantations shall be supported but in scientific manners and more care shall be given to the threatened or endangered species (Siddiqui et al., 1999).

Surface and Ground Water

Based on the reports issued by World Bank in 2006, Pakistan was listed among the 17 countries who were facing the problem of water shortage. The climate change has a huge impact on the water availability. The increase in temperature in dry areas makes them more dryer causing drought and decline of ground water table, whereas, the increase in temperature in cold areas makes it more wetter causing more rain which results in the rise of ground water table (NEF, 2001).

The declining water table are most common majority part of the province where the dug well and tube wells are drying out at a rapid face. Similarly, due to variation in the intensity, pattern, and amount of rainfall, as a consequence of climate change, the retention time and the pathways of runoff water in water shed will change which will affect the quality of the water and it may become unsuitable in the catchment area causing deterioration of the water quality (IPCC, 2007). Moreover, due to the seasonal shift observed in the Khyber Pakhtunkhwa, the winters have shortened due to which the glacial melting starts earliers due to which the availabilty of the water coming from glaciars in extreme hot weather is low which affects the irrigation and power generation in the hydropower plants (Roohi, 2004). If the streamflow is reduced by 1%, it reduces the electricity generation by 3% (Laghari, 2013). Besides, the increase in temperature causes more evaporation which will reduce the water flow in the streams and the springs may dry up in the Khyber Pakhtunkhwa (NEF, 2001). It is also worth mentioning that during the period of 2003-2009, an estimated amound of 174 gigatones of water was lost from the glaciers in the Himalayas due to the increased global temperature rise and it is enhancing glacial receeding (Gardener et al., 2013). The satellite images and other remote sensing data clearly elaborates that the glacieal cover in the Himalayan region, which lies in the north of the Khyber Pakhtunkhwa, has reduced by 9% in early 2000s as compared to the 1970s (Yao et al., 2012).

In order to cope with the water security problem arising due to the global warming and climate change, it is imperative for the government to build new dams, which will store water and produce electricity and contribute in agriculture. Similarly, scientists need to map out the glacial receding along with the awareness to reduce emissions that enhance the greenhouse effect (Laghari, 2013).

Extreme Weather Events

Due to the climate change, extreme weather events are likely to occur in Pakistan. The change in the timings, pattern and amount of precipitation will cause severe flooding as happened on 29 July, 2010, when excessive seasonal rainfall occurred and caused flooding in Khyber Pakhtunkhwa, some parts of Punjab and Sindh province. It is considered the worst flood in past 80 years in the history of Pakistan. About 2000 people lost their lives whereas about 700,000 buildings were destructed (Salma et. al., 2012). Furthermore, extreme temperatures, droughts and severe storms are likely to occur in Pakistan as a consequence of climate change which will affect large number

of people as 40% of Pakistan's population is vulnerable to the disasters. Moreover, the rainfall will get intensified with time in the northern areas of Khyber Pakhtunkhwa and Gilgit Baltistan with unpredictable rainfall pattern causing difficulty for the public to adopt anticipatory measures (Saeed et. al., 2010). Apart from the floods, the land sliding and mud flow will also increase, however, the total annual precipitation in some parts of the Asia has been observed to be showing a declining trend (Mirza, 2002). The climate change will give rise to sever heat waves all across the globe but developing countries like Pakistan will suffer a lot from it (Fischer and Knutti, 2015).The climate change is held responsible for the shift of heat waves from India to Pakistan and to bear these waves transfer, more energy (electrical or human energy) will be required otherwise temperature above 53 °C will cause hyperthermia and temperature below 58 °F will cause hypothermia (Pan et al., 2016). The climate change is likely to affect the "monsoon" and "winter rains" patterns and intensity in Khyber Pakhtunkhwa and all across Pakistan which will affect the water flow in the water bodies. Similarly, in summers, the high temperature will cause more evaporation creating high demand for irrigation water supply which may lead to local public disputes (Asian Development Bank [ADB], 2017).As consequences of climate change, in 2015, Pakistan faced many natural disasters which include flood, heat waves, earthquake, cyclone, and drought (Syeda and Adnan, 2016).

