CHAPTER 7

COMBATING CLIMATE CHANGE

Combating Climate Change

7.1 Introduction

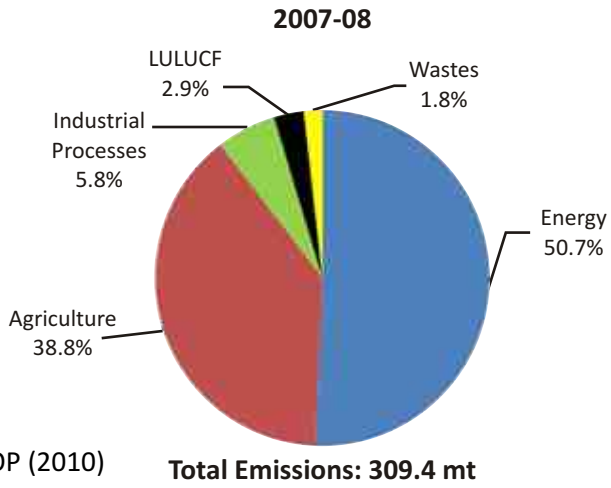
Pakistan is a major victim of global climate change although it contributes very little to the global greenhouse gas emissions. This chapter after briefly discussing the country's contribution to Green House Gases highlights the vulnerabilities and threats from and the likely impacts of climate change in Pakistan. This is followed by an analysis of response measures to climate change with special focus on mitigation and adaptation strategies. The concluding section of the chapter sums up the findings.

7.2 Pakistan's GHG Emission Status

Pakistan's per capita emissions of greenhouse gases (GHG) fall far below the global average; with 1.9 tons of per capita GHG emissions, it stands at a level which corresponds to about one-third of the world average, one-fifth of the average for Western Europe and one tenth of the US per capita emissions. It is ranked 135th among the countries of the world on the basis of per capita GHG emissions (GOP 2010). Pakistan's total GHG emissions in 2008 amounted to 309 million tons of Carbon Dioxide Equivalent, comprising about 54 percent CO_2, 36 percent Methane, 9 percent Nitrous Oxide and 1 percent other gases. The biggest contributor is the energy sector with a 50 percent share, followed by a 39 percent share from the agriculture sector. Industrial processes contribute about 6 percent and other activities account for another 5 percent share (Fig. 7.1).

However, the low carbon emission status of the country provides no safety from adverse impacts of climate change (Box 7.1).

Fig. 7.1 Pakistan: Sectoral Contribution to GHG Emissions



Source: GOP (2010)

Box 7.1 Challenge of Climate Change to Pakistan

Pakistan is highly vulnerable to the adverse impacts of climate change. Maplecroft's (2011) Index of vulnerability to climate change ranks Pakistan 16th among 170 nations of the world. The country has moved up in the vulnerability index since 2010, when it was rated 29th. The 2012 Global Climate Risk Index of Germanwatch ranks Pakistan as eighth among over 180 nations of the world while it ranked Pakistan first in 2010. This is rather ironical for a county that contributes very little to the global greenhouse gases (GHGs) ranking 135th in the world in per capita GHG emissions.

The adverse effects of climate change are already being felt in Pakistan. Two examples of these are the history's worst flood that hit the country in 2010 and the history's worst drought that it experienced in 1998-2001. The drought and flood events are likely to enhance in the wake of possible drastic shift in weather pattern in the wake of climate change.

Sources: Harmeling 2012; Maplecroft 2010, 2011

7.3 Vulnerability and Threats

Climate change is likely to affect many sectors and across ecosystems with particularly adverse impacts on natural resources and the livelihoods that these support. The vulnerabilities of Pakistan are due to its warm climate, preponderance of arid and semi-arid lands, and dependence of its rivers on the Hindukush-Karakoram-Himalayan glaciers which are reported to be receding due to global warming. The economy of the country is largely agrarian, hence highly climate sensitive, and increasingly at risks because of variability in monsoon rains, large floods and extended droughts. Because of all these factors the Water Security, the Food Security and the Energy Security of the country are under serious threat. Compounding these problems are the expected increased risks to the coastal areas (particularly to Karachi, Pakistan's largest city and the hub of its industrial activity and international trade) and the Indus deltaic region due to sea level rise and increasing cyclone activity; to the mountainous regions due to glacier lake outburst floods (GLOFs) and landslides; to the country's scanty forests (about 5 percent of the land area is under forest cover) due to forest fires as well as reduced regeneration under rapidly changing climate conditions; to human health due to heat strokes, diarrhoea, cholera and vector borne diseases; and to human settlements due to floods and cyclones (GOP, 2010). These and other key concerns have been discussed below under the economic, social and biophysical arenas.

7.3.1 Economic Impacts

Economically the detrimental impacts of climate change will be widespread and have bearing not only on water security, food security and energy security but also on diverse sectors including agriculture, livestock, forests, and fisheries. In view of widespread adverse impacts of climate change on various economic sectors, a major challenge for the national planners and policymakers is to translate these into monetary terms so as to have some idea on the total costs of these negative impacts on the national economy of the country. A serious concern is to estimate the cost that the country will incur on the coping mechanism, i.e. towards adaptation measures, in order to minimize the risks to the key sectors. Yet another economic concern is to make contributions to the global mitigation effort (GOP, 2010).

7.3.1.1 Water Security

Due to its impacts upon all economic sectors water security has crucial importance to the economy. Water demand in the future will increase in all sectors as a result of the need for economic development and population increase. However, the demand in the agriculture sector, the biggest user of water, will increase much faster to compensate for increased evapotranspiration rates due to elevated temperatures resulting from climate change. The two main sources of water, the Glaciers of Hindu Kush Karakoram Himalayas (HKH) and precipitation will also be affected due to melting glaciers (first increasing the water and then decreasing) and erratic rainfall. Therefore, in the wake of the limited scope for expanding the supplies of water, Pakistan will have to improve the efficiency of water use in all the sectors, particularly in agriculture as mentioned in chapter 4 on the aquatic ecosystem. On average about 128 billion cubic meter (BCM) of the river flows, in Pakistan is diverted to the canal system. The minimum outflow to the sea below Kotri is as low as one BCM (in 2000-01) and the maximum flow as high as 113 BCM in 1994-95 (GOP, 2005a). In the low-flow years, water going to the sea is less than that necessary to prevent intrusion of seawater into the Indus deltaic region (IPOE, 2005). With the rise in sea level caused by climate change, the minimum flow requirements will go up in future. At present on the average 43 BCM of water flows to the sea annually during flood season. There is a need to conserve every drop of this water to use it later in maintaining optimal ecological flow into the sea (GOP, 2007) and for combating the droughts.

Major Concerns in Water Security

The major climate change related threats to water security as identified by the Task Force on Climate Change (GOP 2010) are given below:

- Changes in river flows due to increase in the variability of monsoon and winter rains and loss of natural reservoirs in the form of glaciers;
- Increased demand of irrigation water because of higher evaporation rates at elevated temperatures in the wake of reduced per capita availability of water resources and enhanced overall water demand;
- Increase in sediment flow due to increased incidences of high intensity rains resulting in more rapid loss of reservoir capacity;
- Changes in the seasonal pattern of river flows due to early start of snow and glacier melting at elevated temperatures and the shrinkage of glacier volumes with serious implications for storage of irrigation water and its supply for cropping;
- The need for considerable expansion in reservoir capacity a) to address the increasing frequency and intensity of floods and droughts, b) to save the increased water flows over the next two to three decades due to glacier melting as well as to address the expected decreases of flows in the subsequent years after the glaciers have largely melted, c) to provide regulated minimum environmental flows to the sea to prevent excessive intrusion of sea water into the Indus deltaic region, d) to take care of the loss in existing reservoir capacity due to silting, and e) to meet future increases in water demand (even without specific consideration of the climate change related impacts, the Planning Commission envisages that without additional storage the water shortfall will increase by 12 percent over the present decade alone (GOP, 2007);
- Increased degradation of surface water quality due to increase in extreme weather events like floods and droughts; and
- Lack of current knowledge and monitoring efforts on climate change impacts in the HKH region; also lack of understanding and modelling capability on the patterns of glacier melt and rainfall feeding the Indus River System and the corresponding impact on its flows.

