

COUNTRY PAPER: PAKISTAN

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INTRODUCTION

Global Climate Change resulting from an increasing concentration of Greenhouse Gases (GHG) in the atmosphere caused by the use of fossil fuels and other human activities is now an established phenomenon and its effects have been observed in most parts of the world including Pakistan. With continued heavy reliance of the world energy system on fossil fuels for the foreseeable future much larger climatic changes and their adverse impacts are to be expected in the coming decades. According to the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), the average temperature of the earth's surface increased by 0.6 °C over the past century and is projected to increase further by 1.1 to 6.4 °C by the end of the current century (IPCC 2007). It will be accompanied by large variations (both, increases and decreases) of temperature and precipitation in different world regions, considerable worldwide increases in the frequency and intensity of extreme climatic events (floods, droughts, cyclones etc.), large scale shrinking of Arctic sea ice and recession of mountain glaciers, rise in average sea level by up to 0.6 meter etc., with serious adverse impacts on various socio-economic sectors in many parts of the world.

Pakistan is particularly vulnerable to climate change because it has generally a warm climate; it lies in a world region where the temperature increases are expected to be higher than the global averages; its land area is mostly arid and semi-arid (about 60 per cent of the area receives less than 250 mm of rainfall per year and 24 per cent receives between 250-500 mm); its rivers are predominantly fed by the Hindukush-Karakoram-Himalayan glaciers which are reported to be receding rapidly due to global warming; its economy is largely agrarian and hence highly climate sensitive; and because the country faces increasingly larger risks of variability in monsoon rains, large floods and extended droughts. Under the influence 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 (these include 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 cyclonic activity; to the mountainous regions due to glacier lake outburst floods (GLOFs) and landslides; to the country's scanty forests (less than 5% of the land area is under forest cover) due to forest fires as well as reduced regeneration under rapidly changing climatic conditions; to human health due to heat strokes, diarrhea, cholera, vector borne diseases, etc.; and to human settlements due to floods and cyclones.

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Although Pakistan has been rather late in realizing the intensity of the climate change threat to its socio-economic development, the country is now taking this threat very seriously: A dedicated research centre (called, Global Change Impact Studies Centre, GCISC) focusing on climate change related aspects was initiated in 2003 and a high level committee chaired by the Prime Minister (called Prime Minister's Committee on Climate Change, PMCCC) was established in 2005 to provide national level policy guidelines on climate change related issues. More recently, in October 2008, the Planning Commission (PC) set up a Task Force on Climate Change (TFCC) with a view to take stock of country's situation vis-a-vis climate change; to contribute to the formulation of a climate change policy that would assist the government in achieving sustained economic growth by appropriately addressing climate change threats so as to ensure water security, food security and energy security of the country; and to recommend policy measures for promoting large scale Adaptation and Mitigation efforts, for raising awareness of various stakeholders; and for enhancing the capacities of relevant national institutions.

While Pakistan is highly vulnerable to the adverse impacts of climate change, its own contribution to the total global GHG emissions is a miniscule (about 0.08%) and its per capita GHG emissions correspond to about one-fifth of the average for Western Europe (IEA/OECD 2006). As such, the main thrust of the country's response to climate change is bound to be on Adaptation measures. Still, as a responsible member of the international community, Pakistan would like to contribute as much to the global Mitigation effort as it possibly can while trying to meet the country's basic minimum energy needs consistent with its socio-economic developmental requirements, energy security considerations, and financial and technological constraints.

MAJOR CLIMATE CHANGE RELATED CONCERNS

Pakistan stands among the group of developing countries which are extremely vulnerable to the adverse impacts of climate change. The most serious concerns for Pakistan are the threats to its water, food and energy security and the vulnerability of its coastal areas. Other climate change related particular concerns include increased risks of extreme events (floods, droughts and cyclones) and adverse impacts on forests, biodiversity, human health and vulnerable regions (mountainous areas, rangelands, arid regions etc.). Briefly discussed below are the key concerns:

Water Sector: Current Status and Vulnerability: Pakistan is extremely short of fresh water resources. Under the pressure of increasing population, it became a water-stressed country (i.e. having overall per capita water availability less than 1800 cubic meters per year (m^3/y) at the turn of the century and is now heading to become a water-scarce country (per capita availability less than 1000 $m^3/year$ by 2035 (WB 2006). Pakistan's primary sources of water are rainfall [about 50 Million acre-feet (maf) or 60 Billion cubic meters (bcm)] brought down by monsoon and westerly winds and river inflows (about 142 maf or 175 bcm) in the Indus River System (IRS) fed largely by glacier and snow melt from the Hindukush-Karakoram-Himalayas (HKH) mountain ranges. The shares of main contributing rivers to the IRS in Pakistan are: Indus: 44%, Chenab: 19%, Jhelum: 16%, Kabul: 16% and Others: 5% (see Figure 1). The per capita availability of river water, which was 5,650 $m^3/year$ in 1951 and 1200 $m^3/year$ in 2003, is expected to decline further to 1000 m^3/y in 2010 and to 800 m^3/y in 2026 under the pressure of increasing population (GoP-PC 2007). The water security of the country is therefore a very critical issue for Pakistan.