Human Health and Habits

The variation in weather conditions due to climate change has caused various impacts on human health amongst which, the most prominent are the spread of gastro-intestinal diseases, take for instance, cholera and diarrhea. Whereas, other diseases, which could be associated with the climate change or the consequences of climate change i.e. water quality deterioration, include hepatitis and dengue fever (Shah, 2008). Climate change is also responsible for the migration of people from one place to another to meet their needs (Ellison et al., 2017). Further, it has changed the human habits in terms of necessities. The dressing has changed due to extreme weathers, both summers and winters. Moreover, excessive use of air conditioners and refrigerators are also an impact of climate change, which on other hand, are releasing dangerous gases into the atmosphere that are likely to deplete the ozone layer.

The atmospheric temperature also effects on the human health. Increased temperature creates anger and behavioral violence which ultimately leads to war and conflicts; thus, climate change has been contributing to the emotional changes in humans which included stress, anger and enmity (Solanki, 2016). Furthermore, the culture and societal norms play an important role in effecting the mentality of its society members, therefore, the government must design and impose such adaptive and mitigatory policies which do not contradict with the society values because the policies not aligned with the societal norms cannot be practically implemented (Leiserowitz, 2006).

Adaptation and Mitigation Methodologies

In order to mitigate the impacts of climate change in Pakistan, several sectors need to be worked upon and improved which include the transportation system, animal breeding, agricultural farming, forest management, urban and rural planning, energy production and industrial sectors (Lin and Ahmad, 2017). One of the major mitigation measures to tackle the current climatic change scenario in Pakistan is to ensure the use of eco-friendly, energy efficient and renewable energy operated appliances. To achieve the aforementioned goal, Pakistan need to invest 7 to 14 billion US dollars per annum (Government of Pakistan [GOP], 2017). Pakistan has also worked on certain managerial and technological advancement strategies to minimize the impact of climate change which include the sustainable management of forest resources and vehicular advancement, take for instance, Bus Rapid Transit (BRT) corridor in Khyber Pakhtunkhwa and compliance of vehicular tune-up by Vehicle Emission Testing Agency (VETS) in the province (Ministry of Climate Change, 2016).

To cope with the challenges faced by the water sector in Pakistan, the best approaches are to harvest the rain water, storage of flood water in the water reservoirs, and the anthropogenic recharge of the ground water. Similarly, other suggestions include the use of efficient irrigation system which include sprinkling and drip irrigation. The use of drought resistant crops species can also be a fruitful mitigation in agriculture sector and will result in reducing the water stress (Ministry of Climate Change, 2017). Furthermore, in the rural areas of Khyber Pakhtunkhwa, the process of crop rotation, excessive use of pesticides and fertilizers, change in timings of sowing plants, and use of hybrid seeds are some of the adaptative measures used by farmers to cope with climate change (Fahad and Wang, 2018).

Conclusion

Climate change is taking place and its consequences are becoming more prominent day by day. It is imperative that if the emissions of greenhouse gases are not controlled, the global temperature will increase to an extreme and that will be destructive as it will result in reduced crop productivity, occurrence of natural hazards, water scarcity, and negative changes in human behavior particularly anger.

Recommendation

The first and most important recommendation is to adopt anticipatory planning approach in the Khyber Pakhtunkhwa as well as Pakistan so that Pakistan could cope with the adversities of climate change. This approach includes, construction of water reservoirs, prevention of water wastage, and implementation of waste water treatment. Furthermore, climate change is declining the crop yield, therefore, genetically modified plants shall be introduced that can bear the harsh weather conditions without affecting the productivity. Moreover, the plantation is necessary as trees are considered the lungs of the environment. Thus, more trees shall be planted in order to absorb the excessive amount of carbon dioxide released into the atmosphere which will reduce the "enhanced greenhouse affect" and control the average global temperature. There is need for behavioral change and awareness among public regarding the climate change in the province of Khyber Pakhtunkhwa.

