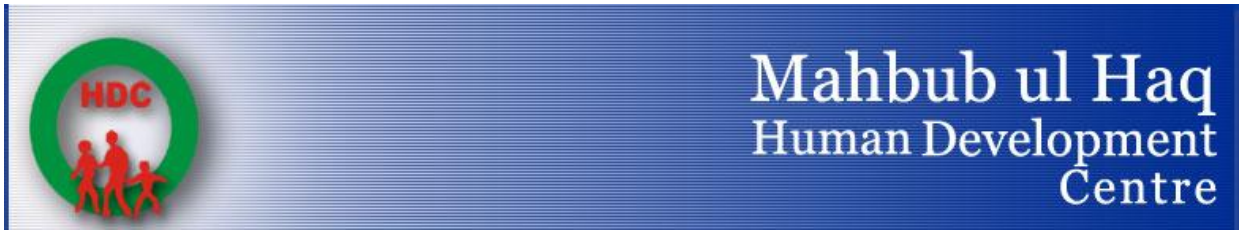

Working Paper # 01

Environment, Energy and Climate Change in Pakistan: Challenges, Implications and Required Responses

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with
Abeer Masood

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Contents

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"Poor people and poor countries depend on the soil for food, the rivers for water and the forests for fuel…financial savings will not be sufficient for sustainability if some natural resource required to sustain life becomes seriously depleted…"

MahbubUl Haq,
Reflections on Human Development

Environmental insecurities, energy scarcity and climate change present rapidly growing threats to human development and security in Pakistan. According to one estimate, the average annual cost of environmental degradation and natural resource damage in the country is about US$ 365, or US$ 1 billion a day.[1]

Both natural and man-made factors contribute to these problems. They include a rapidly growing population, urbanisation, industrialisation, the unsustainable harvesting of resources and inadequate, poorly implemented state policies. The consequences can be seen in the form of severe health hazards, food and livelihood insecurity and the increasing vulnerability of marginalised communities that are heavily dependent on natural resources. The severity of the situation necessitates immediate actions to assess the causes and extent of damage and recommend practical measures to safeguard natural life support systems from further damage.

This working paper analyses and synthesises some of the most important trends and challenges in the areas of environmental insecurities, energy scarcity and climate change in Pakistan. It studies the driving factors behind these problems, assesses the implications for human development and security, and presents recommendations for more responsible natural resource management by both the state and civil society.

Environmental insecurities: Causes and implications

The following subsections examine the issues of water scarcity, water pollution, air pollution and deforestation, some of the gravest environmental challenges in the country, particularly in terms of the extent of their impact on human, animal and plant life.

Water scarcity and distribution

Surface and groundwater availability

Pakistan depends on a combination of an intricate river system which starts in the Karakoram, Hindu Kush and Himalaya mountain ranges.These permanent rivers are the main source of surface water in Pakistan,[2] followed by springs and seasonal rivers. Unfortunately, the country has invested very little in building its water storage capacity and only has the capacity to store 30 days of river runoff, far lower than neighbouring India, which can store between 120 to 220 days of runoff from its major peninsular rivers.[3]

A large proportion of the population also depends on groundwater for domestic consumption and irrigation. Pakistan's groundwater resources include trans-boundary aquifers shared with India, called the India River plain. This is a porous aquifer system with a 560 thousand kilometer square extension area, covering the provinces of Punjab and Sindh in Pakistan and the western regions of India. Over the years, an ever-expanding population and reduced river and canal water supplies at critical cropping times have increased the reliance on groundwater for domestic consumption, irrigation and other purposes.

As shown in table 1, more than 169.4 billion cubic meters (cu. m) were withdrawn in 2007. In contrast, only 55 billion cubic meters of groundwater were recharged that year. Moreover, the quality of groundwater in many parts of the country is also beginning to deteriorate because of the intrusion of saline water into non-saline water areas. While about eighty per cent of the Punjab still has fresh groundwater, the situation is quite alarming in other provinces. In Sindh, more than seventy per cent of groundwater is saline.[4] In the province of Khyber Pakhtunkhwa (KP), wells are now extracting saline water layers, and much of Balochistan has saline groundwater. This fall in fresh groundwater resources exacerbates inter-provincial conflicts over the distribution of surface river waters.

Table 1 Freshwater in Pakistan, 2007

Renewable internal freshwater resources		Annual freshwater withdrawals					Water productivity	Access to an improved water source*	
Flows billion cu. m	Per capita cu. m	billion cu. m	% of internal resources	% for agriculture	% for industry	% for domestic	GDP/water use 2000 $ per cu.m	% of urban population	% of rural population
55	339	*169.4*	308	96	2	2	0.4	95	87

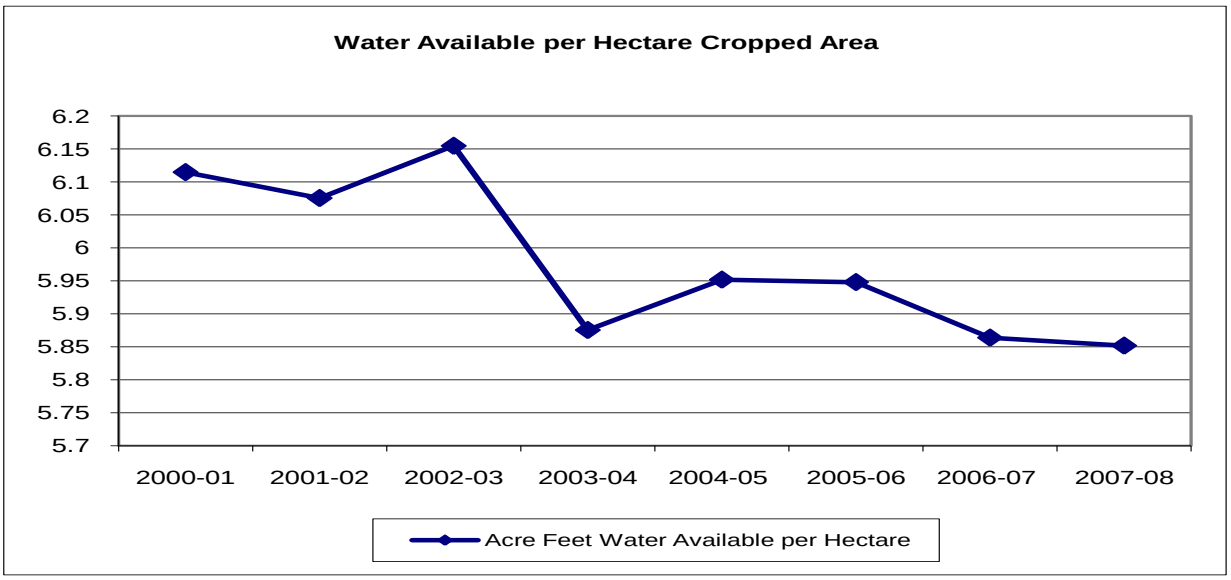
Note: *: Values are for the year 2006.
Source: World Bank 2009.

Allocation of scarce water resources

While Pakistan does face a deficiency of water resources, this scarcity is aggravated by problems of water sharing and allocation. The first critical challenge that the country faces with respect to water distribution is between agriculture and other sectors with water needs.

Agriculture is one of Pakistan's main economic activities and agricultural commodities comprised about one-fifth of Pakistan's gross domestic product in 2008.[5] Pakistan's agricultural and economic growth is dependent on water from the Indus River. The annual flow of water in the Indus is about 115 million acre feet (142 cubic kilometers) and the river is the lifeline of one of the largest irrigation networks in the world.[6] Agricultural irrigation absorbs 96 per cent of this water in Pakistan, as compared to the global average of 70 per cent.[7] About 23 million hectares of land were cultivated in Pakistan in 2008 and 87 per cent of this area had irrigation water available.[8]Any change or reduction in water availability for agriculture could be devastating for Pakistan's economy and its people. In a **w**orrying trend, there has been a decline in the volume of water available per hectare of cropped area in Pakistan (figure 1), posing considerable challenges for future productivity.

Figure 1 Irrigated agriculture in Pakistan

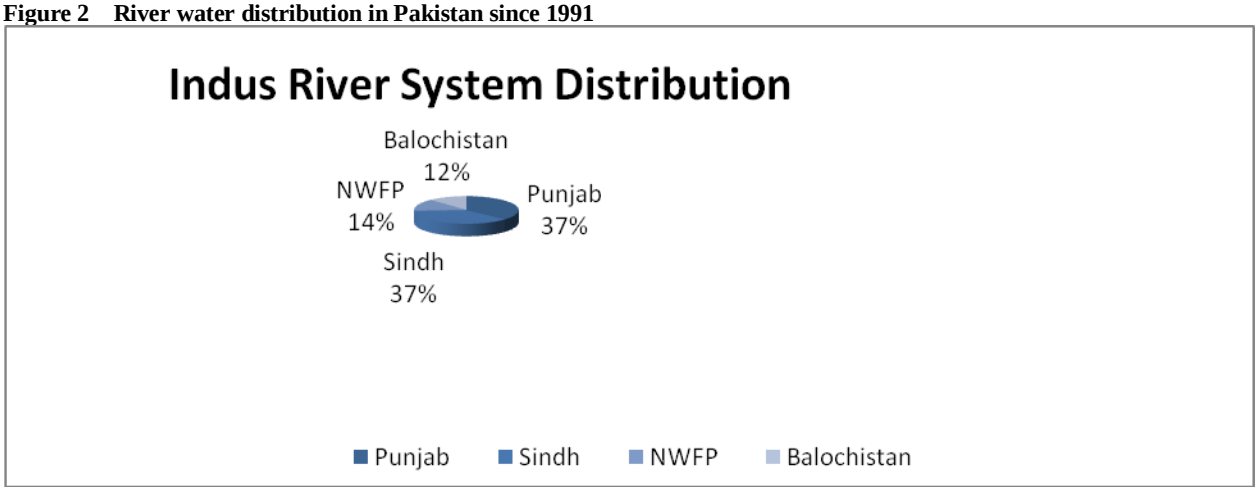


*Source:*GOP 2008a.