7.3.1.2 Food Security and Agriculture

The Agriculture and Livestock sector is the mainstay of the national economy. It contributes over 21 percent to Gross Domestic Product (GDP), accounts for 60 percent of the country's exports, and provides livelihood to about 63 percent of the country's population living in rural areas (GOP, 2010a). The critical challenge to the sector is to adequately provide for the food and fibre needs of a growing population without damaging the fragile ecosystems. Highly susceptible to vagaries of nature, the sector is extremely vulnerable to climate change. Climate change will affect the food security of the country mainly through reduced crop productivity and adverse impacts on livestock health, productivity and reproducibility as well as through increased production losses due to extreme weather events (floods, droughts and cyclones). Overall the country would face a decline in GDP from agriculture due to climate change. Considerable efforts are needed to combat climate-related impacts particularly in view of the time required for crop, livestock and fishery production systems to adapt. Success hinges upon factors relating to biology, ecology, technology and management regimes.

a. Crop Subsector

Reduction in production together with the loss resulting from floods and droughts are two very serious implications for crop subsector in Pakistan due to climate change (Box 7.2).

b. Livestock and Fisheries Subsectors

Livestock and poultry contribute 11 percent to the national GDP, half the value added by the agriculture sector. Like the crop, the livestock sector is highly vulnerable to the impacts of climate change, directly and indirectly. The direct impacts include physiological stresses on animals due to high temperature, lower productivity of milk and meat and reduced reproduction capacity at elevated temperatures, weather-related disease epidemics, and impacts on animal habitats and environment due to weather extreme events such as floods, droughts, heavy rainfalls, hailstorms, and cyclones. The indirect impacts include reduced productivity of fodder crops, decreased nutritional quality and palatability of forage plants due to increasing concentration of CO_2, which alters carbon and nitrogen ratios of plants (GOP, 2010), competition for land between the fodder crops and the staple food, cash and high value crops, increased water requirements (of both fodder crops and animals), and host-pathogen interactions. The vulnerability of the livestock sector to climate change is particularly high because it depends largely on grazing on rangelands, which has a very low adaptation capacity.

Climate change will also negatively affect the fisheries sub-sector through direct and indirect impacts. For example temperature changes will cause a shift in the range of fish species and their distribution. Moreover, warming will increase disease transmission and also influence marine pathogens. However, not much research has been conducted in Pakistan specifically with the view to assess climate change impacts on livestock and fisheries and evaluate alternative adaptation measures.

Major Concerns in Food Security and Agriculture:

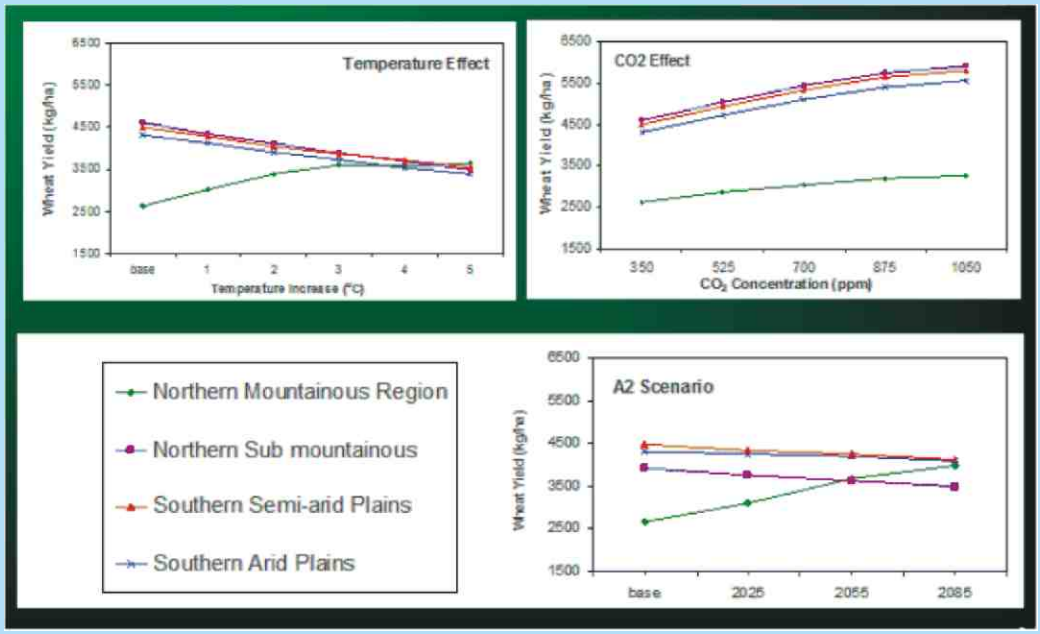
The major climate change related threats to food security of Pakistan (GOP, 2010) are identified as:

- Reduced productivity of crops and livestock due to heat stress and other adverse impacts of changes in climatic parameters;
- Increased requirements of irrigation water due to higher evapotranspiration rates at elevated temperatures;

Box 7.2 Impact of Climate Change on the Crop Sector in Pakistan

Simulations show that the national wheat production in Pakistan by 2080 under the influence of the climatic factors in the IPCC high and low scenarios A2 and B2 will be 6-8 percent lower than the potential production if the climate remained unchanged. Rice, the other major food crop is more sensitive to climate change. By 2080 the Basmati rice production in the country will suffer a reduction of 15-18 percent due to climate change anticipated under the A2 and B2 scenarios.

Change in Wheat Yields in Different Agro-Climatic Zones with Change in Temperature and CO_2 Concentrations for the A2 Scenario



These findings have very serious implications for the future food security in Pakistan. Expected increases in the frequency and intensity of precipitation events involving heavy rainfall within short periods will cause damage to crops and also result in loss of topsoil. The flood of 2010 mirrors this, which resulted in agricultural and livestock losses of over US$ 5 billion. More than 2.1 million ha of farmland was damaged destroying rice, cotton and sugar cane crops. It also had devastating effect on subsequent wheat production. In addition, more than 100,000 farm animals were lost, and about 3,000 fish farms and 2,000 poultry farms destroyed. These production losses, together with those resulting from the expected more frequent and more intense floods and droughts could further aggravate the food security situation of the country.

On a positive side, the findings show that the cereal production in the northern mountainous areas will benefit from climate change. The wheat yield in these areas will increase by 40-50 percent by 2080 under A2 and B2 scenarios. However, this will not be of much help at the national level as the contribution of the northern mountainous region to the national wheat production is merely 2 percent (GOP, 2010).

Source: GOP 2010, GCISC 2009a, GCISC 2009b, World Bank and ADB 2010.

- Uncertainty in timely availability of irrigation water caused by changes in river flows due to glacier melting and altered precipitation pattern; shortage of irrigation water due to inadequate storage capacity;
- Erratic and uncertain rainfall patterns affecting particularly the rain-fed agriculture;
- Increased frequency and intensity of extreme weather events such as floods, drought and cyclones resulting in heavy damages to both crops and livestock;
- Greater abundance of insects, pests and pathogens in a warmer and more humid environment, particularly after heavy rains and floods;
- Degradation of rangeland and further deterioration of the already degraded cultivated land particularly those suffering from water erosion, wind erosion, water-logging and salinity;
- Intrusion of sea water into the deltaic region affecting coastal agriculture;
- Lack of technical capacity to predict with reasonable certainty the expected changes in climatic parameters (temperature, precipitation, extreme events etc.) in different parts of the country, and in seasonal, inter-annual and inter-decadal river flow patterns; as well as lack of technical capacity to fully assess, in quantitative terms, the corresponding impacts on the agriculture and livestock sector; and
- Low adaptive capacity to adverse climate change impacts due to lack of technical knowhow and financial resources.

7.3.1.3 Energy Security

Pakistan's development will demand enormous amounts of energy. Because of the links between sustainable development and energy, increased efforts are needed for the long-term energy security (GOP 2005b, GOP, 2005c). The matter has acquired urgency because Pakistan depends heavily (50 percent) upon its reserves of natural gas for industry, power generation, and commercial and household use. These reserves have started declining. Ensuring availability of usable affordable energy is therefore the bedrock of the country's current and future development. Pakistan's energy growth between 2006 and 2010 was about 7.2 percent while a future 8.8 percent annual growth in energy demand has been predicted, leading to a total energy need of 361 MTOE by 2030 (GOP, 2007). Provision of energy means without adverse impacts is therefore crucial.

