Paper No. 290

CLIMATE CHANGE AND ITS IMPACT WITH SPECIAL FOCUS IN PAKISTAN

Zia Mustafa

CLIMATE CHANGE AND ITS IMPACT WITH SPECIAL FOCUS IN PAKISTAN

Zia Mustafa[1]

1. INTRODUCTION/BACKDROP OF PHENOMENON

Climate change is one of the most important global environmental challenges facing humanity, with implications for food production, natural ecosystems, fresh water supply, health, etc. The harmful impacts of climate change are already manifesting themselves around the world in the form of extreme weather events like storms, cyclones, floods, droughts that are mounting in frequency and intensity. According to the latest scientific assessment, the earth's climate system has demonstrably changed on both global and regional scales since the pre-industrial era. The Inter-Governmental Panel on Climate Change (IPCC) projects that the global mean temperature may increase between 1.4 to 5.8^{o}C before the present century ends. This unprecedented increase is expected to have severe impacts on the global hydrological system, ecosystems, sea level, crop production and related processes. The impact would be particularly severe in tropical areas, which mainly consists of developing countries, including Pakistan.

In Pakistan, climate change raises concerns with its tremendous social, environmental and economic impacts. Pakistan is frequently exposed to natural hazards like floods, droughts and cyclones. These hazards when combined with the vulnerabilities in the shape of poverty, exclusion and inappropriate political decisions and actions make people more susceptible to the impacts of hazards. The agriculture sector is most vulnerable to climate change and changes in cropping and productivity as a result of weather changes will affect the poor rural communities of the country. The dry land areas, including arid and semi-arid regions are most vulnerable to these changes, as these regions are already facing significant water shortages and high temperature. The biophysical relationships could also be altered due to seasonal changes in cultivating crops which will consequently lead to changing irrigation requirements, altering soil characteristics and increasing the risk of pests and diseases, thereby negatively affecting agriculture productivity. In the Pakistani context, this vulnerability is particularly high because of its large population and economic dependence on primary natural resources, being basically an agriculture economy.

[1] Senior Engineer, EPHE Division, NESPAK

2. GLOBAL PERSPECTIVE

Mounting awareness of climate change's inevitability has been coupled with the realization that the future of everyone is at stake, but not equally so. The poverty and resource scarcity of developing countries puts them at a greater risk of victimization than the more advanced nations that have a stronger capacity to adapt. Reports coming forth demonstrate an already evident disparity in impacts on different regions, with the heaviest burden falling on populations of developing countries.

Climate change is an especially critical concern in the South Asian Region, where climatic variability has a significant impact on human societies and economies. Countries in the region are geographically and ecologically diverse with large populations living along coastal lines and river deltas which are at immediate risk of backwater flooding and sea level rise from climate change. Likewise, the heavy livelihood dependence on agriculture puts many communities at higher risk. The evidence of predicted impacts of climate change is slowly unfolding. Crop yields are declining in most countries in the region, partially as a consequence of rising temperatures, while increases in frequency of climate-induced diseases have also been recorded. There is also evidence of accelerating recession of the Himalayan glaciers, rainfall variability and changes in marine ecosystems. The most serious threat arising from climate change in Asia is to freshwater availability which is projected to decline especially in large river basins and will adversely affect more than a billion people by the year 2050. Table-1 shows summary of climate risks for South Asian Countries.

Table-1: Summary of Climate Risks by South Asian Countries

	Afghanistan	**Bangladesh**	**Bhutan**	**India**	**Nepal**	**Pakistan**	**Maldives**	**Sri Lanka**
Sea Level Rise	-	High	-	Modest	-	Modest	High	High
Glacier Retreat	High	High	High	High	High	High	-	-
Temperature Increase	-	High	High	High	High	High	Modest	High
Floods more Frequent		-	Likely	High	High	Likely	High	
Drought more Frequent	Likely	High some areas		High		Likely	-	

The above table indicates that Pakistan is faced with high climate risks as compared to other South Asian Countries.

It is obvious that the inter-relation between poverty and climate change vulnerability spells apprehensions for the poverty reduction and development targets of the world. Already facing impediments to progress in the shape of poor governance, violence and resource scarcity, the developing world is poised to suffer even greater set-backs with growing incidences of natural disasters and resource shortages.

This knowledge does not bode well for Pakistan which unfortunately falls in the group of countries, highly exposed to negative consequences of climate change. Among the damages already evident in the country is the growing frequency of droughts and flooding, increasingly, erratic weather behavior, changes in agricultural patterns, reduction in freshwater supply and the loss of biodiversity. Moreover, the earthquake and flooding calamities suffered by Pakistan in the recent past have further eroded the coping capacity, of people and institutions, making them more vulnerable to future negative impacts of climate change.

3. PAKISTAN PERSPECTIVE

Pakistan is the second largest country in South Asia and mainly comprises dry or cold areas with low production potential. Geography varies across the country, shaping the great variation in the country's climate. Climate ranges from mild winters and hot, dry summers in the north to semi-arid and arid zones in the west and the south. The country is bounded by the Himalayas in the north, the mountain ranges of Sulaiman in the east, and the low land plains of the River Indus in the south, west, and coastal areas. Sixty percent (60%) of the total watershed area of the Indus basin lies within Pakistan's territory.