Study Limitations and Future Outlook

This study was carried out on analyzing the secondary data, particularly the literature. There is need to conduct a research and collect primary data which may include the glacial receding analysis, rate of deforestation in Khyber Pakhtunkhwa, variations in the productivity of crop, and most importantly the changes within the human physical and mental health due to climate change. It will provide the required relevant and up to the date data, the unavailability of which was a hindrance in this study. Further, this study did not give any idea about the future trends of climate change. Therefore, in the future, if a study is conducted which predicts the climate change trends in Khyber Pakhtunkhwa and the severity of the impacts then that will be noble research as it will

help the policy makers to design policies that could cope with the future adversities of climate change.

References

1. ADB. (2017). climate change profile of Pakistan.

2. Ahmad, I., Tang, D., Wang, T., Wang, M., & Wagan, B. (2015). Precipitation Trends over Time Using Mann-Kendall and Spearman's rho Tests in Swat River Basin, Pakistan. *Advances in Meteorology, 2015*. doi:http://dx.doi.org/10.1155/2015/431860

3. Ali, S., & Iqbal, M. (2004). Total Factor Productivity Growth in Pakistan's Agriculture: 1960-1996. The Pakistan Development Review, 493-513.
4. and Values. Climate Change, 77(1), 45-72.
5. Barry, R. G., & Chorley, R. J. (2009). Atmosphere, weather and climate. Routledge.

6. Bouma, M. J., Dye, C., & Kaay, H. J. (1996, August). Falciparum Malaria and Climate Change in the Northwest Frontier Province of Pakistan. *The American Journal of Tropical Medicine and Hygiene, 55*(2), 131-137. doi:https://doi.org/10.4269/ajtmh.1996.55.131

7. Bradley, R. S. (2015). Climate and Climatic Variations. In R. S. Bradley, *Paleoclimatology* (pp. 13-54). Academic Press. doi:https://doi.org/10.1016/B978-0-12-386913-5.00002-8

8. Bukhari, S. S., & Bajwa, G. A. (2008). Temporal Temperature Rise and its Effects on other Climatic Factors in Peshawar-Pakistan. *Pakistan Journal of Forsetory, 1*(58), 1-18.

9. Change, C. (2017). Towards building a climate resilient nation. 2015–2018.
10. Cline, W. R. (1991). Scientific basis for the greenhouse effect. The Economic Journal, 101(407), 904-919.
11. Cruz, R. V., Harasawa, H., Lal, M., Wu, S., Anokhin, Y., Punsalmaa, B., ... & Huu Ninh, N. (2007). Impacts, Adaptation and Vulnerability. Contribution of Working Group II to

the. Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 469-506.

12. El-Fadel, M., & Massoud, M. (2001). Methane emissions from wastewater management. Environmental pollution, 114(2), 177-185.
13. Ellison, D., Morris, C. E., Locatelli, B., Sheil, D., Cohen, J., Murdiyarso, D., ... & Sullivan, C. A. (2017). Trees, forests and water: Cool insights for a hot world. Global Environmental Change, 43, 51-61.
14. Fahad S, Wang J (2018) Farmers' risk perception, vulnerability, and adaptation to climate change in rural Pakistance. Land Use Policy 79: 301–309
15. Farooqi, A. B., Khan, A. H., & Mir, H. (2005). Climate change perspective in Pakistan. Pakistan Journal of Meteorology, 2(3).
16. Farooqi, A. B., Khan, A. H., & Mir, H. (2005, March). CLIMATE CHANGE PERSPECTIVE IN PAKISTAN. *Pakistan Journal of Meteorology, 2*(3), 11-21. Retrieved from http://pjm.pmd.gov.pk/index.php/pjm/article/view/112
17. Fischer, E. M., & Knutti, R. (2015). Anthropogenic contribution to global occurrence of heavy-precipitation and high-temperature extremes. Nature Climate Change, 5(6), 560-564.
18. Gardner, A. S., Moholdt, G., Cogley, J. G., Wouters, B., Arendt, A. A., Wahr, J., ... & Paul, F. (2013). A reconciled estimate of glacier contributions to sea level rise: 2003 to 2009. science, 340(6134), 852-857.
19. GOP. Pakistan economic survey 2017–2018. Economic advisor's wing, Finance division government of Pakistan, Islamabad.
20. Hussain, A., Agrawal, N. K., & Leikanger, I. (2016). Action for Adaptation: Bringing climate change science to policy makers-a synthesis report of a conference held in Islamabad on 23–25 July 2015. Food Security, 8(1), 285-289.
21. Hussain, M., Liu, G., Yousaf, B., Ahmed, R., Uzma, F., Ali, M. U., ... & Butt, A. R. (2018). Regional and sectoral assessment on climate-change in Pakistan: social norms and indigenous perceptions on climate-change adaptation and mitigation in relation to global context. Journal of Cleaner Production, 200, 791-808.