The second challenge of water sharing is the distribution of water, especially the division of irrigation water, among Pakistan's provinces. This has become an increasingly contentious issue over the years, especially between the provinces of Punjab and Sindh, with serious sociopolitical consequences of reduced water flow in the Indus River System.

The four provinces agreed to a formula to share water from the Indus in 1991 under the 'Agreement on Apportionment of Water from the Indus River System' (figure 2) and the Indus River System Authority (IRSA) monitors the flow of this water.However, in May 1994, the provinces of Punjab and Sindh agreed on a temporary 'ministerial arrangement' because of water shortages brought on by droughts and reduced precipitation. The arrangement distributed water between Punjab and Sindh based on the average Indus River water used during 1977 to 1982. On the basis of this 'historical use', the share of Punjab increased to 51 per cent, significantly reducing Sindh's share of water.

Figure 2 River water distribution in Pakistan since 1991



*Source:*Kazi 2009.

The consequent decrease in the flow of freshwater at the downstream delta area in Sindh leads to several problems, including the ingress of seawater into the Indus River Delta. This has led to heightened

tensions between the two provinces, with irrigation and ecology experts fromSindh and Punjab disagreeing on the methodology needed to prevent the ingress of seawater into the Indus Delta. While ecology experts from Sindh suggest that a minimum of 18 million acre feet (MAF) river water outflow is needed to safeguard marine life, mangroves and prevent the ingress of seawater into the Indus Delta, experts from Punjab do not agree with the need for this amount of water below Kotri Barrage and suggest that a wall could be built to prevent the ingress of seawater instead.[9] With increasing demand from agriculture and looming water shortages, there is an urgent need for a more effective water distribution policy to avoid inter-provincial conflict.

Finally, Pakistan also faces serious cross-border water sharing and distribution issues with India. The Indus Water Treaty - a water sharing treaty, formulated by the World Bank - was signed between India and Pakistan in 1960 and was meant to guarantee that Pakistan would receive water from the Indus River independent of upstream control by India. According to the treaty, Pakistan is entitled to 142 MAF; 93, 23 and 26 MAF from the Indus, Jhelum and Chenab, respectively. This amount was estimated on the records of 50 years' mean flows at the rim stations of Attock on Indus, Mangla on Jhelum and Marala on Chenab as these rivers enter the Indus plain.[10] However, while Pakistan was entitled to receive 55,000 cusecs of water in the Chenab River under the treaty in 2008, its share was drastically reduced to 13,000 cusecs in the winter and 29,000 cusecs during the summer,[11] causing considerable damage to agricultural crops. As India continues to expand its investments in building dams on its western borders, serious concerns arise in Pakistan on the former's ability to disrupt the flow of river waters.

Impact of water shortages

The water available per capita in 1951 in Pakistan was 5,300 cubic meters but has now fallen to 1,105 cubic meters, perilously closer to the internationally accepted scarcity level of 1,000 cubic meters per capita.[12] This scarcity of freshwater resources has threatened productivity, hurt incomes, led to conflict and outmigration and caused considerable ecological degradation.

On the production side, Pakistan depends heavily on irrigation water for the production of water intensive crops such as cotton, rice and sugarcane for both domestic consumption and export earnings. As water becomes scarcer, farmers have to make expensive investments in efficient water usage techniques such as sprinkler and drip irrigation systems. However, these systems are unaffordable for most of the country's agricultural producers, particularly small-scale and subsistence female farmers who have little or no access to institutional credit and extension services. Many farmers also do not possess sufficient knowledge on how to use these newer technologies. Consequently, water scarcity decreases agricultural productivity and increases food prices, thus threatening the livelihoods and food security of workers in the agricultural sector and poor populations who cannot afford higher food prices.

Furthermore, the decline in water storage capacity in Pakistan's biggest dams because of siltation and the period of low precipitation that preceded the 2010 floods, led to a fall in hydropower production. This contributed to severe loadshedding, which increased production costs and made everyday life more difficult for the average citizen.

The prolonged drought in Balochistan provides another example of the human costs of water scarcity. During the drought of 1997-2001, 84 per cent of Balochistan's population was declared calamity-hit, agricultural productivity fell, livestock was lost and surviving animals were sold in distress sales to avoid further losses. The drought devastated agricultural and pastoral communities who already had little access to health and education facilities and low incomes per capita. Many families and individuals, particularly men, migrated to other regions not affected by the drought, there were cases of people selling their daughters for food and many children were pulled out of school. Furthermore, conflicts broke out between sedentary and migratory pastoral communities as the latter's right to access traditionally shared grazing lands were challenged during the drought.[13]

Finally, the ecological impact of water scarcity must be examined. A prime example of this is the intrusion of seawater into the Indus Delta. With growing water scarcity, supplies of fresh river water below Kotri Barrage have declined. Together with frequent cyclones, this has led to the intrusion of

seawater 54 kilometers into the Indus Delta along the river's course.[14] The sea has invaded over 1.2 million acres of fertile agricultural land in Thatta and surrounding areas, damaged mangrove and riverine forests and led to a decline in wildlife, migratory birds, fish and shrimp species.[15] This ecological degradation has also hurt livelihoods as many agricultural and fishing communities in the region have experienced a fall in agricultural productivity, a decline in fish catches and have had to migrate to other places to survive.

Water pollution

Pollution compounds the problems of water scarcity and distribution and has become a critical concern in Pakistan. The disposal of untreated urban sewage, industrial effluent and agricultural drainage runoff is responsible for most of the contamination of lakes, rivers and groundwater aquifers. The following sections present an analysis of the causes of deterioration in water quality in the country and the implications of this phenomenon on soil, vegetation, marine, animal and human life.

Urban and industrial waste

Rapid urbanisation has contributed significantly to water pollution in Pakistan. Most urban centers and peripheries release sewage into waterways with minimal or no treatment, threatening human health and aquatic life. In Pakistan, domestic urban municipal sewage is one of the major sources of water pollution. About two million wet tons of human excreta are produced annually in urban areas and about half of this goes into water bodies to pollute them.[16]

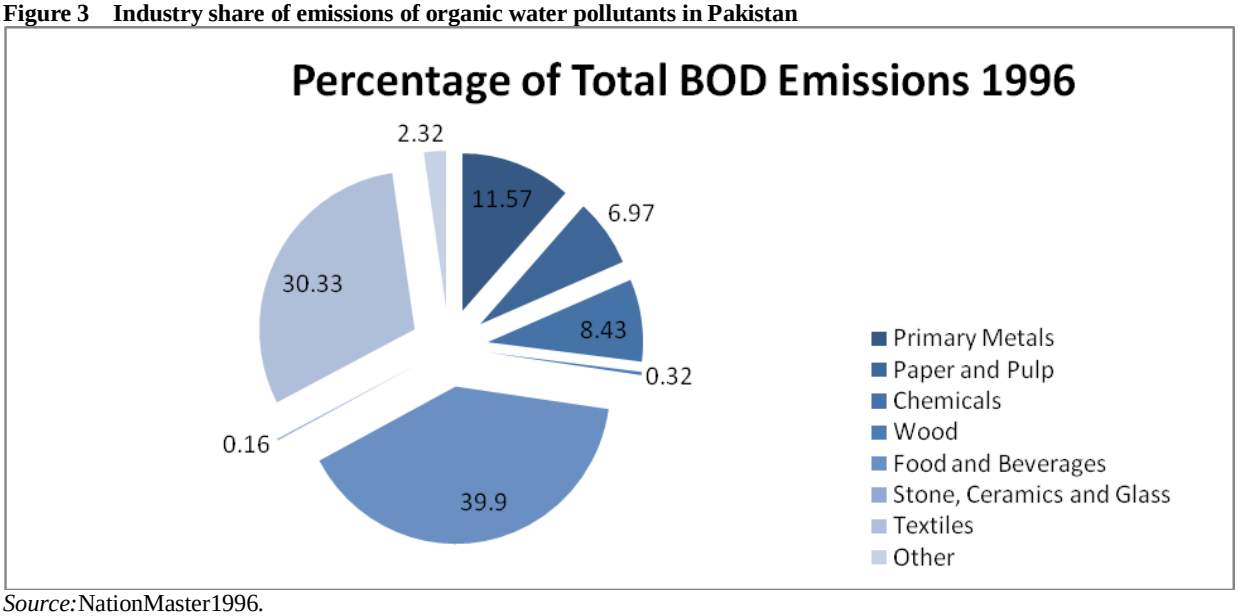
The problem is aggravated by the release of industrial effluents into surface and groundwater around industrial areas and densely populated cities. Reports indicate that the indiscriminate discharge of industrial wastes in the form of liquids, solids, gases, radioactive materials and toxic chemicals, is deteriorating water quality adjacent to industrial areas in Sindh, Punjab and Khyber Pakhtunkhwa.