Climate change exposes these areas to risks of glacial retreat, sea level rise, temperature increase, more frequent floods and droughts. As more than half of its land area is arid and semi-arid, expected changes in temperature and rainfall patterns in the future could impinge upon its food security and the welfare of millions of its people. The preliminary studies carried out indicate that Pakistan's 22.8 percent area and 49.6 percent population is at risk due to the impact of climate change.

Pakistan is more susceptible to the effects of changing climate because of its agrarian base and high dependency on natural resources for livelihoods. As agriculture is the lifeline of our economy, the influence of changing temperatures is expected to be most lethal in this sector. Pakistan's Food Security has been put at risk and a reduction in annual crop yields brought on by various factors including increased water logging, desertification of land, growing frequency of pest attacks and disasters has been observed. According to projections, with just a 1°C rise in temperature, wheat yield in Pakistan is estimated to decline by 6-9% and an even lesser rise in temperature will severely impact cash crops like mango and cotton.

The effect on agriculture is linked with the impact of climate change on water availability as Pakistan relies on irrigation for more than 90% of its agricultural production. Considering that only 40% of water diverted from rivers actually reaches the crop, affecting irrigation efficiency as a result of water shortage. Projections for future water availability scenario are mixed; on one hand reports by the Intergovernmental Panel on Climate Change (IPCC) suggest that Pakistan will receive higher levels of rainfall with the increasing temperatures, meaning that we will get more water. However, storms and floods resulting from the increase in precipitation coupled with the irregularity of water distribution will most probably offset the benefits of receiving more rainfall.

Pakistan receives around 80% of water in the Indus Basin System from the melting of glaciers and snow melting. The system is in dynamic equilibrium with the annual availability of water in the Indus River system. The rise in temperature would, thus, interact with the availability of flows. More water is likely to be available in the earlier periods and less in the later stage in view of reduction in volume of glaciers and less snowfall. This is likely to dispel disasters in the long-term availability of water in the Indus Basin System.

Pakistan economy is dependent on agriculture in more ways than one and is posed to suffer risk greater than the ones already mentioned. The dependency of our industrial sector on agricultural raw material indicates that climate change is set to sabotage the supply chain of industry as well. Consequently, damage to livelihoods will not remain confined to the agricultural sector alone but will also spillover to the industrial markets.

It is pertinent to mention here the risk to National Energy Security, as energy is both a cause and casualty of climate change. It is a casualty in Pakistan's case because the shortage of water and variation in river flows affects our potential to generate hydropower. It is also likely that global energy costs will increasingly begin to reflect the true environmental cost of production and consumption and become prohibitively expensive for populations of developing countries. Historical data demonstrates a positive correlation between per capita energy consumption and the development level of nations; hence the decrease in this consumption level will cause further setback to development in the region.

Moving from economic issues to issues of a more social nature, a significant vulnerability factor for Pakistan is the threat of climate change to our human settlements in Coastal Areas. Rising sea levels coupled with the increasing precipitation in some regions threaten to wreak havoc on many coastal towns and cities and can even possibly submerge them underwater. In 2007, the tropical cyclone Yemyin killed 529 people and caused damages to

2.5 million people in Sindh and Balochistan. With storm surges expected to increase and intensify and sea levels projected to rise, the populations in Karachi and other coastal belts are at great risk of displacement and destitution. This also means greater pressure on disaster relief agencies to reach out to growing number of disaster victims and could very well be facing population displacement crisis if the worst case scenario takes place in our coastal areas.