Figure 1. Indus River System (IRS). The water from the tributaries Ravi and Sutlej is not received by Pakistan under the Indus Water Treaty

Rainfall: The annual rainfall is low and irregular, with the national average being about 278 mm, varying from around 160 mm during a dry year (e.g. 2002) to over 440 mm in a wet year (e.g. 1994), thereby contributing an average of 180 maf of rainwater over the country's total land area. The spatial variation of rainfall is also huge; it varies between 1500 mm in the northern mountainous areas and northern Punjab to less than 100 mm in the south with southern Punjab and upper Sindh getting about 150 mm per annum. About 80% of the annual rainfall occurs from July to September (the monsoon period). As Pakistan is located at the western edge of the monsoon system, heavy summer rains occur only in the northern part of the Punjab province, while the rest of the country is in a permanent state of water shortage. The monsoon in the Punjab is also highly variable from year to year. It is expected that climate change will enhance the variability of monsoon and winter rains.

River Flows: The average annual river inflows are about 142 maf or 175 bcm at RIM (River Inflow Monitoring) stations, varying from 97 maf in a low-flow year (2002) to 172 maf in a high flow year (1992) during the period 1977-2003. Some 82% of the water inflows are during the Kharif period (i.e. the summer months: April – September) and about 18% in the Rabi period (i.e. the winter months: October – March). The summer flows in Indus and Kabul rivers are dominated by snow and glacier melt, while those in Chenab by snow and glacier melt together with monsoon rains; Jhelum is mainly fed by snowmelt and rains from summer monsoon. The source of winter flows in all the IRS rivers is winter rainfall combined with the base flow. It is expected that due to increased variability of monsoon and winter rains and the loss of natural reservoirs caused by glacier melting (see below) as a result of climate change, the inter-annual and intra-annual variability of river flows will increase and also there will be more frequent and intense occurrences of floods and droughts.

Irrigation System: Pakistan possesses the world's largest contiguous irrigation system (commonly called as Indus Basin Irrigation System) which commands an area of about 14.3 million hectares (mha) or 35 million acres representing about 76% of the cultivated area. The

system encompasses the Indus River and its major tributaries and includes three large reservoirs (Tarbela, Mangla and Chashma). On the average about 104 maf of the river flows is diverted to the canal system. Besides the river water some 48 maf of pumped ground water is also used for irrigation. The current accountable use of water is: Agriculture: 92%, Industries: 3% and Domestic & infrastructure: 5%. In future, while the water demand by all the sectors will increase due to socio-economic development and population increase, that by the agriculture sector will increase much faster due to higher demand for irrigation water to compensate for higher evapotranspiration rates at elevated temperatures resulting from climate change. There being limited scope for expanding the supplies of water, Pakistan will have to go for improving the efficiency of water use in all the sectors, particularly in the agriculture sector.

Outflow to Sea: The average outflow to the sea (i.e. the flow below Kotri) is about 35 maf (average for 1976-77 to 2002-03 period) with the minimum flow being as low as 0.8 maf (in 2000-01) and the maximum flow as high as 92 maf (in 1994-95) (GoP-MoW&P 2005). In the low-flow years, water going to the sea is less than that necessary to prevent intrusion of sea water into the Indus deltaic region (IPOE 2005). With the rise in sea level caused by climate change, the minimum flow requirements will also go up in future.