In Karachi, almost all of the city's six thousand industrial units discharge their untreated effluents - containing heavy metals and chemical compounds - directly into the water system leading to the sea. Consequently, studies have established that the marine environment around Karachi has become highly toxic, harming aquatic flora and fauna.[17] Research conducted on the heavy metal and chemical composition of soil and vegetation surrounding industrial estates in the city indicates physico-chemical parameters well above the maximum safe limits set by the WHO.[18] The soil showed significant concentrations of trace metals and some soil extracts were found to be highly acidic, indicating that the effluents ultimately pollute vegetation as well. A high level of trace metal concentrations was also observed in groundwater samples collected from the periphery of these industries. This shows the percolation of pollutants into groundwater through the soil and the unsuitability of the groundwater for drinking purposes.[19]

In the province of Punjab, over a thousand industrial units and municipalities in Lahore, Sialkot, Kasur, Sheikhupura and Faisalabad are also directly discharging more than five thousand cusecs of untreated toxic effluents into drainage systems. Similarly, there are more than a hundred sewage water point sources around cities and towns that are disposing wastewater into drains and canals. This wastewater eventually flows and seeps from drains and canals into open rivers and groundwater aquifers.[20]

Some farms adjacent to these industrial estates are experiencing a slow build up of soil salt content and the pollution of shallow open wells because of the use of wastewater for irrigation. More worryingly, the contamination is gradually reaching deeper aquifers as well.[21] Figure 3 shows the organic water pollutant biochemical oxygen demand (BOD) emissions of major industrial units in Pakistan and box 1 discusses the effluent discharge from the textile industry.

Figure 3 Industry share of emissions of organic water pollutants in Pakistan



Source: NationMaster1996.

Box 1 Effluent discharge from chemical processing in the textile industry

Textile processing is a water intensive process; cotton mills consume a large volume of water for processes such as bleaching, dyeing, printing and finishing of fabric, sizing, de-sizing, scouring, mercerisation, and ultimately washing. The wastewater generated by the industry essentially originates from the effluent produced during the various stages of wet processing of textiles.

Currently, industry effluents are discharged without any treatment, with serious negative impacts on the environment. Chemical processing is responsible for about 70 per cent of industry pollution. As seen in table 2, this polluted water affects the aquatic eco-system in a number of ways, such as the depletion of dissolved oxygen content and settlement of suspended substances.

Table 2 Characteristics of textile processing wastewater in Pakistan

Parameters	Prevailing ranges	National Environmental Quality Standards (NEQS) limits
Biological Oxygen Demand (BOD)	120-440	80
Chemical Oxygen Demand (COD)	300-1,100	150
Total Dissolved Solids (TDS)	200-5,000	3,500
Total Suspended Solids (TSS)	50-240	150
PH value	8-11	6-10
Oil and grease	10-45	10
Chromium	0.5-2.5	1

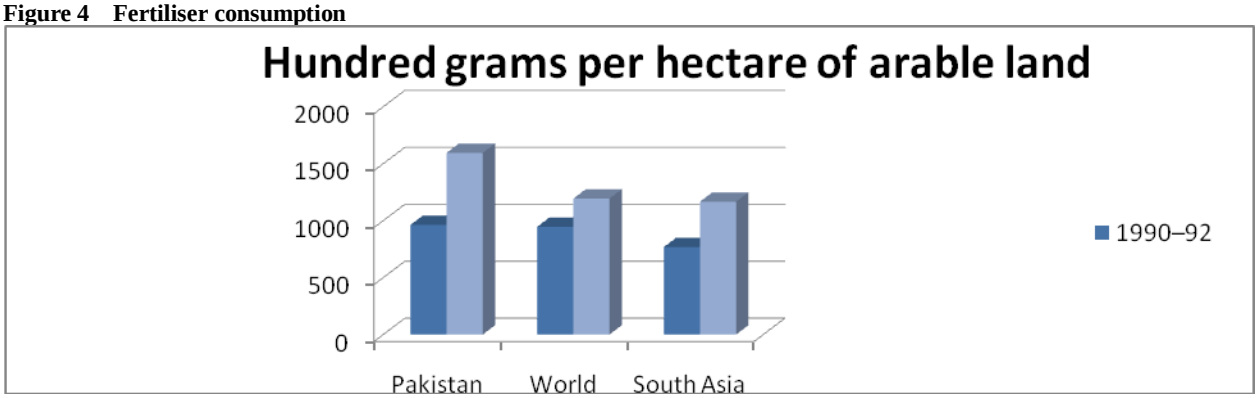
Note: All values are in parts per million (ppm), except pH.
Source: Malik 2002.

Sources: Das 2009 and Malik 2002.

Agriculture and water quality

Agricultural activities are linked strongly to the deterioration of water quality in Pakistan. The country uses an estimated 5.6 million tonnes of fertiliser and some 70,000 tonnes of pesticides annually[22] and its per hectare intake of fertiliser is increasing at a faster rate than most other countries over time (figure 4). Not surprisingly, these chemicals cause surface and groundwater pollution through agricultural runoffs. This refers to the process of water carrying fertiliser, soil particles and pollutants, leaving agricultural fields and being deposited into lakes, rivers and groundwater sources.[23]

Figure 4 Fertiliser consumption



Source: World Bank 2009a.

The contamination of water resources through agricultural runoff in Pakistan has been highlighted in various studies. In one investigation, the Pakistan Council of Research in Water Resources (PCRWR) tested the water system in Punjab for pesticide contamination due to agricultural runoff and found that one-fifth of the samples tested had traces of pesticide residues beyond World Health Organization (WHO) safety limits.[24] Another study indicates the damage done to wetlands through agricultural runoffs and human activity in the Uchalli Wetlands (box 2).

Box 2 Water quality in theUchalli Wetlands

The Uchalli Wetland Complex is an internationally renowned combination of three independent wetlands: Uchalli, Khabbaki and Jahlar, located in the Salt Range of North Punjab, Pakistan. There has been a dramatic change in the ecosystem of the Uchalli Wetlands in the last ten years, affecting its ability to function as a habitat for waterfowl, shorebirds, and migratory birds.

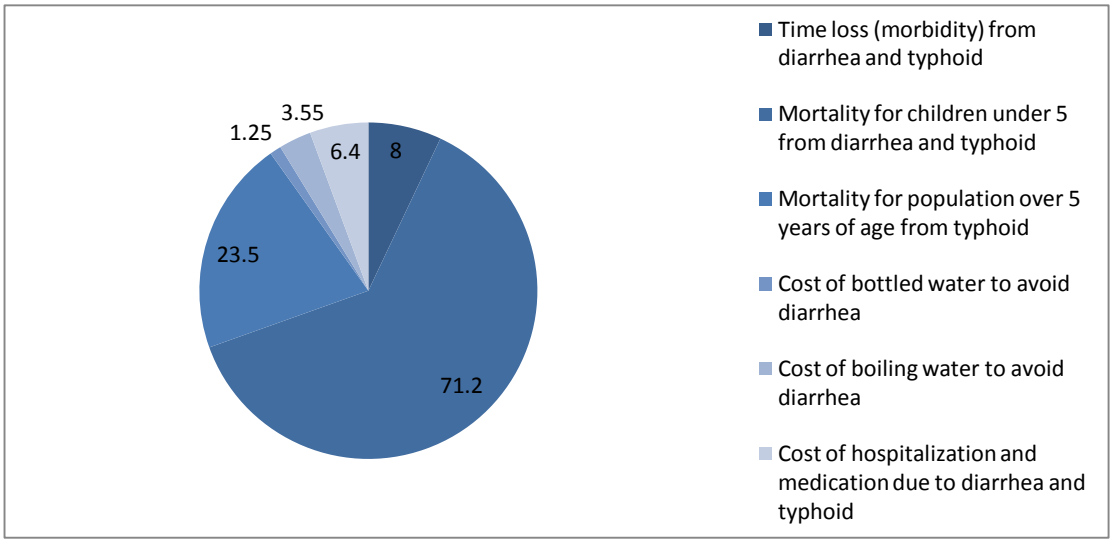
A study undertaken between 1992 and 2004 revealed that the waters of the three wetlands were highly alkaline and had heavy concentrations of dissolved solids and nutrients as a result of agricultural runoffs and anthropogenic activities in surrounding areas. This led to weed infestation, algal blooms, oxygen deficiency, bad odours and eutrophication, inducing considerable changes in the dynamics and distribution patterns of avian population in the three wetlands. The avian habitat loss has been further intensified by factors such as agricultural chemicals and pesticides, overgrazing, deforestation in catchment areas, siltation, illegal hunting of birds and changing climatic conditions.

Source: Ali 2005.