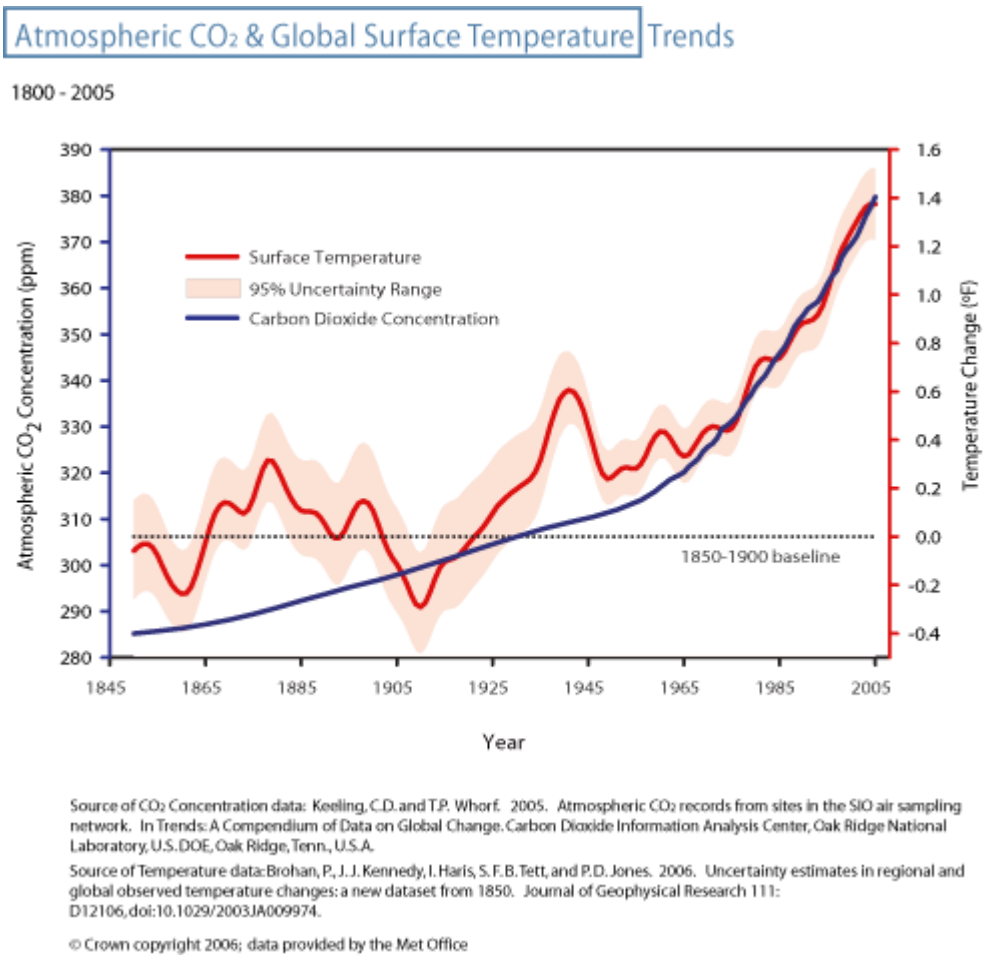
All things considered, the impact of climate change on human health is obvious. In the face of calamities and natural resource shortages, human health is bound to suffer. Additionally, many diseases such as malaria, dengue and cholera are known to be sensitive to climatic factors. Warmer weather creates a more favorable environment for mosquitoes and other disease carrying pest and, therefore, increases the likelihood of disease break-outs among the masses.

Pakistan has been paying attention to tackle climate change concerns and was one of the first signatories to the United Nations Framework Convention on Climate Change (UNFCCC), ratifying it in 1994.

4. FACTORS CONTRIBUTING TO CLIMATE CHANGE – GHG EMISSIONS

The radiative energy by greenhouse gases is the primary cause of climate change. Greenhouse gases are also important in understanding the Earth's climate history. These gases trap heat and play a key role in regulating Earth's temperature. Changes in the greenhouse gases and aerosols, in solar radiation and in land surface proportions have altered the energy balance of the climatic system. During the pre-industrial era, the concentrations of these gases were almost constant. Since the industrial revolution, global atmospheric concentrations of these gases have increased significantly.

Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1850 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are as a result of agriculture. Figure 1 shows trend in atmospheric CO_2 and global surface temperature from pre-industrial period to the year 2005.



Source of CO_2 Concentration data: Keeling, C.D. and T.P. Whorf. 2005. Atmospheric CO_2 records from sites in the SIO air sampling network. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. DOE, Oak Ridge, Tenn., U.S.A.

Source of Temperature data: Brohan, P., J. J. Kennedy, I. Haris, S. F. B. Tett, and P. D. Jones. 2006. Uncertainty estimates in regional and global observed temperature changes: a new dataset from 1850. Journal of Geophysical Research 111: D12106, doi:10.1029/2003JA009974.

Figure 1: Trend in atmospheric CO_2 and Global Surface Temperature from Pre-Industrial Period to the Year 2005

Carbon dioxide is the most important anthropogenic greenhouse gas. The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005. The primary source of the increased atmospheric concentration of carbon dioxide since the pre-industrial period results from fossil fuel use, with land use change providing another significant but smaller contribution. Annual fossil carbon dioxide emissions increased from an average of 23.5 Gigatons CO_2 per year in the 1990s to 26.4 $GtCO_2$ in 2005. Carbon dioxide emissions associated with land-use change are estimated to be 5.9 $GtCO_2$ per year over the 1990s.

The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb to 1,732 ppb in the early 1990s, and was 1774 ppb in 2005. It is very likely that the observed increase in methane concentration is due to anthropogenic activities, predominantly agriculture and fossil fuel use, but relative contributions from different source types are not well determined.

The global atmospheric nitrous oxide concentration increased from a pre-industrial value of about 270 ppb to 319 ppb in 2005. The growth rate has been

approximately constant since 1980. More than one third of all nitrous oxide emissions are anthropogenic and are primarily due to agriculture.

5. CONTRIBUTION OF INDUSTRIALIZED AND DEVELOPING COUNTRIES

Historically, the industrialized countries have been the primary contributors to emissions of carbon dioxide (CO_2). In the year 2004, the United States emitted over seven billion metric tons of greenhouse gases (CO_2E). Carbon dioxide accounted for the largest percentage of greenhouse gases (83%), followed by methane (9%), nitrous oxide (5%) and the high global warming potential gases (2%). Figure 2 shows United State's greenhouse gas emissions.