Climate change will affect the energy sector directly as well as indirectly through the ripple effect from its impacts on other sectors such as water, industry, agriculture and infrastructure. For example it would affect the amount and timing of water availability for both hydropower generation and thermal power plant cooling, and meet the enhanced energy need in agriculture for pumping water for irrigation. It may also result in a decrease in the efficiency of thermal power plants as a result of the increase in ambient temperatures. Damage to the energy infrastructure located in coastal area could happen due to sea level rise as a result of climate change.

Major Concerns in Energy Security

The major impacts of climate change on energy security (GOP, 2010) have been summed up below:

Direct Impacts

- Changes in water availability and the timing of water availability for both hydropower generation and thermal power plant cooling;
- Increased rate of sedimentation of major reservoirs resulting in reduced hydropower generation

capacity;

- Reduced thermal power plant efficiency at elevated temperatures;
- Impact of changes in cloud cover, wind and agricultural productivity will affect harnessing solar, wind and biomass sources of renewable energy respectively;
- Impact of sea level rise and increased cyclone activity affecting existing energy infrastructure located along the coast;
- Increased Transmission and Distribution (T&D) losses due to elevated temperatures, and increased occurrence of blackouts resulting from line sagging.

Indirect Impacts

- Higher temperatures will result in increased demand of energy for pumping ground water to meet higher irrigation requirements due to increased evapotranspiration, and to compensate for water losses due to evaporation.
- Higher temperatures will increase electricity demand for space cooling, thereby increasing the peak demand requiring additional generation capacity.

7.3.2 Social Impacts

Climate change will also have social impacts such as adverse effects on health, cause displacement of people and loss of their income due to enhanced extreme natural events such as floods and droughts or sea level rise, which could also jeopardize hundreds of jobs. It may result in inflation of food prices and increase number of people at risk of food security and hunger and might result in migration and civil unrest. The capacities of individuals, communities and societies in Pakistan to effectively respond to such hazards will depend upon a combination of natural, human, social, financial and physical factors. For example coastal communities and small farmers will be at greater risk. Rural houses constructed from mud and makeshift materials will be more at risk compared to better quality houses in urban areas. The poor will have problems due to the increased cost of living as a result of reduced food security, enhanced health related expenditure and increase in energy prices.

The findings of community level surveys in three selected areas (Badin District in Sindh, Rajanpur in the Punjab and Khuzdar in Balochistan) show that climate change is already enhancing the environmental problems in these three districts and they are likely to be exacerbated in the future. The report of the survey states: “Poor and marginalized communities tend to be most vulnerable to climate change and be able to cope least with weather-related disasters because of lack of access to information and resources to reduce their risk. The predicted impacts of climate change will further increase existing vulnerabilities, inequalities and exposure to hazards.” Communities interviewed reported hotter temperatures and more erratic rain, and shortening of crop-growing season with serious implications for food security (Oxfam, 2009a).

It is extremely important for policy makers to take these factors into account while implementing climate change policies and adaptation measures. The two major elements that would exacerbate social impacts are health and extreme weather events.

7.3.2.1 Health

Warmer temperatures and greater humidity will increase the months of the year in which mosquitoes are

active and hence aggravate malaria. This can be anticipated to be a major new hazard in northern areas of Pakistan where the mosquito season is currently limited by low winter temperatures. Malaria is only one of the vector-borne diseases expected to expand northwards. Higher air and water temperatures are favourable to reproduction rates of many types of flies and other vectors of disease and thus an increase in infectious diseases is expected (Table 7.1), particularly in the northern half of Pakistan. The recent outbreak of dengue fever in parts of Pakistan might be having its origin in the change of climate.

Table 7.1 Pakistan: Implications of climate change for diseases

DISEASE TYPE	CLIMATE CHANGE IMPACT
Infectious diseases: transmission of infectious diseases is determined by many factors, including social, economic, climatic, and ecological conditions.	Water and food security and hygiene are compromised in hot weather particularly during extreme weather events such as floods.
Water borne diseases: drought and the resultant decline in water quality are responsible for the increased incidence of water-borne diseases.	Water contamination by bacteria, viruses, protozoa and parasites occurs or increases in hot weather and is often enhanced during drought and flooding.
Food borne diseases: contamination of food by viruses, bacteria and pathogens.	Increased heat (surface and ocean temperature) enhances prevalence of food contaminants.
Vector-borne diseases: pathogens being transmitted from human to human or animal to human via mosquitoes.	Increased temperatures and flooding exacerbates the breeding cycle of mosquitoes.
Respiratory illnesses: atmospheric pollution, which inhibits respiratory functioning.	Prolonged heat creates more smog and dispersal of allergens.
Malnutrition: diseases that can be greatly affected by poverty/diet.	Higher prices for food result in lower-income people/poor to eat lower quality/less nutritious diet resulting in malnutrition, which could aggravate the impacts of other diseases.

Various other health impacts are expected to result from the increase in extreme weather conditions caused by climate change. The most feared are: increased incidence of pneumonia, heat stokes, cholera and heart attacks. Another climate change related impact of particular concern to Pakistan is the 'winter smog', which has been seriously affecting almost the entire Punjab in December and January for the last several years (See Chapter 5). Believed to be due to the continental scale air pollution known as Atmospheric Brown Cloud (UNEP, 2008), it is expected to increase as the use of coal and petroleum increases in India, and China over the coming decades. Climate change will not only affect human health, the overall social development will also suffer from outbreaks of heat related and vector-borne diseases, coupled with malnutrition caused by food and water insecurity.

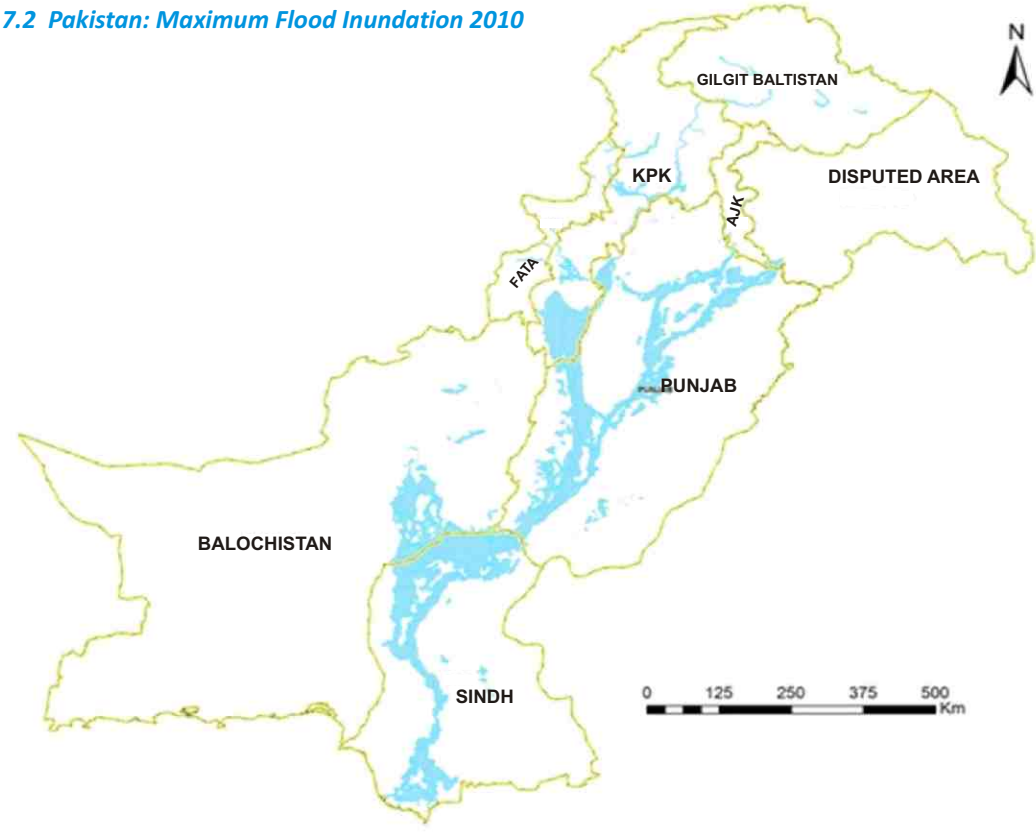
7.3.2.2 Extreme Weather Events

One of the most feared consequences of climate change in Pakistan is the likelihood of increased frequency, occurrence and severity of extreme events such as floods, droughts and cyclones with disastrous economic and social effects. The country is particularly vulnerable to such events as is obvious from the large-scale destruction in the recent past. For example, the floods in 1991-92 rendered agricultural growth rate for 1992-93 negative, thereby dragging overall GDP growth from 7 percent in 1991-92 to a mere 2 percent in 1992-93

(GOP, 2010). Similarly, the drought during 1998-2001 affected over 3.3 million people, including thousands who became refugees and hundreds who died of thirst and starvation, and about 30 million livestock, including over 2 million perished (GOP, 2003). The drought reduced GDP growth rate from 6 to 2.6 percent (GOP, 2007a). Besides floods and droughts associated with climate change, the expected increase in the tropical cyclone activity in the Arabian Sea is also an issue of serious concern due to the fact that a large fraction of the country's industrial infrastructure and jobs are associated with the coastal city of Karachi, which is quite vulnerable to the tropical cyclones spawning in the Arabian Sea.