Impact of water pollution

The pollution of surface and ground waters from domestic, industrial and agricultural activities has had a negative impact on human security through its influence on health, productivity, livelihoods and animal, marine and plant life. The greatest cost of water pollution arguably lies in its impact on human health. The long-term use of polluted water can cause colon and bladder cancer, birth defects, bone deformation, miscarriages and sterility.[25] In the immediate period, it can cause skin problems, stomach illnesses, typhoid, cholera, intestinal worms, diarrhea and hepatitis. A UNICEF study found that people suffering from water related diseases occupied 20 to 40 per cent of hospital beds. Death and disease due to diarrhea and typhoid, two of the most prevalent water related diseases, lead to the annual loss of 1.6 million and 900,000 disability adjusted life years, respectively. One estimate puts the total health costs of water related morbidity and mortality in Pakistan at PKR 114 billion (figure 5 provides a breakdown of these costs).[26]

Figure 5 Costs of water related mortality and morbidity (PKR. billion per annum)



Source: World Bank 2006b.

The impact of polluted waters on food security, productivity and livelihoods is also quite significant. In the agricultural sector, the industrial chemicals, fertilisers, and pesticides used to increase productivity have instead ironically hurt the livelihoods of thousands of farmers. Agricultural runoff seeping into soils causes waterlogging and salinity. Soil is regarded as waterlogged when the groundwater table approaches the soil surface. This stops air from getting into the soil, making it difficult to grow agricultural crops in waterlogged soils. Waterlogging and salinity have affected 13 per cent of the cultivated area in Pakistan. These 2.2 million hectares of land have a water table less than 5 feet from the surface.[27] In addition to this, irrigation water contains high levels of contaminants, salts and chemicals. Once this water evaporates from the surface, it results in topsoil damage. One estimate suggests that 25 per cent of irrigated land suffers from various levels of salinity and that yield reductions and lost opportunities from cropping on lands with high salinity levels cost Pakistan between PKR 30 to 80 billion, with a mean cost of PKR 55 billion annually.[28] The fishing industry, and small-scale farmers in particular, have also suffered considerable losses as algal growth spurred on by nutrients in agricultural runoff, effluent from industries such as leather tanning and textile units, and untreated domestic wastewater, kill off aquatic life.[29]

Finally, the effect of water pollution on biodiversity and coastal ecosystems cannot be ignored. Pakistan's coastal ecosystem is heavily dependent on mangroves that protect feeder creeks from sea erosion and provide habitat to a diverse range of interdependent invertebrates, fish, birds, reptiles and crustaceans. South Asian waterfowl also seek food and shelter in these mangroves along their migratory paths. Severe pollution from a combination of municipal and port transportation activities, oil spills from ships and industrial activities, have all contributed to the thinning of mangroves and threaten the many species dependent on them.

Air pollution and air quality

Air pollution has turned into a significant environmental problem in Pakistan. In the period 1990 to 2005, carbon dioxide, methane and nitrous oxide emissions in the country increased by 97.4, 33.2 and 44.5 per cent, respectively.[30] While air pollution is primarily considered to be an urban problem, rural areas also face challenges of air pollution, primarily in the form of indoor air pollution (IAP) and emissions from industries located nearby.

Rapid urbanisation spurred on by a burgeoning population, the combustion of municipal waste, growth in vehicular emissions and industrialisation have been the principal anthropogenic factors behind the increase in air pollution. The problem is exacerbated by emissions from transboundary pollution, the burning of biomass in poorly ventilated homes and an arid climate that leads to the suspension of fine dust particles, particularly in cities in the provinces of Punjab and Sindh. Factors such as poor coordination between federal, provincial and local bodies and ill-equipped and understaffed environmental protection agencies (EPAs) further limit the management of air quality.

Urbanisation and transportation

Rapid population growth, declining productivity in agriculture, limited employment opportunities and poor facilities and infrastructure in rural areas encourage increasing numbers of people to migrate to cities every year. This ever-expanding urban population has aggravated the crisis of air pollution in Pakistan's cities.

A study by SUPARCO in Karachi, Lahore, Peshawar, Quetta, Rawalpindi and Islamabad revealed that the level of fine particulate matter (PM) exceeded internationally accepted standards in all these cities, with the highest levels recorded in Quetta and Lahore. Another study by the Pakistan Environmental Protection Agency (EPA) together with the Japan International Cooperation Agency (JICA) in Lahore, Faisalabad, Gujranwala, Rawalpindi and Islamabad showed that fine PM levels were 6-7 times greater than WHO guidelines.[31]

A number of factors help explain the poor air quality found in many Pakistani cities, the most important of which is the growth in vehicular emissions. Experts estimate that between 60 to 70 per cent of the degradation of urban air quality can be attributed to vehicles.[32] The number of motor vehicles registered in the country has increased from 4,303,296 to 5,366,460 between 1998 and 2007,[33] an increase of 24.7 per cent.

This growth was encouraged by liberal leasing systems adopted by financial institutions in the last few years and the absence of an efficient public transport system. The use of adulterated fuels and diesel with high sulphur content (0.5 to 1 per cent), infrequent vehicle inspections, inadequate transport control, poor traffic management and driving on ill-maintained roads exacerbate the effect of this continuously expanding fleet of vehicles on the environment.

However, the government has taken certain positive steps to curtail harmful vehicular emissions. First, it has actively promoted the use of compressed natural gas (CNG)[34] and in December 2009, Pakistan had 2.4 million vehicles running on CNG, the highest in the world. Moreover, it had 3,105 CNG refueling stations, also the highest in the world.[35] Many cities have begun to ban or restrict the use of two stroke engine rickshaws and have introduced public buses and rickshaws that run on CNG. For example, in 2008, the Punjab Transport Department banned the registration of two stroke engine rickshaws in

Lahore, Gujranwala, Rawalpindi, Faisalabad and Multan, while the City District Government of Karachi (CDGK) introduced the CNG Bus Project. However, the recent closure of CNG stations over the 2009-10 winter led to people switching to petrol and was estimated to have increased carbon emissions by 28.5 per cent.[36]Gas shortages in the winter of 2010-11 are likely to continue to contribute to carbon emissions.

Second, unleaded gasoline was introduced in 2002 and has been produced and marketed since 2003. Moreover, in May 2009, the Ministry of Environment decided to enforce Euro-II emission standards, which limit hydrocarbon, carbon monoxide and nitrogen oxide emissions, for petrol driven vehicles from July 2009 and for diesel driven vehicles from July 2012.

Another factor that has contributed to deteriorating air quality is the lack of proper waste disposal systems in Pakistani cities. An estimated 54,888 tons of solid waste are generated everyday and dumped in low-lying areas and/or burnt.[37] The combustion of this waste at low temperatures releases particulate matter, carbon monoxide, oxides of nitrogen, dioxins (highly toxic compounds that are persistent organic pollutants) and other carcinogenic pollutants that are detrimental to air quality.

Industrialisation

Industrial activities are unarguably the most important source of air pollution together with vehicular emissions. The increasing demand for energy, combustion of fossil fuels and waste products by industry has intensified the problems of air pollution in the country. Many large units such as those of fertiliser, cement, sugar, steel and power plants, use furnace oil with high levels of sulphur. Smaller units such as those involved in steel recycling, plastic molding and brick kilns also have a large impact on air quality by using dirty waste fuels such as textile waste, wood, paper and old tires.[38] The main pollutants from these industries include particulate matter and oxides of sulphur and nitrogen.

In a worrying trend, a clear demarcation between residential and industrial areas no longer exists in the country. Cities have expanded in every direction and consequently, industrial estates that were previously in the suburbs now encroach into the municipal limits of large cities, sitting side by side with residential and commercial areas. For example, about 450 brick kilns are situated in and around the city of Peshawar.[39] These kilns employ used mobil oil and tires for fuel, emitting a mixture of hydrocarbons, carbon monoxide and sulphur dioxide into the air. Loadshedding and the unavailability of power supplies have further compounded the problem of air pollution as more and more manufacturing units have begun to rely on the use of diesel powered electric generators to meet their needs. These developments have severe implications for the quality of air and health of urban populations living nearby.

Winter fog and trans-boundary air pollution

During the past decade, Pakistan has witnessed increasingly dense and longer durations of fog in the winter. A satellite image from December 2008 showed that the fog covered an area of 46,281 sq. km in North Eastern Pakistan and Northern India.[40]

The fog is thought to be transported as air pollution in the North East monsoon season from India and China. Emissions from coal and oil fired power stations, vehicles, refuse burning and other sources consist of pollutants such as sulphur dioxide, carbon monoxide, nitrogen oxides and particulate matter that travel over hundreds of thousands of kilometers as trans-boundary pollution and impact regions far from the source of emissions. A study in Lahore indicates that the sulphur dioxide particles observed during and after a period of fog came from a source hundreds of kilometers away.[41] It is believed that the fog was caused by coal burning activities in Northern India as Lahore is downwind of this region.

Every year the fog impacts both economic activities and human health. Several flights have to be cancelled or delayed during fog days and road and railway traffic face severe disruptions, leading to economic losses of billions of Rupees. It also aggravates respiratory illnesses and has implications for agricultural productivity and global and regional climate.