22. IFAD, U. (2013). Smallholders, food security and the environment. Rome: International Fund for Agricultural Development, 29.
23. Intergovernmental Panel on Climate Change (IPCC). Climate change 2001: The Scientific basis. Cambridge University Press, Cambridge, UK; 2001.
24. International Energy Agency. Emissions database. IEA/OECD, Paris, France; 2015.
25. IPCC-Pachauri, R. K., & Reisinger, A. (2007). Synthesis Report: Contribution of Working Group I, II, III to the Fourth Assessmnet Report of the Intergovernmnetal Panel on Climate Change. Geneva: IPCC.
26. Iqbal, M. J., & Qaumar, J. (2011). Measuring temperature variability of five major cities of Pakistan. *Arab Journal of Geoscience, 4*, 595-606. doi:10.1007/s12517-010-0224-0
27. Jones, P. D., New, M., Parker, D. E., Martin, S., & Rigor, I. G. (1999, May). Surface air temperature and its changes over the past 150 years. *Reviews of Geophysics, 37*(2), pp. 173-199. doi:10.1029/1999RG900002
28. Khattack, A. K. (1992). Development of a model forest management plan for the Panjul Forest in Western Himalaya (Pakistan). Forstliche Forschungsberichte München, (117).
29. Kweku, D. W., Bismark, O., Maxwell, A., Desmond, K. A., Danso, K. B., Oti-Mensah, E. A., ... & Adormaa, B. B. (2017). Greenhouse effect: Greenhouse gases and their impact on global warming. Journal of Scientific research and reports, 1-9.
30. Laghari, J. (2013). Climate change: melting glaciers bring energy uncertainty. Nature News, 502(7473), 617.
31. Le Treut, H., Somerville, R., Cubasch, U., Ding, Y., Mauritzen, C., Mokssit, A., ... & Prather, M. (2007). Historical Overview of Climate Change Science. Chapter 1. p.96
32. Leiserowitz, A. (2006). Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery,
33. Lin, B., & Ahmad, I. (2017). Analysis of energy related carbon dioxide emission and reduction potential in Pakistan.J Clean Prod, 143, 278–287. https://doi.org/10.1016/j.jclepro.2016.12.113.

34. Mao, K. B., Ma, Y., Tan, X. L., Shen, X. Y., Liu, G., Li, Z. L., . . . Xia, L. (2017). Global surface temperature change analysis based on MODIS data in recent twelve years. *Advace in Space Research, 59*(2), 503-512. doi:https://doi.org/10.1016/j.asr.2016.11.007

35. Minallah, S., & Steiner, A. L. (2021). Role of the atmospheric moisture budget in defining the precipitation seasonality of the Great Lakes region. Journal of Climate, 34(2), 643-657.
36. Ministry of climate change. (2016). Government of Pakistan barrier analysis and enabling framework for climate change mitigation technologies.
37. Mirza, M. M. Q. (2002). Global warming and changes in the probability of occurrence of floods in Bangladesh and implications. Global environmental change, 12(2), 127-138.
38. NEF, 2001. The End of Development? http://newseconomics.org/gen/uploads/e_o_d.pdf
39. Pan, L., Zhang, Q., Zhang, W., Sun, Y., Hu, P., & Tu, K. (2016). Detection of cold injury in peaches by hyperspectral reflectance imaging and artificial neural network. Food chemistry, 192, 134-141.
40. Paulson, C. A. (1970). The mathematical representation of wind speed and temperature profiles in the unstable atmospheric surface layer. Journal of Applied Meteorology and Climatology, 9(6), 857-861.
41. Rashid, N. (2008). Climate changes in Peshawar and Abbotabad; issues, sources and recommendations. BES thesis report. Department of Environmental Sciences, University of Peshawar. 34, 37, 57
42. Roohi, R. (2004). Farm Mechanism Options under Climate Change Scenario in Pakistan. Islamabad: Natioanl Agricultural Research Centre.
43. Saeed, R., Iqbal, Z., Iqbal, M., Sattar, A., & Nadeem, R. (2010). Climate Change, River Flows and Their Imminent Impact on Pakistan's Economy. Scientific Papers. 191.