A recent reminder of what climate change impacts mean to Pakistan was witnessed in the most devastating 2010 floods (Fig. 7.2) that wiped off 5.8 percent of the national GDP. The economic loss amounted to U$ 8.74-10.85 billions, averaging to about US$ 10 billion (ADB-WB 2010) in damage and reconstruction costs. The floods made all stakeholders realize the urgency and seriousness of addressing the climate change issues in Pakistan. It is a clear reminder that climate change is turning out to be an unfortunate but stark reality for Pakistan. The issue is now confronting the country head-on while demonstrating the strength and ferocity of its impact in terms of human, economic and environmental costs.

Fig 7.2 Pakistan: Maximum Flood Inundation 2010



Major Social Concerns

Due to their low capacities, poor and vulnerable individuals, communities, and societies will not be able to respond effectively to impacts of climate change particularly to extreme natural events. Some serious concerns in this regard are given below:

- Displacement of poor and loss of their income due to impacts of climate change such as extreme natural events and rise in sea level;
- Enhanced cost of living due to reduced food security, enhanced health related expenditures and increase in energy prices;
- Migration due to livelihood loss, and maladjustments leading to civil unrest;
- Warmer temperatures and greater humidity would increase water- and food-borne, as well as vector-borne diseases; and
- Increase in extreme weather conditions caused by climate change will increase incidence of pneumonia, heat strokes and heart attacks.

7.3.3 Biophysical and Exacerbated Environmental Impacts

Climate change will also have serious impacts on biophysical conditions such as a change in the ecology and habitats; quantity and quality of land, soil, water and biotic resources; sea level rise and ocean temperature and salinity; as well as the occurrence of weeds and pests, which in turn may exacerbate environmental changes. Greater risks will be posed to Pakistan's coastal and marine environment, forest and biodiversity, and other vulnerable ecosystems such as rangelands, degraded lands and mountain ecosystems.

7.3.3.1 Coastal and Marine Environment

With a coastline of about a thousand kilometres, Pakistan has been grouped by the UNEP's Oceans and Coastal Areas Programme Activity Centre among the countries which are most vulnerable to the effects of sea level rise (GOP, 2003). According to studies carried out at the National Institute of Oceanography (NIO), the sea level along the coast of Pakistan has been rising approximately at 1.2 mm per year; somewhat lower than the average global rise of 1.7 mm per year over the last century. However, even at this rate, coastal zones and marine ecosystems, in particular in the Indus delta, could be damaged from increased saline water intrusion due to sea level rise and increased storm events. The NIO is of the view that the ground subsidence rates in the Indus deltaic region due to lack of sediment flux and excessive ground water extraction are probably in the range of 2-4 mm per year. The ground subsidence has already resulted in the seawater intrusion upstream of the delta extending up to 80 km in the coastal areas of Thatta, Hyderabad and Badin districts (Panhwar, 1999; Inam et al., 2007). The primary impacts of sea level rise on the coastal zone include the risk of erosion of beaches, flooding and inundation of wetlands and lowlands, salinization of ground and surface waters, increased intrusion of sea water into the Indus deltaic region, and adverse impact on coastal agriculture. The Indus Delta covers approximately 600,000 ha with a coastline of 250 km, bordering the city of Karachi in the northwest. The main factor responsible for intrusion of seawater into the Indus deltaic region is an insufficient flow of Indus water downstream of Kotri barrage.

7.3.3.2 Forest

The rate of climate change may be too fast to allow gradual migration of various tree species to neighbouring areas with relatively more favourable climatic conditions. High temperature and increased precipitation will increase forest insects, pests and weeds, which may result in greater damage to forest vegetation. As a result, climate change will decrease productivity, change species composition, and reduce forest area. This is quite serious for the country, which due to low forests density is already incurring an annual loss of 2.3 billion rupees from flooding, erosion of fertile soil from upland watersheds and siltation of reservoirs and irrigation system. Yet, despite realizing the pressing needs to protect the existing forests and enhance their size, it has not been possible to increase the forest cover significantly over the last few decades (GOP 2005a). The most

serious is the case of coastal mangrove forests, which are a rich source of nutrients and protection for a variety of marine species. They will be under serious threat due to increased intrusion of seawater into the Indus delta as a result of sea level rise caused by climate change.

7.3.3.3 Biodiversity

In general, climate change affects the competitiveness of different species by differentially altering their growth and mortality as well as their regeneration success rates. Synchronous functioning of the lifecycles of plants, animals and soil organisms will also be potentially affected. Under the present rate of climate change, a wide range of species is unlikely to adapt or migrate fast enough. Climate change in the past would have certainly caused alterations in biomes and ecosystems. However, presently the non-availability of the required data on different aspects of biodiversity and ecosystems and the relevant techniques such as eco-climate classification and analysis through climate envelopes and profiles are the major constraints in a quantitative analysis of the impact of climate change on biodiversity. Nevertheless, according to a study by the Ministry of Environment and UNEP (GOP/UNEP, 1998), 31 species of mammals, 20 of birds and 5 of reptiles are already endangered and many more are on the list of Convention on International Trade in Endangered Species of Wildlife and Fauna (CITES). Therefore it is important to pay serious attention to flora and fauna as well as their habitats, and to save them from the adverse impacts of climate change as far as possible.

7.3.3.4 Other Vulnerable Areas and Ecosystems

a. Rangelands

The rangelands in Pakistan are particularly vulnerable to the impacts of climate change because the capacity for adaptation in these impoverished regions is very low. Besides supporting two-thirds of the entire population of sheep and goats and over half the cattle population of the country, they provide livelihood to millions of herders and pastoralists. However, in the absence of proper rangeland management system in Pakistan, heavy grazing pressure and utilization beyond their carrying capacity has been reducing their productivity. It is therefore important to save them from further degradation due to impacts of climate change.

b. Degraded/Desertified Lands

The main causes of large scale land degradation and desertification in Pakistan are: a) improper land use, uncontrolled livestock grazing, and illegal removal of vegetation, b) water logging, salinity and sodicity, and c) over-exploitation of ground water resources in the western dry mountains of Balochistan causing severe water scarcity. It is estimated that some 43 million ha land has already been affected by desertification, whereas land reclamation programmes, like National Drainage Programme would recover only up to 2 million ha (GOP 2005a). Like rangelands, it is the lack of adaptation capacity of the degraded land that makes them highly vulnerable to the adverse impacts of climate change.

c. Mountainous Regions

The mountainous regions of Pakistan are also highly vulnerable to climate change in view of the following: a) more frequent formation of glacial lakes outburst floods (GLOFs): there are 2,420 glacial lakes in the Indus basin, 52 of these are potentially dangerous and could cause GLOFs with serious damage to life and property;

the risk of GLOFs has increased due to climate change (Rehman & Kamal, 2007), b) loosening of the frozen soil and stones, making landslides and avalanches more common, and c) depletion of forests which form an important source of livelihood for the people living in mountain areas.