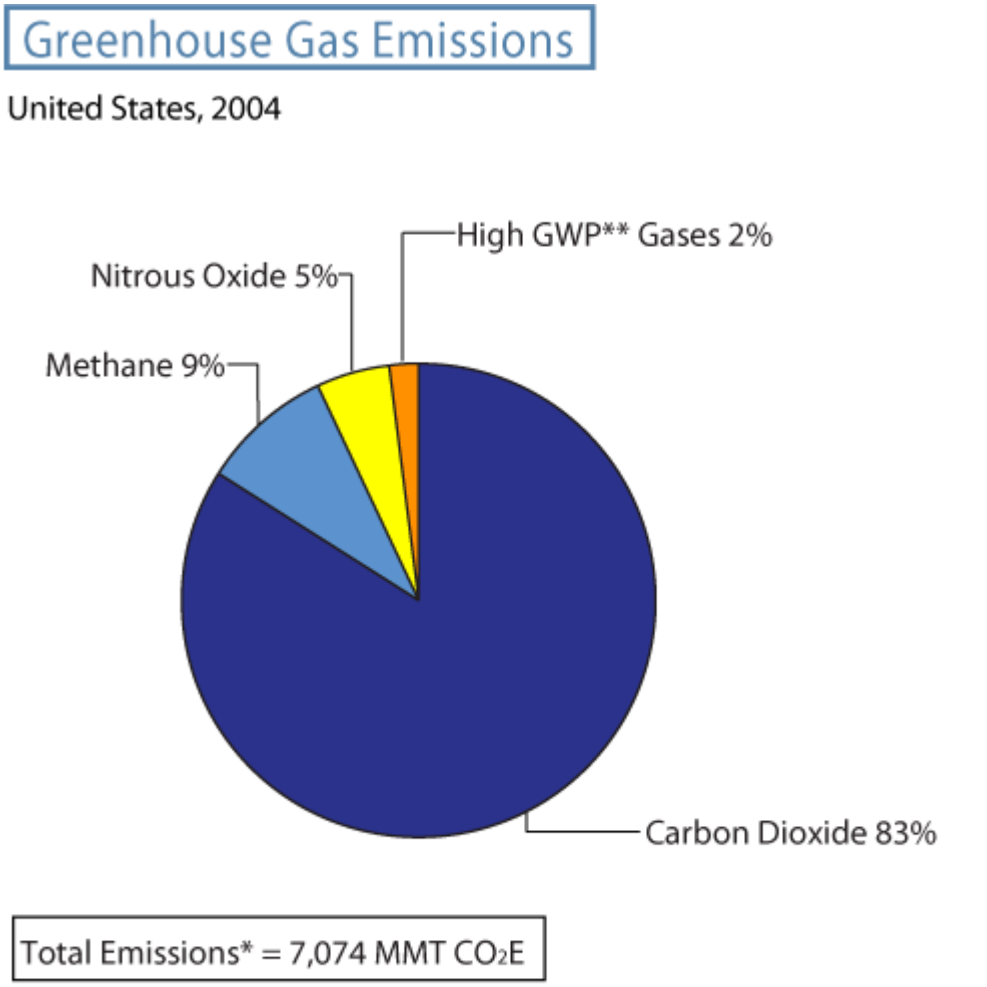


Figure 2: United State's Greenhouse Gas Emissions

US greenhouse gases are emitted by all sectors of economy, including industry (30% of total), transportation (28%), commercial (17%), residential (17%) and agriculture (17%) Figure 3 shows US contribution of different sectors to GHG emission.

China is the world's second largest greenhouse gas emitter after the United States and its emissions are linked rapidly with strong economic growth and rising energy demand. Emissions have grown by about 80% since 1990, driven heavily by increased consumption of electricity generated from coal. Coal accounts for about 80% of China's energy consumption, with demand exceeding 2 billion tons a year. China has significantly reduced its emission intensity (emissions per unit of GDP), largely through aggressive energy efficiency policies. Greenhouse gas intensity has fallen significantly in China over the past few decades, though it remains among the highest in the world. Per capita emissions are below the world average and about one fifth those of the United States.