Indoor air pollution (IAP)

In Pakistan, IAP is caused primarily by the use of biomass fuels such as wood, crop residues and dung for heating and cooking in poorly ventilated houses. It is more prevalent in rural areas and has severe health implications for women and young children in particular, as these groups spend the most time indoors. One study estimates that indoor air pollution leads to over 28,000 deaths annually.[42] However, Pakistan still does not have regulations to provide guidelines for IAP and the problem is yet to be recognised as a hazard at a policy level.

Impact of air pollution of human security

The biggest threat that air pollution poses to human security is in terms of health costs. For example, suspended particulate matter can aggravate breathing problems and cause eye irritation, lead exposure has been linked to reduced intelligence in children, carbon monoxide interferes with the blood's ability to carry oxygen and nitrogen and sulphur oxides can aggravate asthma.[43] Long term exposure to polluted air can cause lung cancer, chronic obstructive pulmonary disease, respiratory infections and cardiovascular disease. One study estimates that urban air pollution alone is responsible for 22,000 premature adult deaths and 700 deaths among children. The total health costs amount to between PKR 62 to 65 billion annually (table 3 presents a breakdown of these costs).[44]

Table 3 Annual health impact of urban air pollution

	Attributed total cases	Total annual costs (billion PKR)
Premature mortality adults	21,791	58-61
Mortality children under 5	658	0.83
Chronic bronchitis	7,825	0.06
Hospital admissions	81,312	0.28
Emergency room visits/Outpatient hospital visits	1,595,080	0.80
Restricted activity days	81,541,893	2.06
Lower respiratory illness in children	4,924,148	0.84
Respiratory symptoms	706,808,732	0.00
Total		**62-65**

Source: World Bank 2006.

Indoor air pollution is estimated to impose further health costs between PKR 55 to 70 billion, with average costs of PKR 62 billion annually.[45]Poor rural communities who rely on biomass fuels and often do not have access to modern health facilities, suffer the most from IAP. Table 4 presents upper and lower estimates for the number of cases of acute respiratory illness and chronic obstructive pulmonary diseases in children and women (the groups in any community who are most exposed to IAP) in Pakistan.

Table 4 Health problems associated with indoor air pollution		
	Estimated number of cases	
	Low	High
Acute respiratory illness:		
Children (under the age of 5 years) - increased mortality	21,933	31,060
Children (under the age of 5 years) - increased morbidity	29,508,800	41,788,200
Females (30 years and older) - increased morbidity	10,754,600	15,229,800
Chronic obstructive pulmonary disease:		
Adult females - increased mortality	7,408	11,433
Adult females - increased morbidity	21,850	33,721

Source: World Bank 2006.

Air pollutants such as sulphur and nitrogen oxides are also responsible for acid rain, which leads to further health, environmental and economic damages. It acidifies water bodies and kills off marine life; corrodes structures such as buildings and bridges; and hurts plant life. In Germany, for example, acid rain damaged almost half the trees of the Black Forest. In India, rapid industrialisation is believed to be linked to growing incidences of acid rain, causing significant damages, such as the well-known case of the corrosion of the TajMahal.

Finally, studies suggest that air pollution can cause significant reductions in agricultural productivity. Experiments in suburban Varanasi, in neighbouring India, showed that using charcoal filtered air with lower concentrations of sulphur dioxide, nitrogen dioxide and ozone than the ambient air, increased the shoot length, leaves per plant, leaf area and root and shoot weight of carrot plants.[46] Studies on the outskirts of Lahore found that air pollution led to significant reductions in wheat and rice yields.[47] These findings are very worrying for Pakistan, where rapid population growth fuels the demand for fossil fuels, creating more air pollution. This may hamper the very improvements in agricultural output that are needed to feed the country's continuously expanding population.

Shrinking forests

A variety of natural forests exist in the diverse ecological regions in Pakistan including conifers, riparian areas, thorn forests and mangroves. Forty per cent of the total forest area in Pakistan comprises of conifers in the hills and mountains of the Northern part of the country with scrub forest on the foothills and in temperate zones. The other sixty per cent of forest area includes: irrigated plantations; trees planted on farmlands; riverine forests of thorny shrubs and riparian plantations along major rivers in the Indus plains; and mangrove forests in the Indus Delta and Arabian Sea coastal areas.

Each province has its own particular types of forests. Punjab is famous for pine forests located mainly in the Northern Murree mountain ranges. Balochistan has two types of forests. The first is the Zarghoon Juniper Forest, situated about 30 km away from Quetta and one of the most fragile ecosystems in Pakistan. The forest has an extremely slow growth rate and faces very harsh climatic and geophysical conditions. The second is the SuleimanRange, the largest pure stand of Chilghoza pines in the world and a critical habitat for the endemic Suleiman markhor. Sindh and Balochistan are also home to mangrove forests, which cover about 257,500 hectares in the country. Those found in the Indus Delta in Sindh are the world's sixth largest contiguous mangrove forests. Finally, the Khyber Pakhtunkhwa is home to 1.3 million hectares, or about 30 per cent of Pakistan's forests, comprising of deodar, pine, chilghoza, fir, nandar, partal, kail and other trees. Seventeen per cent of the province is covered by forests, with the largest concentration of forest area found in the Malakand and Hazara divisions.[48]

These forests cover less than five per cent of Pakistan's total area and at current rates, the country's woody biomass will be totally consumed within 10 to 15 years.[49] Total natural forest cover has declined from 3.6 million to 3.3 million hectares, at an average of 27,000 hectares annually. The estimated rate of deforestation is 0.2 - 0.5 per cent annually, the highest in the world, and accounts for a 4-6 per cent decline in Pakistan's wood biomass per annum.[50] The highest rates of deforestation are found in the Northern Areas and KP, at 34,000 and 8000 hectares, respectively. The country is also losing its riverain and mangrove forests at 2,300 and 4,900 hectares annually.[51] In 2008, the production of roundwood and fuelwood stood at 32,650,000 and 29,660,000 cubic meters, respectively[52] and this demand for wood continues to increase as the population expands.

Forests provide essential ecosystem services for climate stability, watershed protection, soil erosion control, biotic diversity and wildlife habitat. They also provide much needed wood biomass, supplying 32 per cent of Pakistan's total energy needs in the form of fuelwood and timber for construction activities. Furthermore, rangelands and forests provide forage for one third of Pakistan's 143 million head of livestock.[53]

As recognition of the multiple values of forests has grown, so have concerns over their disappearance. Unsustainable land use practices and the ever-increasing demand for timber and firewood are leading to shrinking forest cover nationwide. Whereas the consumption of wood was thirty million cubic meters in 1993, it is projected to go up to more than fifty million cubic meters by 2020.[54] As more than 70 per cent of the land area of Pakistan is arid and semi-arid, and annual rainfall is too low and erratic to plan and sustain afforestation and forest regeneration programmes, concentrated efforts are needed to understand the root causes of deforestation and design policies to rejuvenate and maintain forest areas.

Forest ownership, management and deforestation

The state, communities and private individuals own the forests in Pakistan. However, the state is by far the biggest owner, possessing about two thirds of the total forest area. Presently, the Forest Department controls 4.5 million hectares of forests and 6.4 million hectares of rangelands that provide sustenance to livestock.[55] Forest management is the responsibility of both the public sector and private owners (table 5).

Table 5 Type and category of forests in Pakistan

Type	Category	Management	Pakistan (km^2)
State	Reserved Forests*	State	16,820
	Protected Forests**	State	9,940
	Other	State	2,510
Private	Guzara Forests***	State/Communal	6,220
	Communal Forests	Communal	8,780
	Other	Private	510

Notes: *: Reserved forests are owned by the state and communities only have very limited rights. **: Protected forests are owned by the state but the community is given more rights such as a share of timber sales proceeds, the use of timber and fuelwood, animal grazing rights, etc. ***: Guzara forests are lands close to settlements that were set aside to meet the needs of Hazara communities in 1872. They are managed by the Forest Department, which regulates the commercial and local use of timber.[56]
Source: Knudsen 1999.

In the past two decades in particular, deforestation and forest degradation have become immense problems in Pakistan, leading to the disappearance of trees, shrubs and ground flora together with the vertebrate and invertebrate fauna and other biodiversity they normally support. For example, mangrove forests in Pakistan's coastal regions are disappearing rapidly, with four out of eight mangrove species in the Indus Delta extinct already. Indigenous trees found in riverine forests such as Kandi, Gugar, Lohero

and Bahan are also under threat from unrestricted logging.[57] Furthermore, deforestation threatens the livelihoods of mountain communities who rely on forests, turning them into migrants displaced by the destruction of the natural resources they were dependent upon.

An important factor behind deforestation in Pakistan is the combination of governmental mismanagement, poor monitoring, and an ill-trained, ill-equipped and understaffed Forest Department. The Forest Department does not explicitly account for the fact that forests do more than provide timber; they also absorb carbon, provide fresh air and are the natural habitat for various flora and fauna. Forest management approaches and laws are heavily tilted in favour of income generation instead of developmental and conservation needs and there is a lack of involvement of local stakeholders in the political process of forest policy making. Forest Department officials often give preference to certain tree species on the basis of commercial interests changing the taxonomy of the region and bringing some tree species to the verge of extinction.