Major Biophysical and Related Environmental Concerns

- Climate change affects the competitiveness of different species by differentially altering their growth and mortality as well as their regeneration success rates;
- The rate of climate change may be too fast to allow adjustment and gradual migration of various tree species to neighbouring areas with relatively more favourable climatic conditions;
- Enhanced temperatures may increase insects, pests and weeds, which may result in greater damage to forest and plant biodiversity resulting in decreased productivity, changes in species composition, and reduction of forest area;
- Coastal zones and marine ecosystems, in particular the Indus delta, could be damaged from increased saline water intrusion due to sea level rise and increased storm events;
- Sea level rise in the coastal zone increases the risk of erosion of beaches, flooding and inundation of wetlands and lowlands, salinization of ground and surface water;
- Climate change may result in the rise of sea surface temperature and salinity;
- Possible drastic shift in weather pattern, both on temporal and spatial scales;
- Likelihood of increased frequency and severity of extreme events such as floods and droughts with adverse impacts on the environment;
- Increased vulnerability of rangelands and degraded lands to the impacts of climate change due to low capacity for adaptation in these impoverished areas; and
- Increased incidence of high altitude snow avalanches and GLOFs generated by surging tributary glaciers blocking main un-glaciated valleys.

7.4 Programmes and Policies Related to Climate Change

In the light of the multi-sectoral and multidimensional impacts of climate change discussed above, climate change response measures in Pakistan need to be multi-faceted not only cutting across priority sectors but also incorporating an interlinked array of economic and political decisions. Moreover, they should be developed within the overall context of international policy frameworks including the Climate Change Convention and the Kyoto Protocol while safeguarding national environmental imperatives.

7.4.1 Response Measures Adopted

In terms of responses related to multilateral environmental agreements on climate change, Pakistan acceded to the United Nations Framework Convention on Climate Change (UNFCCC) as a Non Annex-I Party in June 1994. Subsequently the country adopted the Kyoto Protocol in 1997 and acceded to it on 11th January 2005. As a follow up to these international commitments the country has undertaken climate related studies including the ALGAS study (ADB/GEF/UNDP, 1998), the UNEP (1998) country study on adaptation, the Initial National Communications on Climate Change (GOP 2003) and a high level report called the Task Force Report on Climate Change (GOP 2010). In addition, the Government in collaboration with UNFCCC commissioned a National Economic and Environmental Development Study (NEEDS). The NEEDS study aimed to bring out some of the priority areas for possible climate mitigation while drawing out the probable future course of Pakistan's growth and the costs associated with moving along a low carbon development pathway. The study also gives strategic options for adaptation and preliminary cost estimates (GOP & UNFCCC, 2011). The

Government has also remained active in global negotiations on climate change and integrated its international commitments into national policies and plans (Box 7.3) All these efforts managed to create institutional and stakeholder awareness about the climate change issue as well as build a strong constituency on combating climate change.

Box 7.3 Pakistan's Contribution in Combating Global Climate Change

Pakistan has been a responsible and active participant in the global negotiations right from the inception of the climate change debate. As the chair of the G77 negotiating group in 1992 and 2007, Pakistan spearheaded consensus building on the basic founding principles of the UNFCCC as well as agreement on the four building blocks of climate change - Mitigation, Adaptation, Technology and Finance, which have framed the debate ever since.

Pakistan's international commitments regarding climate change also find expression in its national policy frameworks such as the Climate Change Policy of Pakistan, Framework for Economic Growth, One UN programme on Environment, National Environmental Policy as well as the National Energy Conservation Policy. These documents clearly describe how the government intends to honour its international commitments. The country also announced and implemented the CDM National Operational Strategy (GOP 2006) as a signal for its entry into the global carbon market.

"The Framework for Economic Growth" (long-term growth strategy of Pakistan) gives great importance to climate change in view of its grave negative consequences for the country. The Framework under the subtitle, "Ensuring economic growth is sustainable and climate resilient" discusses various themes. The first theme on protecting growth from the risk and costs of climate change-induced disasters, stresses integration of risk reduction and management concerns within the planning process. The second theme relates to climate proofing economic growth from the impacts of climate change in particular on the agriculture, water and energy sectors. The third theme focuses on the green growth through investment in low carbon technologies. The Framework pledges provision of adequate resources for the Government's climate change policy and related action plans.

Source: United Nations 2009, GOP 2011, 2006, 2005c, and 2005d.

7.4.2 Institutional Arrangements

In terms of institutional development, the Cabinet Committee on Climate Change was formulated in 1995 to provide a policy coordination forum for dealing with climate change. In 2004 this was changed to the Prime Ministers Committee on Climate Change (PMCCC), which also aimed for establishing high-level inter-ministerial linkages and proved to be extremely effective in initiating the country's entry into the global carbon market. The autonomous Global Change Impact Studies Centre (GCISC) was established to act as the secretariat of the PMCCC and is now the primary scientific research body engaged in conducting research on impacts of and adaptation to climate change in the country and the regional level. The PMCCC needs to be activated and utilized to provide a forum for integrating climate change into mainstream policy making (GOP and UNFCCC, 2011).

The Climate Change Division, which also looks after the Environment is the designated national focal point for UNFCCC and the Kyoto Protocol. The Division has been coordinating with other concerned agencies and

institutions on various technical aspects, including the National Energy Conservation Centre (ENERCON), the Alternative Energy Development Board and the Pakistan Council of Renewable Energy Technologies. As an autonomous research organization on climate change, GCISC is also working under the umbrella of the Climate Change Division.

The current focus of research at GCISC is on: (i) projection of change in climate for Pakistan over the next several decades based on a) world level coarse resolution projections made by various GCMs, and b) dynamic downscaling of the outputs of selected GCMs using Regional Climate Models to obtain high resolution projections; (ii) Assessment of past temporal changes in the Karakoram glaciers using Remote Sensing data from satellites; (iii) Monitoring Assessment of the impacts of projected climate change on a) glacier melt and water inflows in main rivers of Pakistan, and b) productivity of various agricultural crops in different climate zones of the country, using respectively Watershed Models and Crop Growth Simulation Models; (iv) identification and assessment of appropriate adaptation measures; (v) development of indicators and indices for extreme weather events and development of methodological tools for projecting the occurrence of such events; (vi) Seasonal predictions and climate forecasts for decadal and inter-annual periods; (vii) RS/GIS based studies of temporal changes resulting in deforestation, land degradation, inundation of deltaic region, glacial lakes formation and associated flooding; and (viii) assessment of alternative energy supply strategies for Pakistan with focus on GHG mitigation and preservation of local environment.

Other major relevant organizations in the country working on research in climate change and sea level rise include the Pakistan Meteorological Department, the Water and Power Development Authority (WAPDA), the National Agriculture Research Centre (NARC), the National Institute of Oceanography (NIO) and the Space and Upper Atmosphere Research Commission (SUPARCO). There are several other organizations including universities in the country, with mandates and activities that cover climate change related issues and which have either some highly relevant climate change related capacities or are pursuing climate change related projects. Oxfam (2009b) published the results of a survey of these organizations in a report.

7.4.3 Mitigation and Adaptation

As discussed above there are a number of priority sectors and areas for coordinated mitigation and adaptation responses within the country. In particular the energy, water, transport, industries, agriculture/livestock, and forestry together with natural hazards are the key sectors/areas that have implications on the country's economic development. A majority of these have a two-way interaction with climate change whereby they not only have implications for future increase in GHG emissions in the country but also are directly affected by climate change. They need to be analysed to bring out the priority mitigation and adaptation actions that can be undertaken to ensure a climate sensitive development in the country.

As pointed out at the beginning of this chapter, the energy sector is the single largest source of carbon emissions. Therefore, it also has the greatest potential for GHG reductions along with positive synergies with local sustainable development priorities in such areas as the energy conservation, efficiency enhancement and promotion of renewables. In terms of adaptation, agriculture, the mainstay of the economy and a major commodity-producing sector, is seriously threatened by the adverse effects of any shift in climate patterns and changes in precipitation. Hence, it is a key sector demanding an effective adaptation response. There is a substantial opportunity for undertaking "win-win" mitigation activities in this sector corresponding to national agricultural priorities which can lead to cost savings, conservation of valuable inputs such as water as well as effective GHG reductions. In terms of forestry, Pakistan suffers from an alarming rate of deforestation. The sector offers a great potential for mitigation through tree cover enhancement as a sink of GHGs, while

utilizing innovative financial instruments such as UN-REDD (The United Nations Collaborative Programme on Reducing Emission from Deforestation and Forest Degradation in Developing Countries).