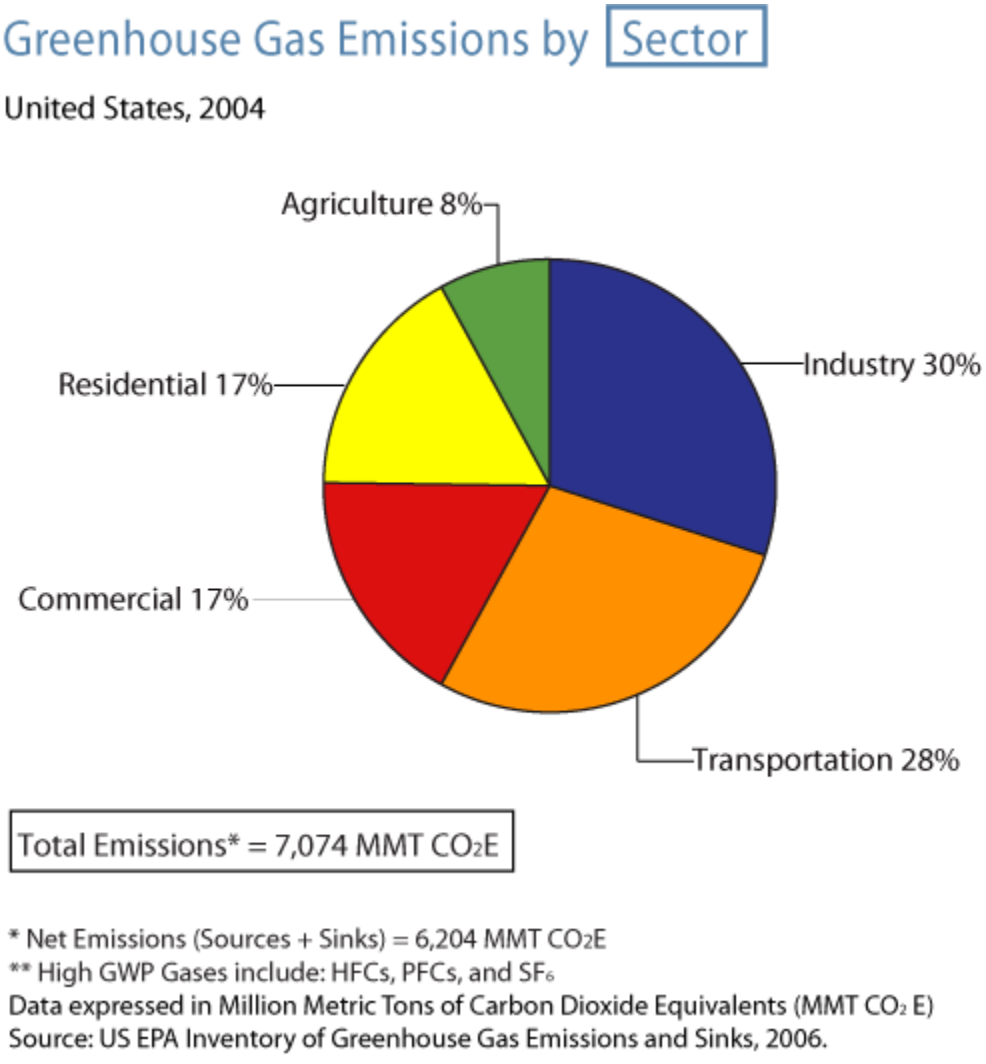


Figure 3: United States Contribution of Different Sectors to GHG Emissions

China's emissions are projected to continue rising rapidly another 65% to 80% by 2020 and annual emissions may surpass those of the United States as early as 2012. (In cumulative terms, however, China's contribution to global emissions is about one-fourth of the United States).

India is the world's fourth largest economy and fifth largest greenhouse gas (GHG) emitter, accounting for about 5% of global emissions. India's emissions have increased 65% between 1990 and 2005 and are projected to grow another 70% by 2020. On a per capita basis, India's emissions are 70% below the world average and 93% below those of the United States.

India's GHG intensity is currently 20% lower than the world average and15% and 40% lower than the United States and China's respectively.

Pakistan having 2.4% of World's Population accounts for 0.4% of global emissions-an average of 0.8 tonnes of CO_2 per person. These emission levels are below those of South Asia. Table 2 shows comparison of carbon dioxide emissions of different countries of the world.

Table 2: Carbon Dioxide Emissions

Country	Total Emissions ($MMTCO_2$ 2004)	CO_2 Emissions Share of World Total 2004	CO_2 Emissions per Capita (tCO_2) 2004
United States	7,074	20.9	20.6
China	5,007	17.3	3.8
Russian Federation	1,524	5.3	10.6
India	1,342	4.6	1.2
Iran	433	1.5	6.4
Pakistan	125	0.4	0.8
Nepal	3.0	0	0.1
Maldives	0.7	0	2.5
Bhutan	0.4	0	0.2

Source: Human Development Report 2007 Country Fact Sheets – Pakistan

6. IMPACTS OF CLIMATE CHANGE IN PAKISTAN

Pakistan like other developing countries remains extremely vulnerable to the impacts of climate change. The low GHG emission status of the country provides no safety from the adverse effects of global climate change. Pakistan being an agricultural based economy, lying in arid & semi-arid region, with heavy dependence on irrigated agriculture is highly vulnerable to climate change. Pakistan is facing the adverse impacts of climate change with higher glacial melt, prolonged droughts, hot winter & early summers which are negatively affecting

water resources & overall agricultural productivity. The carbon sinks are degrading fast as the country has low forest cover (4.5%) with a high rate of deforestation of about 0.2-0.4% per annum. Long term impacts of climate change are expected to threaten our biodiversity (loss of species and their habitats), water availability, food security, human health and overall well being. The major impacts of climate change in Pakistan are given as under:

a) Ecological Fragility

The climatic and agro-agriculture zones in Pakistan are as sensitive as they are diverse and some are already under threat of extinction as a consequence of climate change. At particular risk from the ecological non-equilibrium are population in marginal zones, coastal, mountain and arid areas. Communities dwelling in fragile mountainous ecosystems in the active monsoon belt are at risk of increasing incidences of sheet erosion and landslides, resulting in the destruction of uplands, farms and forests. These settlements are also at danger of more frequent flooding from the accelerating rate of glacial melts and depleting capacity of water reservoirs.