Reservoir Capacity: Pakistan's water storage capacity comprises three large reservoirs Mangla, Chashma and Tarbela built in the years 1967, 1971 and 1974 with original capacities of 5.88 maf, 0.87 maf and 11.63 maf respectively (total original capacity: 18.37 maf). Due to silting the capacities of all the three reservoirs have been decreasing with time. The total capacity decreased to 13.68 maf in 2003 and is projected to decrease to 12.34 maf by 2010 (GoP-PC 2005). The present reservoir capacity (live storage) corresponds to only 9 percent of the IRS average annual flow and is low when compared with the corresponding figures for the world average (40 percent), India (33 percent), Nile river basin (347 percent) and Colorado river basin (497 percent) (GoP-PC 2005). Furthermore, the water storage capacity per inhabitant in Pakistan is also very low: only 150 cubic meters as compared to 2,200 cubic meters in People's Republic of China and 5,000 cubic meters in the U.S. and Australia (WB 2006). At present on the average 35 maf of water flows to the sea annually during flood season, while there is need to conserve every drop not required for optimal ecological flow into the sea (GoP-PC 2007). With the frequency and intensity of floods and droughts increasing as a result of climate change, there will be even greater need to store the surplus water during high river flow periods.

The major climate change related threats to water security are identified as:

- Increased variability of river flows due to increase in the variability of monsoon and winter rains and loss of natural reservoirs in the form of glaciers;
- Likelihood of increased frequency and severity of extreme events such as floods and droughts;
- Increased demand of irrigation water because of higher evaporation rates at elevated temperatures in the wake of reducing per capita availability of water resources and increasing 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 (this will have serious implications for storage of irrigation water and its supply for Kharif and Rabi crops);
- Possible drastic shift in weather pattern, both on temporal and spatial scales;
- Increased incidences of high altitude snow avalanches and GLOFs generated by surging tributary glaciers blocking main un-glaciated valleys;

- The need for considerable expansion in reservoir capacity (a) to take care of the increasing frequency and intensity of floods and droughts, (b) to take advantage of the greater 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 Indus deltaic region, (d) to take care of the loss in 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 per cent over the next decade alone (GoP-PC 2007);
- Increased degradation of surface water quality due to increase in extreme climate events like floods and droughts; and
- Lack of current knowledge and monitoring effort on climate change impacts in the HKH region; also lack of understanding and modeling capability about the patterns of glacier melt and rainfall feeding the IRS and the corresponding impact on IRS flows.

Agriculture & Livestock Sector: Current Status and Vulnerability: Agriculture and Livestock sector is the mainstay of the national economy in Pakistan. It contributes 22% to Gross Domestic Product (GDP), accounts for 60% of country's exports, provides livelihood to about 68% of the country's population living in rural areas and employs 43% of the national labor force. The foremost challenge before the sector is to adequately provide for the food and fiber needs of a growing population without irreversibly damaging the fragile ecosystem. Being open to vagaries of nature, this sector is highly vulnerable to climate change phenomena. The climate change will impact 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 caused by extreme events (floods, droughts and cyclones).

The major climate change related threats to food security of Pakistan 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 at elevated temperatures;
- 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 climate events of floods, drought and cyclones resulting in heavy damages to both crops and livestock;
- Greater abundance of insects, pests and pathogens in warmer and more humid environment, particularly after heavy rains and floods;
- Degradation of rangeland and further deterioration of the already degraded cultivated land areas such as those suffering from water erosion, wind erosion, water-logging, salinity etc.;
- Intrusion of sea water into 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 river flow patterns at seasonal, inter-annual and inter-decadal levels; also 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 low financial resources.

ADAPTATION MEASURES

There are two types of adaptations which help to cope with the negative impacts of climate change: autonomous and planned. Autonomous adaptations generally refer to those adjustments that are carried out irrespective of the knowledge of climate change, while planned adaptations are those made deliberately in order to address the expected climate change impacts. So far most of the adaptation effort undertaken in Pakistan falls in the category of autonomous adaptations. The following sections describe the adaptation needs of various sectors in Pakistan and identify the corresponding ongoing national actions and plans.

a) Water Resources: As discussed, the fresh water resources of Pakistan are based on snow- and glacier-melt and monsoon, both being highly sensitive to climate change. The existing information strongly suggests the following future trends: decrease in glacier volume and snow cover leading to alterations in the seasonal flow pattern of IRS rivers, increased annual flows for a few decades to be followed by decline in flows in subsequent decades; increase in the formation and burst of glacial lakes; higher frequency and intensity of droughts and floods; and greater demand of water due to higher evapotranspiration rates at elevated temperatures. These trends will further exasperate the already difficult situation of a water stressed-country facing demand increases due to population growth and increasing economic activity.