44. Sajjad, S. H., Hussain, B., Khan, M. A., Raza, A., Zaman, B., & Ahmed, I. (2009, October). On rising temperature trends of Karachi in Pakistan. *Climate Change, 96*(4), 539-547. doi: 10.1007/s10584-009-9598-y

45. Salma, S., Rehman, S., & Shah, M. A. (2012). Rainfall trends in different climate zones of Pakistan. Pakistan Journal of Meteorology, 9(17).

46. Salma, S., Rehman, S., & Shah, M. A. (2012). Rainfall Trends in Different Climate Zones of Pakistan. *Pakistan Journal of Meteorology*, *9*(17), 37-47.

47. Schlenker, W., & Roberts, M. J. (2006). Nonlinear effects of weather on corn yields. Review of agricultural economics, 28(3), 391-398.

48. Shah, S. A., Nisa, S., Khan, A., Rehman, Z. U., & Shah, S. M. (2012). TRENDS AND VARIABILITY IN CLIMATE PARAMETERS OF PESHAWAR DISTRICT. *Science Tech.*, *31*(4), 341-347.

49. Shah, S. M. A. (2008). Impacts of Climate Change on Minimum Temperature Trends in Pakistan (Doctoral dissertation, University of Liverpool).

50. Shah, S. M., Zeb, A., & Mahmood, S. (2010). The Rainfall Activity and Temperatures Distribution Over NWFP during the Pre- Monsoon Season (April to June) 2009. *Pakistan Journal of Meteorology*, *6*(12), 11-30.

51. Sheikh, M. M., Manzoor, N., Adnan, M., Ashraf, J., & Khan, A. M. (2009). *Climate profile and past climate changes in Pakistan.* . Islamabad: Global Climate Change Impact Studies Centre.

52. Siddique, K. M. (2001). Review of wood fuel production and marketing reports in Pakistan. In Wood fuel Production and Marketing in Pakistan National Workshop, Sindh, Pakistan; 20-21 October 1998.

53. Solanki, R. P. (2016). Effect of Climate Change on Mental Health. The International Journal of Indian Psychology, 3(4), 129-135.

54. Stefanski, R., & Sivakumar, M. V. K. (2011). Climate change and food security in South Asia. Climate Change and Food Security in South Asia. Dordrecht, the Netherlands: Springer, 14-30.

55. Stępniewska, Z., & Kuźniar, A. (2013). Endophytic microorganisms—promising applications in bioremediation of greenhouse gases. Applied microbiology and biotechnology, 97(22), 9589-9596.

56. Syeda, M. H., & Adnan, M. (2016). Rebuilding lives: Natural Disasters and Role of a Social Worker in Pakistan. Journal of the Research Society of Pakistan, 53(2).

57. TFCC, 2010. Climate Change in Pakistan. TFCC (Task Force for Climate Change [TFCC], 2010). Recommendations for various adaptation and mitigation measures.

58. Treydte, K. S., Schleser, G. H., Helle, G., Frank, D. C., Winiger, M., Haug, G. H., & Esper, J. (2006, April 27). The twentieth century was the wettest period in northern Pakistan over the past millennium. *Nature, 440*, pp. 1179-1182. doi:doi:10.1038/nature04743

59. UCAR. (2003). *Weather and Climate Basics*. Retrieved from University Corporation for Atmospheric Research: https://eo.ucar.edu/basics/wx_2_c.html

60. Yao, T., Thompson, L., Yang, W., Yu, W., Gao, Y., Guo, X., ... & Joswiak, D. (2012). Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings. Nature climate change, 2(9), 663-667.

61. Zhu, B. (2004). Climate change affecting crops. An article published in Chinese newspaper China Daily.