A stark example of forest mismanagement was the Agro Forestry Policy of 2004 in Sindh, which allowed the leasing, through auctions, of forestlands. The policy was designed without consultation with community members dependent on the forests. It led to the widespread cutting of trees by leaseholders, without adequate planting to replenish them and the illegal seizure of forestlands by influential persons for the cultivation of crops.[58] The Sindh Forest Department realised the negative impact of the policy and it is not operational any longer.

The activities of the timber mafia further worsen the problem of deforestation. The mafia usually consists of commercial loggers engaged in illegal logging activities, corrupt Forest Department officials, landowners, and those who grab and encroach upon forestlands illegally. They are a particularly large problem in the coniferous forests found in the Northern Areas and KP. The Forest Departments often act in collusion with the mafia to the detriment of the local population, appropriating the community's rightful share of timber proceeds as well. For example, the smuggling of trees is a common phenomenon in the Chitral district of the KP and has hurt the Kalash minority residing there. In one case, the timber mafia even attempted to murder a Kalash leader who filed a court case against the illegal smuggling of timber.[59]

The moratorium on timber harvesting in Pakistan following the 1992 floods has not been very effective. Timber traders are still smuggling wood, using all possible means, including political interference, theft and corruption. Furthermore, the moratorium has resulted in increased timber smuggling from Afghanistan to help meet Pakistan's demand. Most of this wood is extracted by the clear felling of forests in Kunar province. As these forests fall within the watershed of the KabulRiver, the adverse impacts of deforestation in Afghanistan will be felt downstream in Pakistan in the future.

A number of other factors also contribute to deforestation in Pakistan:

- Demand pressure from a rapidly growing population for lumber to be used for building materials, furniture and paper products leads to the felling of trees at a faster pace than the natural replacement rate.
- Developmental pressure, i.e., the construction of roads, buildings, and water reservoirs in forested areas has disturbed riparian and mangrove ecosystems.
- 90 per cent of rural and 60 per cent of urban households in Pakistan are dependent on fuelwood as a primary source of energy for cooking and heating.[60] This dependence on fuelwood is unlikely to change in the absence of the provision of alternative means of livelihoods and energy resources.
- A rapidly expanding livestock and cattle population has led to grazing beyond carrying capacity. Overall livestock numbers continue to increase at a rate of two per cent per year in Pakistan.[61] Persistent over-grazing has reduced forage production in Pakistan's western rangelands and the problem has become particularly acute in Balochistan.
- Lack of education makes it difficult for poor communities to appreciate the significance of forests as a source of carbon sequestration.

- Natural factors such as an arid climate, fires, floods, storms, heavy dependence on irrigation water, fragile watersheds and rangelands and the long gestation periods of forestry limit the speed and capacity of forest regeneration.
- Pests and diseases have reduced the regenerative capacity of existing forests.
- The financial resources spent on forests are inadequate to support and sustain natural regeneration processes.
- Remote locations make forest resources difficult to monitor.
- Finally, climate change has begun to stress forests through higher mean annual temperatures, altered precipitation patterns and made extreme weather events like forest fires more frequent.

To offset this deforestation, more responsible forest management approaches are needed that can accommodate both economic and ecological demands from existing forests. Policies such as the development of plantations and afforestation schemes, designation of selected forestlands as national parks and assignation of areas for agro-forestry practices are needed. Moreover, alternatives to construction timber and fuelwood must be provided to stem the demand for wood.

Effects of war and conflict on forest and biodiversity habitat

South Waziristan has a rugged landscape of barren mountains, patchy forest and hidden ravines and similarly, much of Balochistan consists of dry and rocky plateau areas, with very few forest areas. Neighbouring Afghanistan also has some of the most rugged terrain in the world, representing the western edge of the Greater Himalayan mountain chain. Much of the country consists of an endless stretch of barren rocky hills and low mountains. The mountain ecosystem in this region is an important reservoir of biodiversity. Its isolated nature encourages speciation and the creation of unusual species, specifically adapted to the extreme rigours of mountain life. Unfortunately, there has been virtually no consideration of the environmental impact of conflict in the region.

The ongoing conflict in Afghanistan and heavy air strikes in South Waziristanhave disturbed and killed animals such as wild goats, sheep and snow leopards. Bombing and ground fighting affect other species, such as the large numbers of migratory birds that travel down from Northern and Central Russia through the highlands in this region to their wintering grounds in India. Birds such as cranes and pelicans depend upon resting areas in this region during the long migration. Disturbances from bombing, aircraft flyovers, and troop activities can drive birds from these critically important resting areas, with the result that they may face possible death from exhaustion and starvation. Some estimates indicate that nearly eight per cent of forest resources in Malakand (in the Khyber Pakhtunkhwa) were lost during 2007 to 2009 in militancy related activities with a total loss of around PKR 100 billion.[62]

Perhaps the greatest environmental impact of military actions in this region is from the displacement of people and the large number of refugees. In their quest for food and fuel, refugees chop down trees in the few remaining forests, particularly in winter months when they are forced to live in makeshift shelters in below freezing temperatures. This further exacerbates the problem of soil erosion on steep mountain slopes and disturbs the resident wildlife.

Impact of deforestation on human security

As people engage in the increasingly unsustainable harvest of forest products, they threaten their own long-term security. First, their quality of life deteriorates as their access to non-wood forest products for sale and personal consumption, fodder for livestock, medicinal herbs, wild game, timber and firewood for heating and cooking declines. Women and girls who are primarily responsible for collecting forest products bear the brunt of deforestation as they have to walk longer distances to collect wood and fodder, leaving them less time for other activities. Moreover, pristine forestlands attract many visitors and the tourism industry provides employment for thousands of people living near forests in the Northern Areas,

KP and parts of the Punjab such as Murree. Deforestation makes these areas less attractive to tourists, thus threatening the livelihoods of local communities dependent on the industry.

Second, deforestation leads to a higher incidence of disasters such as floods and landslides and causes soil erosion, increasing the risks that vulnerable forest communities are exposed to. Cutting down forests on sloping hills disrupts the absorption of water and weakens soil cohesion, leading to disasters such as floods in downstream areas and landslides. For example, the watersheds of the River Kunar and Kabul River are now quite barren. This increases the runoff from the watersheds to these rivers as they enter Pakistan, in turn leading to floods in downstream areas such as the districts of Charsadda and Nowshehra.[63] When forest areas are cleared on sloping hills, it also exposes the soil to the sun, making it very dry and eventually, infertile, due to the loss of nitrogen nutrients. Rainfall then washes away the remaining nutrients along with the topsoil, leaving the land less productive.

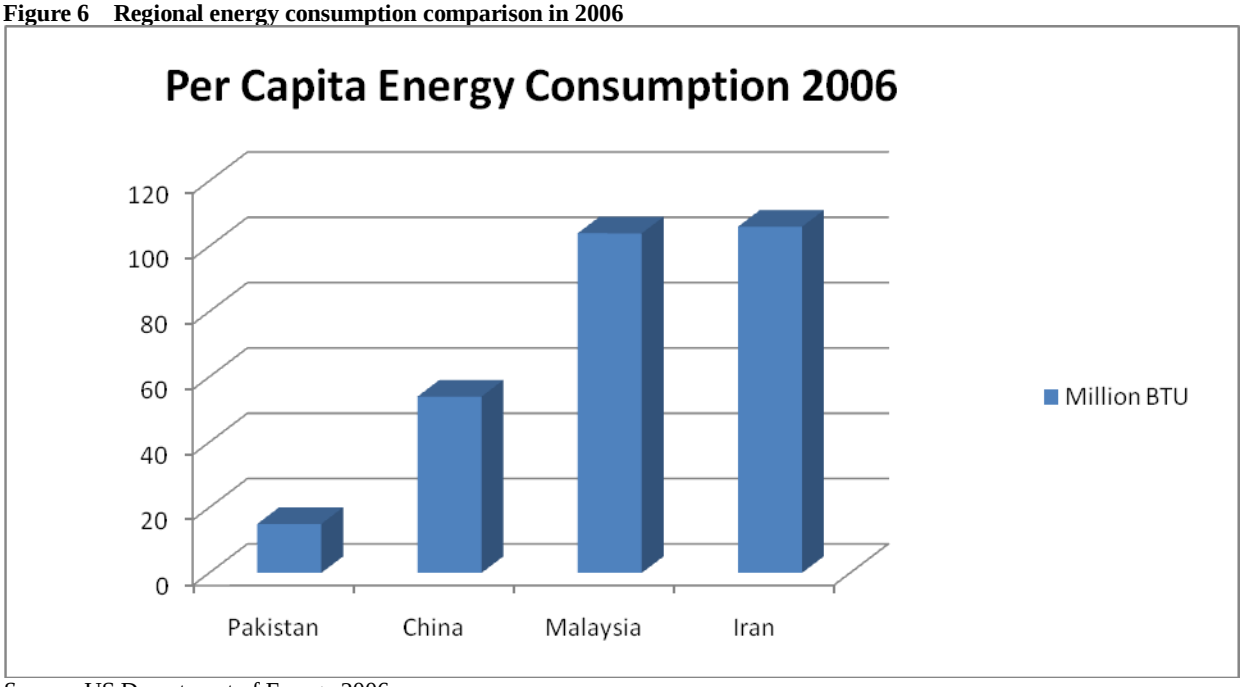
Third, deforestation interferes with the water cycle. Thinning of the forest canopy with clear felling disrupts the uptake of water by trees, reducing the amount of water in the atmosphere, resulting in changes in the micro-climate. Climate experts agree that erratic precipitation, soil erosion of the watershed and reduced flow in the Indus River, is causing the expansion of the country's heat zone and shrinkage of the Indus Delta. This change in climate could eventually have an impact on human health and agricultural productivity in the region.