The water sector, as discussed in Chapter 4 is both the engine and the primary agent of development in Pakistan but the Indus River system that is the main source of water in Pakistan is particularly vulnerable to changes in climate. There is a need for focusing on issues of flood management, water conservation, increasing the efficiency of water distribution as well as enhancing the water storage capacity through small and large dams.

7.4.3.1 Mitigation and its Costs

Pakistan is presently a small GHG emitter but its emissions are bound to increase considerably as the country strives to develop and provide adequate amounts of energy to support its growing developmental needs. The country therefore wishes to contribute to the global GHG mitigation efforts without compromising on its basic minimum energy and food needs consistent with its socio-economic developmental requirements, energy security considerations and existing financial and technological constraints (GOP, 2010).

The projected growth in agriculture, industry and energy consumption gives rise to concerns on the increase in GHG emissions. According to the NEEDS Study (GOP and UNFCCC 2011), these concerns are more aggravated in a scenario that sees Pakistan's energy future being driven by coal. Table 7.2 shows that the overall GHG Emissions (Mt CO_2 eq.) are projected to increase from 347 in 2011 to 4621 in 2050 under a Business as Usual (BAU) scenario. These emissions are linked with and based upon the projected sectoral GDP estimates of agriculture, large-scale manufacturing, energy and transport. The share of the respective sectors were derived from the NEED Study (GOP and UNFCCC, 2011) and are shown in figs 7.3 and 7.4.

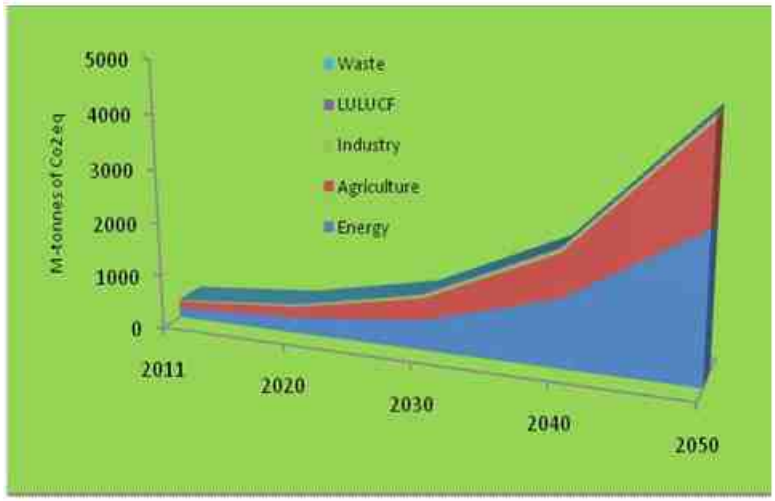
It can be seen that within the projected BAU scenario the energy sector will remain the highest contributor of overall emissions. Its share reaches 59 percent in 2050. The agriculture sector is to maintain a constant share

Table 7.2 Pakistan: Sector wise GHG Emissions 2011-2050

	2011	2020	2030	2040	2050
total GHG Emissions (Mt CO2 eq.)	347	557	1046	2156	4621
Energy	176	295	560	1250	2730
% Share	50.6	52.9	53.5	58.0	59.1
Agriculture	134	210	408	812	1765
% Share	38.7	37.7	39.0	37.7	38.2
Industry	20	30	52	61	75
%Share	5.8	5.4	5.0	2.8	1.6
LULUCF	10	13	15	20	35
%Share	2.9	2.3	1.4	0.9	0.8
Waste	7	9.	11	13	16
%Share	1.9	1.6	1.1	0.6	0.3

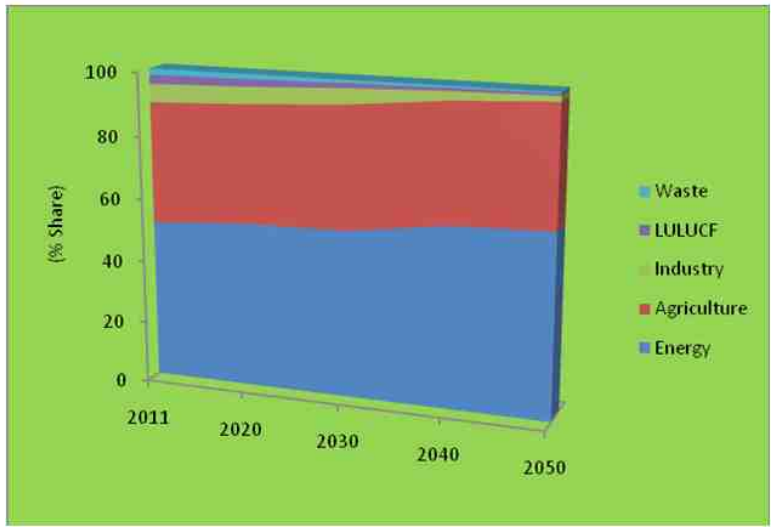
Source: GOP and UNFCCC 2011

Fig 7.3 Pakistan: Total and sector wise emission growth 2011- 2050



Source: GOP and UNFCCC 2011

Fig 7.4 Pakistan: Change in Emission Share by Sector 2011-2050



Source: GOP and UNFCCC 2011

but that of industry in GHG emissions will see a decrease perhaps due to the NEEDS underlying assumption of efficiency in production techniques and availability of greener technologies (GOP and UNFCCC, 2011).

In terms of choices for future energy requirements in Pakistan, the NEEDS indicates that significant financial resources will be required by the country in its efforts to decouple its economic growth from a corresponding growth in emissions. The low carbon development scenarios projected for the country estimate additional investment costs of mitigation ranging between US$ 8 billion to US$ 17 billion by 2050, as progressively cleaner coal and a higher percentage of renewable energy technologies are employed. It is considered feasible to reduce emissions by 40 percent from the BAU scenario by employing cleaner technologies.

The mitigation costs of US$ 17 billion would result in significant carbon reductions which, if priced at a reasonable value of carbon (U$ 25/tC) raises the estimates to US$ 27.3 billion (which can be potentially capitalized through the carbon market) indicating a positive cost–benefit ratio. The question of access and

availability of the requisite climate finance to make this low carbon transition remains unanswered (GOP and UNFCCC, 2011).

Analysis on bridging the energy gap in Pakistan indicates that the country requires an upfront investment of US$ 10 billion if it wants to meet the current shortfall of 5000 MW through incremental renewables (as compared to meeting it through incremental coal). The country does not have domestic resources for this kind of investment. However, the country should carry out an extensive technology needs assessment to clearly identify the best available technologies that can be employed in the future to make a clean energy transition. Moreover, it should strive for access to appropriate GHG reducing technologies and supportive financing if the country is to successfully shift to a low carbon trajectory away from its future BAU growth.

The Energy Security Action Plan 2005-2030 (GOP, 2005b) envisages large roles for hydropower, renewable energy technologies (in particular windmills), nuclear power and imported natural gas in future energy supplies. One windmill of 6 MW capacity has been made operational while work is underway on 18 wind-power projects of 50 MW capacity each. Construction of a third nuclear power plant is in progress. Approval has been given for the construction of the 4,500 MW Bhasha dam. An agreement has been finalized with Iran for the construction of a gas pipeline from Iran to Pakistan with a capacity to transport 21 million cubic meter of gas per day. An approval has been given for the construction of a mass transit system (circular railway) for Karachi metropolitan area. A number of projects on energy efficiency improvement, energy conservation and use of decentralized renewable energy technologies are being implemented by National Energy Conservation Center (ENERCON), Water and Power Development Authority (WAPDA), Karachi Electric Supply Company (KESC), Alternative Energy Development Board (AEDB) and Pakistan Council of Renewable Energy Technologies (PCRET). In terms of carbon sequestration, several afforestation endeavours like the Rachna Doab Afforestation Project are underway. Tree-planting campaigns are launched each year during spring and monsoon seasons (as many as 541,176 saplings were planted in one day on 15 July 2009, which is a world record.

Mitigation is also important in the livestock and agricultural sector where little attention has been paid to address the GHG emissions so far. The mechanism recommended by the Task Force on Climate Change for this sector (GOP, 2010) included (i) new methods of rice cultivation that have lower methane emissions, (ii) new methods for reducing nitrous oxide releases from agricultural soils, (iii) new breeds of cattle which are more productive in terms of milk and meat but have lower methane production from enteric fermentation, and (iv) new economical feeds that reduce the methane production of cattle besides providing them with better nutrition.