Those living in coastal zones are even more vulnerable. Swelling sea levels on the 1,130 km coastline coupled with rising sea surface temperatures could potentially wreak havoc on many coastal towns and cities. Coastal Karachi, Pakistan's largest urban center, is increasingly subjected to floods and storms, resulting in the deaths of hundreds of people. In 2007, the tropical cyclone Yemyin ravaged Sindh and Balochistan, impacting the homes, crops and livelihoods of over a million people.

The survival of important coastal ecosystems like mangrove swamps is also under threat with the intrusion of saline water and rising temperature. The loss of mangroves not only weakens the protection from floods but also destroys the habitat of various species residing within the swamps, some of which are sources of livelihood for poor communities engaged in sustainable fishing.

Rapid climate change effects can also include a possible displacement of communities placed in the threatened ecological zones. Such effects would place greater pressure on disaster relief agencies to reach out to growing numbers of disaster victims and could very well suffer Pakistan with an internal crisis of uprooted millions.

b) Agriculture Impact

The multi-functionality of agriculture is a recognised feature of Pakistan's socio-economic system. Agriculture not only ensures national food security but also employs about half the workforce and contributes 22% to the GDP. The supply chain of a significant industrial segment engaged in processing raw material comes from agriculture as well.

Climate change enhances the susceptibility of agricultural zones to episodic natural catastrophes such as storms, floods and droughts, in turn exposing country to the threat of socio-economic losses. According to IPCC projections, agricultural

productivity in Asia is bound to decline substantially with thermal stress and increasing occurrence of droughts and floods. Recent data recorded indicates a 30% decline in major crop yields due to water logging, salinity and floods. The growing prevalence of pests as a consequence of warmer climate and increased precipitation has also been observed as contributing to crop decline.

It has been observed that sensitivity of cereal and tree crop are affected by changes in temperature and moisture. With just a $1^{o}C$ rise in temperature, wheat yield in Pakistan is estimated to decline by 6-9% and an even lesser increase is expected to severely impact cash crops like mango and cotton.

c) Water Scarcity

According to the Water and Power Development Agency (WAPDA), per capita surface water availability plunged from $5260m^3$ per year in 1951 to just 1000 m^3 in 2008 and is expected to decrease further with the dual impacts of rising temperatures and increasing demand. Confirming the forecasts, the IPCC also predicts continued decline in freshwater availability, particularly in large basins like the Indus, the flow of which constitutes the main source of surface water in Pakistan.

A significant cause of the projected decline is the rapid recession of the Himalayan glaciers and reduction in snow-fed rivers as a result of climbing temperatures and precipitation variability. In the short run, the accelerated glacial melt is expected to increase water flows in river systems and cause greater incidences of flooding from glacial lakes. But as the glaciers recede so does the river water, leading to severe water shortages in the long run.

A decrease in average river flows has serious implications for agricultural production in the country, as 93% of fresh water is used for irrigated agriculture. A critical irrigation supply scenario is expected to emerge in Pakistan by the year 2012-2013, contributing to a projected 12 million tons deficit in grain production. Accessibility of water from alternative sources is on the decline as well with Pakistan having reached the limit of groundwater extraction.

This situation is likely to significantly enhance the risk to national energy security, because the decline and variations in average river flow affects the potential for hydropower generation in the country; the primary source of energy. It is also likely that global energy costs will increasingly begin to reflect, the true environmental cost of production and consumption, becoming prohibitively expensive for population of developing countries such as Pakistan. Historical data demonstrates a positive correlation between per capita energy consumption and the development level of nations; hence the decrease in this consumption level will further impede development progress in the region.

d) Impact on Health

In view of the forecasts for future food security, water quality, increasing heat stress and growing frequency of natural disasters, the direct implications of Climate Change for human health are daunting. Furthermore, vector borne

diseases such as malaria, dengue, typhoid and cholera that are already a significant cause of mortality and morbidity in Pakistan are climate sensitive and known to thrive in warmer regions. An increase in epidemic potential of 12-27 percent for malaria and 31-47 percent for dengue is anticipated as a consequence of climate change scenarios.

The cost of health in Pakistan, which already exceeds a billion dollars, will keep escalating with the projected climatic changes, and further impact poverty reduction and health improvement targets of the country. Moreover, increasing prevalence of diseases in the region has consequences for food security as well: an increasing prevalence of certain types of diseases and ailments among livestock has been observed in the country as an effect of rising temperatures.