Energy use and insecurity

Efficient, affordable and clean energy is central to sustainable development and poverty reduction efforts. At present, the state of energy security is quite dire in Pakistan.

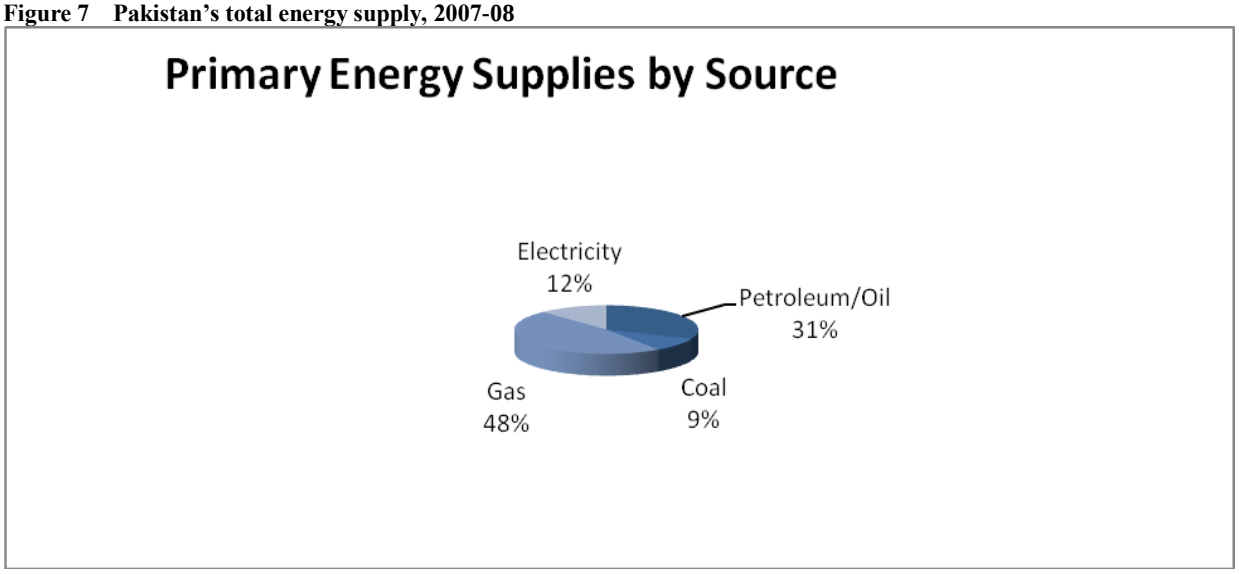
Pakistan's per capita energy consumption is lower than in many other neighbouring developing countries (figure 6) and stood at a low 2.5 barrels of oil equivalent (BOE) in 2006.[64] Total energy supply in 2007-2008 was approximately 63 million tonns of oil equivalent (TOE) with gas reserves providing almost half of this supply (figure 7). The country has 27 billion barrels of estimated oil reserves, 300 million barrels of proven oil reserves[65] and an estimated 280 trillion cubic feet (tcf) of natural gas reserves. One third of all energy consumed is based on imported fossil fuels including petroleum products, crude oil and coal**.** This strains the country's financial resources, creating growing budget and trade deficits.

Figure 6 Regional energy consumption comparison in 2006



Source: US Department of Energy 2006.

Figure 7 Pakistan's total energy supply, 2007-08



Source: GOP 2008b.

Pakistan's current installed capacity is around 20,000 Mega Watts (MW) but according to the Asian Development Bank and the World Bank, over 30 per cent of the power generated is wasted in transmission losses.Forty percent of Pakistani households have yet to receive electricity and only eighteen percent have access to gas pipelines,[66] leaving Pakistan short of about **3,500 MW of** electricity. The current power crisis (2005-2010) and a rapidly increasing population have made it imperative for Pakistan

to address its problems of energy security so that it can foster economic growth and improve the lives of its people.

Fossil fuels

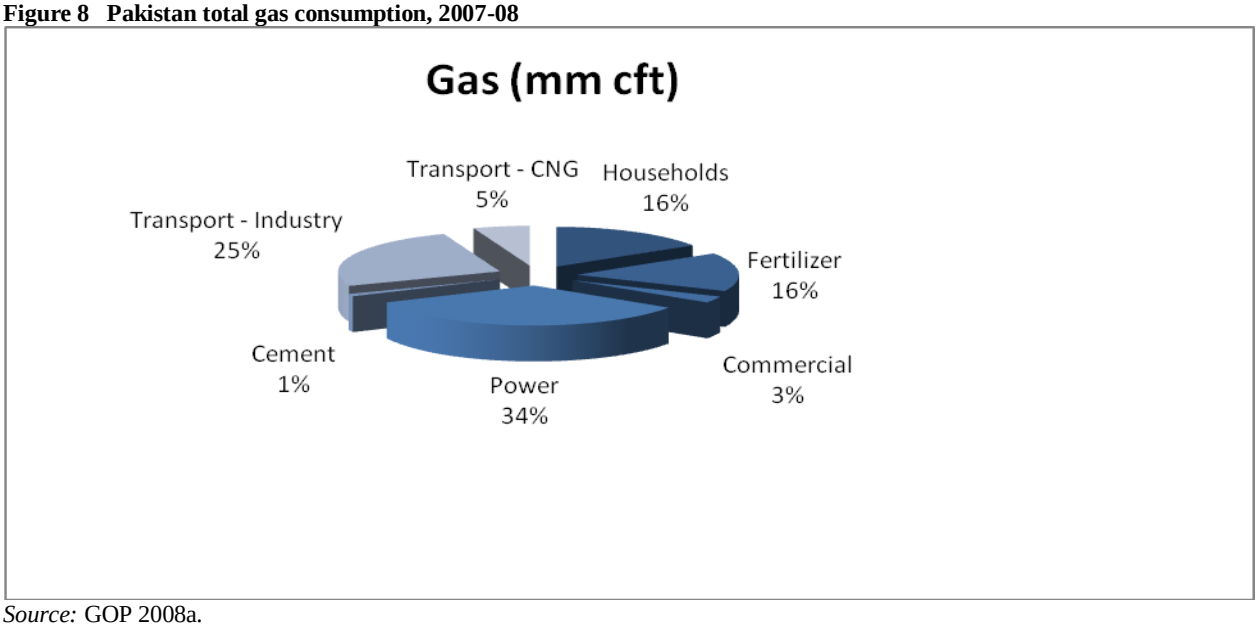
Pakistan has domestic supplies of all three fossil fuels – oil/petroleum, coal and natural gas. In 2008, Pakistan's consumption of petroleum products was about three hundred and sixty thousand barrels per day. However, local production was a mere seventy thousand barrels per day[67] and the consumption balance of two hundred and ninety thousand barrels per day was imported.

Over the past two decades, the consumption of oil/petroleum has increased in the transport and power sectors while decreasing in the household and industry sectors. The latter trend is observed both because of the availability of cheaper alternative fuels such as natural gas and the surge in the prices of kerosene oil and other traditionally consumed domestic petroleum products.

Pakistan also has vast reserves of coal, almost all of which are found in the province of Sindh. The country is the world's seventh largest coal-producer, with coal reserves of more than 150 billion tons.[68] However, much of Pakistan's current infrastructure is built to utilise oil and switching to coal fired plants will require heavy initial capital investment. Coal is also a dirtier fuel than oil or natural gas and rising concerns over climate change limit the desirability of coal fired plants.

Pakistan's gas reserves stand at an estimated 280 tcf; out of these, about 100 tcf are in Balochistan[69] and 1.3 tcf in the Manzalai area in the Khyber Pakhtunkhwa. With the decrease in Sui Balochistan gas production, higher output from the Manzalai area can help meet rapidly expanding consumer demand. Not only is domestic gas substituting for imported fuel in electricity generation but it is also used in general industry to prepare consumer items such as cement and fertiliser and in the transport sector in the form of CNG (figure 8).

Figure 8 Pakistan total gas consumption, 2007-08



Source: GOP 2008a.

Hydropower

Fluctuating oil prices mean that it will be extremely costly to utilise fossil fuels to meet the shortfall in energy supply. In a country like Pakistan, where indigenous fossil fuel supply is limited, hydropower generation can help minimise fuel imports.

In the past, the country had made considerable investments in hydropower. However, after the commissioning of Tarbela Dam in 1976, no sizeable multi-purpose storage development has taken place, leading not just to shortfalls in electricity supplies but also seriously jeopardising the sustainability of existing irrigated agriculture in Pakistan. Moreover, the Tarbela, Mangla and Chashma reservoirs have already lost about five million acre feet of capacity due to sedimentation. It is estimated that by the year 2012, this loss will increase to six million acre feet - almost equal to the combined capacity of the Mangla and Chashma reservoirs.