Some key adaptation measures that will help in enhancing Water Security in the wake of climate change are identified below:

- Reduce losses in the system of irrigation water supply and use to the maximum possible extent by reducing seepages from the canals and distribution networks and by adopting modern, more efficient irrigation techniques (e.g. use of sprinklers and trickle irrigation) to replace the conventional method of flood irrigation.
- Build sufficiently large reservoir capacity on Indus and its tributaries so as to ensure no flow of Indus water down Kotri, even during high flood years, in excess of that necessary for environmental reasons including prevention of excessive influx of sea water into the Indus deltaic region.
- Once a sufficiently large reservoir capacity is in place, use some of it as carry over dams instead of the current practice of seasonal storage only so as to be able to use excess water saved during a high flood year in the subsequent lean years.
- Ensure that, while making water allocations (within gross national availability) to various sectors in the medium- to long-term future, due consideration is given to changes in sectoral demands caused by climate change.

Water Resources: Ongoing and Planned Actions: It is planned to construct a series of large hydropower projects to add 18 MAF of new storage capacity by 2030 to the existing 12.5 MAF capacity (which is decreasing by 0.2 MAF annually due to silting); approval accorded for the construction of 4,500 MW hydropower plant at Bhasha with 6.4 MAF water storage capacity (the construction work will start in 2010); planned to complement the large storages by a comprehensive program of small and medium dams as well as measures for recharging underground reservoirs; investigations for using groundwater aquifers as water storage facilities; a major program underway for lining the water channels; plans to monitor continuously the movement of glaciers in northern Pakistan.

Recommended Measures: Addition of sufficient reservoir capacity on IRS rivers so that even during high flood years no water flows down Kotri in excess of what is necessary for environmental reasons; local rain harvesting and building of surface and sub-surface storages for agriculture and other local needs; adoption of stringent demand management and

efficiency improvement measures in all water-use sectors, particularly in the supply, distribution and use of irrigation water; reuse of marginal quality irrigation effluent.

b) Agriculture and Livestock: Not much attention has so far been paid in Pakistan to address the GHG emissions from the Agriculture and Livestock sector.

Some key measures for development and adoption are: (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 methane production activity of cattle besides providing them with better nutrition.

Agriculture & Livestock :Ongoing and Planned Actions: 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, water saving techniques in combination with the use of high yielding and water-efficient crop varieties, and (iv) increase milk and meat production by developing animals breeds which are less vulnerable to climatic changes, and by improving animal feedstock.

Recommended Measures: Development of new breeds of crops of high yield, resistant to heat stress, drought tolerant, less vulnerable to heavy spells of rain, and less prone to insects and pests; improvement of crop productivity per unit of land and per unit of water by increasing the efficiency of various agricultural inputs, in particular the input of irrigation water; improvement of farm practices by adopting modern techniques such as laser land leveling, crop diversification, proper cropping patterns, optimized planting dates etc; development and introduction of better varieties of livestock which would have higher productivity of milk and are less prone to heat stress and more drought tolerant.

INSTITUTIONAL CAPACITY FOR ADDRESSING CLIMATE CHANGE

Besides GCISC, there are several organizations in the country which could make useful contribution towards addressing climate change by: (i) enhancing capacity of all such organizations, (ii) introducing climate change related scientific disciplines in Pakistan’s leading universities so as to ensure a regular supply of trained manpower, and (iii) establishment of a National Data Bank for climatological, hydrological, agro- meteorological and other climate change related data to cater for the needs of all relevant institutions.

NEEDS FOR INTERNATIONAL COOPERATION

Being a developing country, Pakistan lacks technical capacity and financial resources to address climate change related issues. Following are the salient areas where it needs international cooperation and support for addressing climate change:

Mitigation Effort: Extensive use of renewable energy technologies (windmills, solar cells etc.); introduction and use of Clean Coal Technologies (e.g. CCS, IGCC, CBMC); use of

advanced nuclear power technology; introduction and use of Mass Transit Systems in large cities; infrastructure development for large scale import of natural gas; increase in hydropower generation capacity; large scale afforestation and reforestation activities.

Adaptation Effort: Sufficient expansion of large reservoir capacity; improving efficiency of water supply and distribution in the irrigation system; development of capacity to deal with disasters like floods, droughts and cyclones; construction of structures like dikes and seawalls at strategic points on the coast.

Capacity Building: Expansion of meteorological monitoring stations in various parts of the country, in particular in the northern mountainous areas and over the Arabian sea adjoining Pakistan's coastline, to the level recommended by the World Meteorological Organization; development of a cohort of professionals in the field of climate change by getting a group of young scientists trained with the help of reputable foreign institutions in fields such as regional climate modeling, watershed modeling and crop growth simulation modeling; forecasting of seasonal and inter-annual climatic changes and extreme events; monitoring of temporal changes in glacier volumes and land cover using satellite imagery and GIS techniques

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