7. RECENT FLOODS IN PAKISTAN (AUGUST 2010)

The devastation caused by the recent floods (August 2010) owing to the collapse of pocket of monsoon rains in Wazirastan and Northern Areas as a result of climate change in Pakistan is enormous and of catastrophic proportions. The data collected by National Disaster Management Authority (NDMA) indicates that one fifth of country is bracing itself with the erosion of basic public and private infrastructure. Hundreds of kilometers of roads, railway lines, tubewells, crops, electricity transmitters, bridges, cattle, houses and schools have been damaged apart from 1,754 persons dead and 20 million displaced. Around 400 children are missing while nearly eight hundred thousand people remain stranded in flood waters. The summary of damages due to recent flood in Pakistan is presented in the following table.

Table-3: Summary of Damages due to Recent Floods in Pakistan

Summary of Damages	Balochistan	KPS	Punjab	Sindh	AJ&K	GB	G. Total
Deaths	48	1,156	110	186	71	183	1,754
Injured	98	1,193	350	909	87	60,	2,697
House Damaged	75,261	200,799	500,000	1,058,862	7,108	2,820	1,844,850

The economic cost of the disasters is enormous. For an economy that relies heavily on agriculture productivity and employees two third of the country's population in the farming sector, the massive floods destroyed not only major crops of the season but also large portions of arable land and the capacity of numerous farmers to cultivate crops in the upcoming season. With major food crops damaged or destroyed over 3.2 million, hectares (7.9 million areas) of cultivated land. About 14 percent of Pakistan's total cultivated area has been devastated by the recent floods. It is anticipated that more than 8 billion rupees will be required for the rehabilitation of flood affected people and reconstruction of destroyed or damaged social and physical infrastructure.

8. INTERNATIONAL PROTOCOLS AND CONVENTIONS ON CLIMATE CHANGE

During the 1990s, world started to realize the reality of GHG emissions and its possible impact on climate change. In 1990, IPCC in its first report concluded that the temperature of earth's climate had risen by 0.5°C in the past century, and attributed this to anthropogenic activities in terms of GHG emissions. This assessment report triggered an international debate for the establishment of United Nations Framework Convention on the Climate Change (UNFCCC). In 1992, the second Earth Summit was held at Rio de Janeiro and the UNFCCC was signed by 154 nations with an agreement on an initial target of stabilization of GHG emissions from industrialized countries to 1990 levels by the year 2000. The ultimate objective of the convention was to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. Following are the number of conventions and protocols on climate change.

COP-1 (Conference of Parties), The Berlin Mandate (1995)

COP-2 (Conference of Parties), Geneva, Switzerland (1996)

COP-3 (Conference of Parties), The Kyoto Protocol on Climate Change (1997)

COP-4 (Conference of Parties), Buenos Aires (1998)

COP-5 (Conference of Parties), Bonn, Germany (1999)

COP-6 (Conference of Parties), The Hauge, Netherland (2000)

COP-6 (Conference of Parties), "Bis", Bonn, Germany (2001)

COP-7 (Conference of Parties), Marrakech, Morocco (2001)

COP-8 (Conference of Parties), New Delhi, India (2002)

COP-9 (Conference of Parties), Milan, Italy (2003)

COP-10 (Conference of Parties), Buenos Aires, Argentina (2004)

COP-11 (Conference of Parties), Montreal, Canada (2005)

COP-12 (Conference of Parties), Nairobi, Kenya (2006)

COP-13 (Conference of Parties), Bali, Indonesia (2007)

COP-14 (Conference of Parties), Poznan (2008)

COP-15 (Conference of Parties), Copenhagen, Denmark (2009)

Kyoto Protocol is the major protocol specifically focusing on climate change and reduction of GHG emissions. The description of Kyoto Protocol is given as under:

8.1 Kyoto Protocol (1997)

Kyoto Protocol is the world's primary international agreement on combating global warming. The Kyoto Protocol of the United Nations Framework Convention on Climate Change was adopted by COP-3 in December 1997 in Kyoto, Japan. As per Agreement, industrialized countries will reduce their greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, hydro fluoro carbons and perfluoro carbons) of an average of 6 to 8% below 1990 levels between the years 2008-2012, defined as the first emissions budget period.

National limitations range from 8% reductions for the European Union (EU) and some others to 7% for the United States, 6% Japan, 0% for Russia and permitted increase of 8% for Australia and 10% for Iceland.

The Kyoto Protocol also introduced an international emissions trading regime-the Clean Development Mechanism (CDM) to allow developed countries to work in co-operative projects with developing countries to reduce GHG. It also implemented emission reduction based projects and engaged developing countries in emission reduction activities.