7.4.3.2 Adaptation and its Costs

In light of the discussions in section 7.3 Vulnerability and Threats, a number of adaptation measures are needed in Pakistan related to water resources, agriculture and livestock, coastal areas and the Indus Deltaic Region, and for enhancing forests and other vulnerable ecosystems. In terms of water resources the present efforts are concentrated on increasing the storage capacity through a series of large hydropower projects to add 22 BCM of new storage capacity by 2030, to the existing 15 BCM capacity, (which is decreasing by 247 millon cubic meters annually due to siltation). Approval has been accorded for the construction of a 4,500 MW hydropower plant at Bhasha, with a water storage capacity of about 8 BCM the construction work will start soon). The large storages are to be complemented by a comprehensive construction programme of small and medium dams as well as measures for recharging underground reservoirs and investigations for using groundwater aquifers as water storage facilities. Among water conservation efforts a major programme

underway is for lining the water channels and continuously monitoring the movement of glaciers in northern Pakistan.

Adaptation activities for agriculture need to focus on securing agricultural productivity in a sustainable manner (FAO, 2007). For this purpose it is planned to: (i) develop through biotechnology heat-stress resistant, drought- and flood-tolerant, and water-use efficient high yielding crop varieties, (ii) increase irrigation water availability by reducing losses in the irrigation water supply network, (iii) implement "More Crop per Drop" strategy through improved irrigation methods and practices, as well as water saving techniques in combination with the use of high yielding and water-efficient crop varieties and (iv) increase milk and meat production by improving animal feedstock and by developing animals breeds which are less vulnerable to climatic change (GOP, 2010).

For the coastal and marine environment, it is planned to implement the recommendations of a study by local and foreign experts (IPOE, 2005) to identify what minimum water flows below Kotri Barrage are required (a) to keep seawater intrusion in check and (b) to address other environmental concerns. Plans have also been formulated to restore the degraded mangroves and marine ecosystems and major interventions are planned to boost fisheries. Moreover, a major intervention is underway to use brackish water for aquaculture. The Climate Change Division together with the National Disaster Management Authority (NDMA) has been made responsible for both preparedness and management in respect of all major disasters including cyclones.

For forest and other vulnerable ecosystems, besides on-going afforestation and reforestation activities, it is planned to (a) improve the rangelands by their proper management, and (b) reclaim nearly 6 million ha of salt affected waste land and large areas of sandy desert by planting salt tolerant, fast growing grasses, and shrubs and trees to be used as fodder. It is envisaged to increase the area protected for conservation of wildlife and to develop a national database of threatened and endangered species to encourage their captive breeding for promoting the ex-situ conservation of biodiversity.

Several other measures have been recommended that range from the construction of engineering structures like dikes and sea walls to protect beaches and coastal infrastructures to the development of new breeds of crops and livestock and promotion of optimized planting dates as well as conservation, reuse and recycling of water, particularly reuse of marginal quality water for irrigation.

While it is important to identify adaptation measures, it is equally important to estimate the costs of applying or not applying them. Existing global studies on adaptation costs provide a wide range of estimates, from US$ 4 billion to US$ 109 billion a year for the whole globe, and have many gaps. According to the widely acclaimed Stern report (Stern 2006) the cost of climate change impacts is estimated at 5–20 percent of the global GDP annually, in the absence of adaptation. The World Bank (2010) estimates that up to 10 percent of domestic and foreign direct investment (FDI) flow in developing countries, and up to 40 percent of ODA and concessionary finances might be at risk from climate–related damages. UNDP (2008) estimates that 24.9 percent of all estimated global costs of adaptation would have to be just spent in Asian developing countries.

At the national level, the Adaptation Program of Action (prepared by the Least Developed Countries under the United Nations Framework Convention on Climate Change), identifies and includes costs of only urgent and immediate adaptation needs, and countries do not typically incorporate adaptation measures into long-term development plans.

Although varying in absolute values, the research on the subject does unequivocally suggests that cost–

Box 7.4 Costs of Adaptation to Climate Change in Pakistan

Adoption cost for Pakistan are given in the table below, based on three different criteria: projected GDP, per capita basis and disaster modelling.

The actual forced adaptation costs that Pakistan had to bear in 2010 owing to floods triggered by climate change were about US$ 9.7 billion. The total adaptation costs would be more than this figure as it was just related to the flood damage and did not factor in the costs of other climate related impacts that the country had faced from the drought of 1998-2001 and the glacial lake outburst flood (GLOF) in Hunza in 2010. Calculations, which derived adaptation costs as a percent of future GDP projections, indicate an annual average adaptation cost of US$ 10.71 over the 2010-2050 period. The per capita based approach has derived annual adaptation costs for the country of US$ 7 (in 2010) to 14 billion (in 2050) if a per capita figure of US$ 40 is used.

Pakistan: Comparisons of adaptation cost estimates (in billion US $)

Methodology	Time period	Cost of Adaptation/annum
Actual (2010)	One year (2010)	9.7++
As a percent of GDP	2010-2050	10.71
per Capita Basis	2010-2050	7.12 to 14.0
Disaster Modeling (Floods only)* Multiplication factor of three	2010-2050	6.09 to 11.28

Source: GOP and UNFCCC, 2011

The disaster-based model was developed in the light of the high probability of floods in the medium term. The adaptation cost figures for floods ranged between US$ 2 to 3.76 billion per annum over the 2010-2050 period depending on the frequency and intensity of future floods. This flood adaptation value was multiplied by a factor of three to provide figures of US$ 6 to 11.28 billion. This was done for comparative purposes with the other methodologies, which were costing total adaptation that accounted for the costs associated with other impacted areas/sectors such as coastal zones, energy, agriculture, forestry, health and climate induced disasters such as droughts and cyclones. However, the use of a factor of 3 was rather arbitrary.

Overall results of the study show costs ranging from between US$ 7 to 14 billion per year. This figure may rise over time because initial adaptation will probably be quite feasible but may get increasingly expensive as it deals with impacts, which require high investments or are unavoidable.

effective and timely adaptation strategies which are fully compatible with development objectives are crucial for coping with as well as lowering future climate impacts (Agrawala and Fankhauser 2008; Mishra and Markandya, 2010; Oxfam, 2007; Perry et al., 2009). In the absence of appropriate measures countries will be forced to implement reactive unplanned adaptations, which will cost much more.

In Pakistan, a National Economic and Environmental Study (GOP and UNFCCC, 2011) has estimated adaptation costs for Pakistan. The findings of the study (Box 7.4) show adaptation costs ranging from US$ 7 to

US$ 14 billion per year. These estimates are based on a top–down analysis derived from contemporary research conducted on this nascent subject. The basic aim is to provide a reasonable first approximation. This needs to be refined over time as relevant and reliable local data becomes available to draw conclusions from a bottom up approach to adaptation costing based on predicted impacts and identified adaptation alternatives. There is a need to disaggregate the data, as an average across the country hides a very uneven distribution of the burden of adaptation across regions. It will also be imperative to incorporate the same in the Framework for Economic Growth.

It is important to note that developing countries like Pakistan do not have resources to meet the huge adaptation costs without developed countries meeting their commitments made under the December 2007 Bali Action Plan, adopted at the United Nations Climate Change Conference. Under this plan developed countries have agreed to "adequate, predictable, and sustainable financial resources and the provision of new and additional resources, including official and concessional funding for developing country parties" (UNFCCC, 2008) to help them adapt to climate change.

7.5 Conclusions

Pakistan is one of the most vulnerable countries to climate change despite contributing very little to global greenhouse gas emissions. Dealing with climate change is no longer an option for the country; it has become an unavoidable reality in the wake of increasing symptoms exhibited through cataclysmic floods and droughts. The potential impacts of climate change identified in this chapter are wide-ranging and are likely to affect all dimensions of development with impacts across many sectors and ecosystems. Economically the detrimental impacts of climate change will be widespread and have bearing not only on water security, food security and energy security but also impinge on agriculture, forests, livestock and fisheries, the sectors vital for Pakistan's economy.

In terms of the social dimension, climate change will have adverse impacts on health, cause displacement of people, and result in loss of their income due to enhanced extreme natural events such as floods and droughts or sea level rise. It could jeopardize hundreds of jobs, may result in inflation of food prices and increase the number of people at risk of food insecurity and hunger. It could also trigger migration and civil unrest. Climate change is likely to have serious impacts on biophysical conditions through a change in the ecology and habitats, quantity and quality of land, soil, water and biotic resources and rise in sea level and ocean temperature and salinity. It may exacerbate occurrence of weeds and pests, which in turn may enhance environmental changes.

The capacities of individuals, communities, and societies to respond effectively to these changes will depend on a combination of natural, human, social, financial and physical factors. Coastal communities and small farmers will be at greater risk. The rural houses constructed from mud and makeshift materials will be more at risk compared to better quality houses in urban areas. The poor will have problems due to increased cost of living as a result of reduced food security, enhanced health related expenditures and increase in energy prices. It is therefore extremely important for policy makers to take these factors into account while taking measures to combat climate change.

Pakistan has already acceded to the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol. As a follow up to these international commitments, the country has undertaken substantial climate related work. It announced and implemented the CDM Operational Strategy (2005) as a signal for its entry into the global carbon market. It has completed and approved a National Climate Change Policy. The

Framework for Economic Growth (long-term growth strategy) of Pakistan also gives great importance to climate change and pledges to promote sustainable and climate resilient economic growth. The country also wishes to contribute to the global GHG mitigation efforts without compromising its basic minimum energy and food needs consistent with its socio-economic developmental requirements, energy security considerations, and existing financial and technological constraints.

A number of adaptation measures are being promoted or envisaged related to water resources, agriculture and livestock, coastal areas and the Indus Deltaic Region, and for enhancing forests and other vulnerable ecosystems. A preliminary study's findings show that adaptation costs will be too high, ranging from US$ 7 to US$ 14 billion per year. Developing countries like Pakistan do not have the resources to meet such huge adaptation costs and need the help of developed countries, who made commitments under the Bali Action Plan to help developing countries adapt to climate change.

REFERENCES

ADB/GEF/UNDP (1998). Asia Least-Cost Greenhouse Gas Abatement Strategy (ALGAS) Pakistan. Asian Development Bank, Global Environment Facility, United Nations Development Program, Manila, Philippines.

ADB-WB, Asian Development Bank-World Bank (2010), Pakistan Floods 2010: Preliminary Damage and Needs Assessment.

Agrawala, S. and Fankhauser, S. eds (2008). Economic Aspects of Adaptation to Climate Change: Costs, Benefits and Policy Instruments. OECD, Paris.

FAO, Food and Agricultural Organization of United Nations (2007). Adaptation to Climate Change in Agriculture, Forestry and Fisheries: Perspective, Framework and Priorities. Rome

GCISC (2009a). Iqbal, M.M. Husain, S.S. Goheer, M.A. Sultana, H. Salik, K.M. Mudasser, M. and Khan, A.M. Climate Change and Wheat Production in Pakistan: Calibration, Validation and Application of CERES-Wheat Model. Research Report No.GCISC-RR-14, Global Change Impact Studies Centre, Islamabad.

GCISC (2009b). Iqbal, M. Goheer, M.A. Noor, S.A. Sultana, H. Salik, K.M. and Khan, A.M. Climate Change and Rice Production in Pakistan: Calibration, Validation and Application of CERES-Rice Model. Research Report No.GCISC-RR-15, Global Change Impact Studies Centre, Islamabad.

Government of Pakistan (2011). Pakistan: Framework for Economic Growth, Planning Commission. Islamabad

Government of Pakistan (2010). Final Report of the Task Force on Climate Change. Planning Commission, Islamabad.

Government of Pakistan (2010a). Pakistan Economic Survey 2009-2010. Ministry of Finance, Economic Advisor Wing, Islamabad.

Government of Pakistan (2007). Pakistan in the 21st Century: Vision 2030. Planning Commission, Islamabad.

Government of Pakistan (2007a). National Disaster Risk Management Framework Pakistan. National Disaster Management Authority, Islamabad

Government of Pakistan (2006). Clean Development Mechanism: National Operational Strategy. Ministry of Environment, Islamabad.

Government of Pakistan (2005a). Report of Technical Committee on Water Resources. Ministry of Water and Power, Islamabad

Government of Pakistan (2005b). Energy Security Action Plan. Planning Commission, Islamabad

Government of Pakistan (2005c). Medium Term Development Framework (MTDF 2005-2010). Planning Commission, Islamabad.

Government of Pakistan (2005d).National Environmental Policy. Ministry of Environment, Islamabad.

Government of Pakistan (2005e) National Energy Conservation Policy, Islamabad

Government of Pakistan (2003). Pakistan's Initial National Communication on Climate Change. Ministry of Environment, Islamabad.

GOP/UNEP (1998). Study on Climatic Change Impact Assessment and Adaptation Strategies Study for

Pakistan. Government of Pakistan and United Nations Environment Program, Islamabad.

GOP and UNFCCC (2011). National Economic and Environmental Development Study (NEEDS), unfccc.int/files/adaptation/application/pdf/pakistanneeds.pdf

Inam, A. Clift, P.D. Giosan, L.Tabrez A. R. Rabbani, M. M. Tahir, M and Danish, M. (2007). The Geographic, Geological and Oceanographic Setting of the Indus River in Large Rivers, John Wiley Publishers.

IPOE, International Panel of Experts (2005). Gonzalez, F. J. Basson, T. and Schultz, B. (2005). Final Report of IPOE for Review of Studies on Water Escapage Below Kotri Barrage. Delft, the Netherlands.

Maplecroft - Global Risks Portfolio and services (2011). Maplecroft's Climate Change Risk Atlas.

Maplecroft - Global Risks Portfolio and services (2010). Maplecroft's Climate Change Risk Atlas.

Mishra, A. and Markandya, A. (2010). Costing Adaptation: Preparing for Climate Change in India. Presentation made at SANDEE, MSE and MSSRF Workshop on Economics of Climate Change Adaptation, 12-13 February, Madras School of Economics, Chennai.

Oxfam (2009a). Climate Change, Poverty and Environmental Crisis in the Flood Prone Areas of Pakistan. Oxfam International, Islamabad.

Oxfam (2009b). Climate Change in Pakistan: Stakeholder Mapping and Power Analysis, Oxfam, Pakistan Programme Office, Islamabad.

Oxfam (2007). Adapting to Climate Change. What is Needed in Poor Countries and Who Should Pay? Oxfam Briefing Paper, 104.

Panhwar, M.H. (1999). Seepage of water of the River Indus and Occurrence of Fresh Ground Water in Sindh. In (eds. A. Meadows & P. Meadows), The Indus River Biodiversity, Resources, Humankind.pp180-197, Oxford University Press.

Parry, M. Arnell, N. Berry, P. Dodman, D. Fankhauser, S. Hope, C. Kovats, S. Nicholls, R. Satterthwaite, D. Tiffin, R. and Wheeler, T. (2009). Assessing the Costs of Adaptation to Climate Change A Review of UNFCCC and Other Recent Studies. International Institute for Environment and Development and Grantham Institute for Climate Change, Imperial College London, U.K.

Rehman, H. and Kamal, A. (2007). Indus Basin River System Flooding and Flood Mitigation. Quoted in GOP (2007). National Disaster Risk Management Framework Pakistan. National Disaster Management Authority, Islamabad

Stern, N. (2006). Stern Review: Economics of Climate Change. Cambridge University Press.

UNEP (2008). Atmospheric Brown Cloud, Regional Assessment Report with focus on Asia. United Nations Environment Programme, Nairobi, Kenya.

United Nations (2009). Delivery as One: One Programme Document 2008-2010. Islamabad, Pakistan.

UNDP, United Nations Development Programme (2008). Negotiations on Additional Investment and Financial Flows to Address Climate Change in Developing Countries. An Environment and Energy Group Publication, New York.

UNFCCC (2008). Report of the Conference of the Parties Thirteenth Session, 3 -15 December 2007. Decision 1/CP.13 Bali Action Plan, United Nations Framework Convention on Climate Change.

World Bank. (2010). The Costs to Developing Countries of Adapting to Climate Change: New Methods and Estimates. Economics of Adaptation to Climate Change, Washington DC