8.1.1 Copenhagen Climate Change Conference 7-19 Dec., 2009

The United Nations Climate Change Conference in Copenhagen, Denmark took place from 7-19 Dec., 2009. It included the fifteenth Conference of Parties (COP-15) to the United Nations Framework Convention on Climate Change (UNFCCC) and the fifth Conference of Parties serving as the Meeting of Parties to the Kyoto Protocol (MOP5). A framework for international climate change mitigation as a successors to the Kyoto Protocol after 2012 was to be agreed upon there. An accord was drafted and agreed by leading countries including United States, China, India, South Africa and Brazil. The salient features of the accord are given as under:

- Endorses the continuation of the Kyoto Protocol
- Underlines that climate change is one of the greatest challenges of our time and emphasizes a "strong political will be required to combat climate change in accordance with the principle of common but differentiated responsibilities and respective capabilities"
- About mitigation agrees that developed countries would "commit to economy-wide emissions targets for 2020" to be submitted by 31 January 2010 and agrees that these Parties to the Kyoto Protocol would strengthen their existing targets. Delivery of reductions and finance by developed countries will be measured, reported and verified in accordance with COP guidelines.
- Agrees that developing nations would "implement mitigation actions" (Nationally Appropriate Mitigation Actions) to slow growth in their carbon emissions, submitting theses by 31 January 2010.
- Recognizes "the crucial role of reducing emissions from deforestation and forest degradation and the need to enhance removals of greenhouse gas

emissions by forests", and the need to establish a mechanism (including REDD[1]-plus) to enable the mobilization of financial resources from developed countries to help achieve this.

- Agrees that developed countries would raise funds of $ 30 billion from 2010-2012 of new and additional resources.
- Agrees a "goal" for the world to raise $ 100 billion per year by 2020, from "a wide variety of sources", to help developing countries cut carbon emissions (mitigation). New multilateral funding for adaptation will be delivered, with a governance structure.

The emissions reduction as per the Copenhagen Accord are discussed as under:

a) Emissions Pledges

To date, countries representing over 80% of global emissions have engaged with the Copenhagen Accord.

31 January 2010 was an initial deadline set under the Accord for countries to submit emissions reductions targets. Countries continue to submit pledges past this deadline.

- The Australian Government committed to reduce emissions by 5 to 25% by 2020.
- Brazil: 36.1 to 38.9%
- Canada: 17%
- China: 40 to 45%
- India: 20 to 25%
- Indonesia: 26%
- Israel: 20%
- Japan: 25%
- Mexico: 30%
- Russian Federation: 15 to 25%
- South Africa: 34%
- South Korea: 30%
- United States: 17%

[1] REDD: Reducing emissions from Deforestation and Forest Degradation.

9. GLOBAL ACTORS RESPONSIBLE FOR CLIMATE CHANGE

The United States although a signatory to the Kyoto Protocol has neither ratified nor withdrawn from the Protocol, despite historically being the world's largest emitter of greenhouse gases. The signature alone is symbolic, as the Kyoto Protocol is non binding on the United States unless ratified. The United States is the largest per capita emitter of carbon dioxide from the burning of fossil fuels. China and India, though exempt from protocol provisions as developing countries, have ratified the Kyoto Protocol.

United States contends that the Kyoto Protocol is an unfair and ineffective means of addressing global climate change concerns, claiming it that it exempts 80 percent of the world, including major population centers such as China and India from compliance and would cause serious harm to the US economy. US has instead promoted improved energy technology as a means to combat climate change.

Currently, China is still far lower than the US in terms of its emissions per person. It is China that has committed itself to get 10 percent of its energy needs through renewable sources by 2010. China is already the world's fifth biggest user of wind turbines and of solar panels to heat water.

On the other hand, India is contributing around 4% of GHG emissions. India is also developing a national plan to address the problem of global warming. It has been assessed that India along with China will account for most of emissions in the coming decades, owing to their rapid industrialization and economic growth.

10. STRATEGIES / RECOMMENDATIONS

The major strategies to combat the challenge of climate change are as under:

- Global Adaptation under the United Nations Framework Convention on Climate Change is required i.e. strengthening mechanisms and support for proactive adaptation under the convention by facilitating comprehensive national strategies and committing reliable funding for high priority implementation projects.
- Implement national energy polices and industrial policies which would contribute climate mitigation by reducing or avoiding GHG emissions.
- Limiting global GHG emissions to keep the impacts of climate change will require deployment of currently available and future low carbon technologies across a range of sectors on a global scale, alongwith other changes in economic activities. It should be noted that while energy is the main source of GHG emissions globally and in developed countries land use change, forestry and agriculture currently account for almost 50% of GHG emissions in developing countries pointing to additional opportunities in these sectors in the immediate future.
- Reducing reliance on fossil fuels for energy is the essential factor for controlling climate change. Shifting from fossil fuels to renewable energy

resources such as solar energy and hydropower, that do not emit CO_2 will help stem climate change.

- Integrate climate polices into Sustainable Development Policies.
- Halting deforestation would reduce carbon dioxide emissions and help preserve biodiversity. To reduce carbon dioxide concentration in the atmosphere, extensive tree plantation should be undertaken.
- Since all greenhouse gases are produced through human activities, therefore, population planning should be considered as a long term solution to the global warming problem.
- Expedite the constitution and amendment of laws and regulations that are favourable to GHG mitigation.
- Promote scientific research and technological development in key areas of climate change.