Energy efficiency and renewable resources

Pakistan faces both a massive power shortage and the degradation of life support systems from unchecked carbon emissions. The country has tremendous potential in wind, solar and biodiesel energy production and can invest in these alternative technologies to improve both energy supplies and the standard of living of its people.

The coastal belt of the southern provinces of Sindh and Balochistan is blessed with a wind corridor that is 60 km wide (Gharo to Keti Bandar) and 180 km long (up to Hyderabad). The corridor has the potential to produce around 5,000 MW of electricity, helping Pakistan to meet a significant part of its electricity requirements.[70]

The utilisation of solar energy for electricity generation is another viable clean energy option in Pakistan as its geographical location presents excellent conditions for small and large-scale solar thermal power plants. The country receives high levels of solar radiation throughout the year, with a daily average of 5.3 kilowatt hour per square meter (kWh/m^2).[71] However, while there is no shortage of the incidence of solar and wind energy in Pakistan, the upfront capital costs of these systems make them prohibitively expensive. Their use, particularly in rural areas, is also limited by the ability of the local population to maintain the systems.

Biodiesel, an energy source produced by the reaction of vegetable oil and alcohol, can be used in diesel engines as a fuel that causes less environmental pollution than petro-diesel.[72] Pakistan is committed to tapping indigenous biomass resources and Pakistan State Oil (PSO) is conducting experiments on biodiesel production to develop green and economical indigenous energy resources.PSO has selected the non-edible plant Jatropha Curas, for the production of biodiesel as it has very low sulphur content (0.13 per cent) compared to petrodiesel (1 per cent). It has developed a Jatropha Model Farm at Marshalling Yard, Pipri, Karachi and is carrying out a trial production of bio-diesel using Jatropha oil that meets the standard specifications of diesel. However, while biodiesel is the only possible reciprocal to petro diesel, the non-continuous supply of vegetable oil is a major hurdle to its general acceptance.

Impact of energy shortages on human security

The energy scarcity in Pakistan has caused massive productivity and employment losses, exacerbated indoor air pollution and led to faster deforestation. In Multan, Bahawalpur, Sahiwal and Dera Ghazi Khan, export-oriented industrial units experienced a 15 to 25 per cent increase in costs of production because of loadshedding and higher electricity and gas tariffs. Profits have nose-dived as domestic costs of production have increased at a faster rate than the international prices of export products.[73] In Sindh, the shortage of gas and water together with unannounced loadshedding led to a decline in industrial production of 13 per cent in 2008-09 as compared to the previous year.[74]

The small and medium enterprise (SME) sector has been hit particularly hard as most SMEs cannot afford the costs of private power generation houses. Consequently, many SMEs and factories have had to cut down their working hours and the number of shifts that they run. This has been very hard on people such as semi-skilled workers and labourers who work on daily wages in the manufacturing sector. With no health or unemployment insurance, very little state-sponsored support and negligible savings, they are unable to cope with the loss in income.

On the household level, the unavailability of gas and electricity, particularly in rural areas, has created a dependence on biomass such as dung and wood for fuel. Not only does this create severe problems of indoor air pollution but it also stresses natural resources and accelerates deforestation rates as people cut down more and more trees to meet their fuel needs. As the responsibility for both collecting fuel and completing indoor tasks falls largely on women, the impact of electricity and gas shortages is particularly severe on them. Not only does their workload increase but they also spend the most time indoors breathing air polluted by biomass fuels.

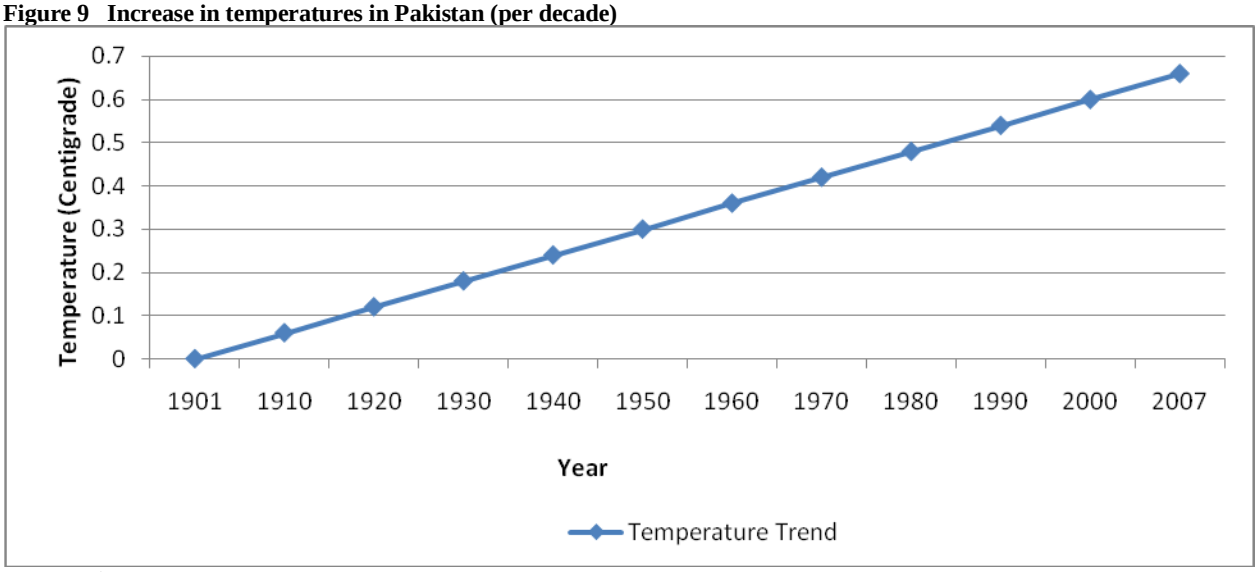
Climate change

Pakistan presents a classic example of a developing country that is highly vulnerable to the adverse impacts of climate change but has done little to contribute to the problem. It ranks 16th out of 170 countries in a recent Climate Change Vulnerability Index[75] and is located in a part of the world where the projected temperature increase due to climate change is likely to be higher than the global average. However, it is only responsible for an estimated 0.8 per cent of global GHG emissions and ranks 135th in the world in terms of per capita GHG emissions.[76] Consequently, Pakistan's major concerns with respect to climate change are related to adaptation, particularly in the areas of water, agriculture and disasters.

Changing climatic trends

On a national level, the annual temperature time series for Pakistan during 1901 – 2007 shows that there is a clear indication of warming in the country. The increasing rate of temperature is 0.06 degrees Celsius (°C) per decade with a total increase of 0.64°C over this period (figure 9). Furthermore, Global Circulation Models estimate that the average temperature across the country will increase by 3.9-4.4°C by the 2080s.[77]

Figure 9 Increase in temperatures in Pakistan (per decade)

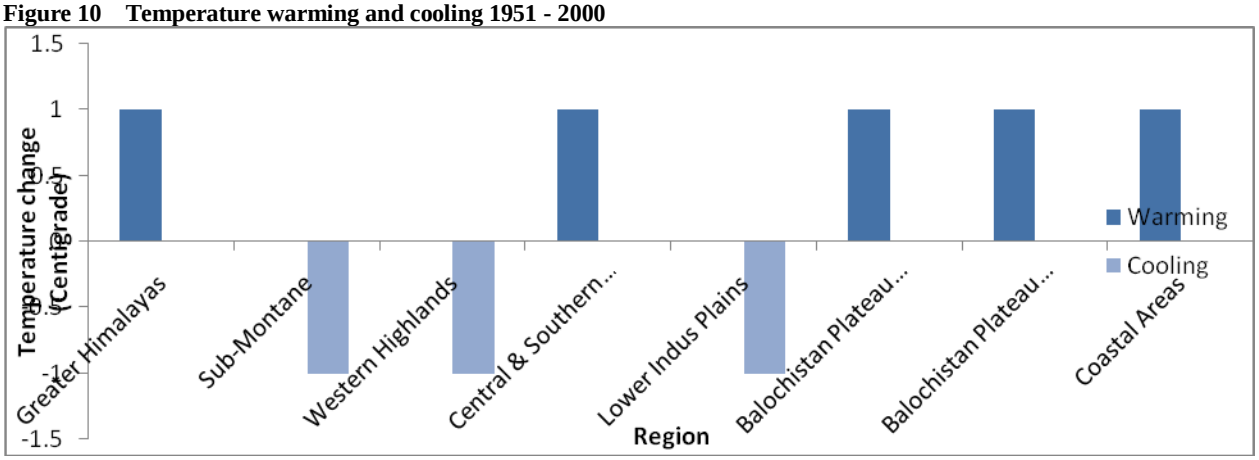


Source: Afzaal, Haroon and Zaman 2009.

However, this warming trend is not consistent across different regions in the country. The Global Change Impact Studies Centre (GCISC) divides the country into eight regions: Greater Himalayas, Sub-montane, Western Highlands, Central & Southern Punjab, Lower Indus Plains, Balochistan Plateau (East), Balochistan Plateau (West) and Coastal Areas. All these regions are experiencing different temperature and precipitation trends.

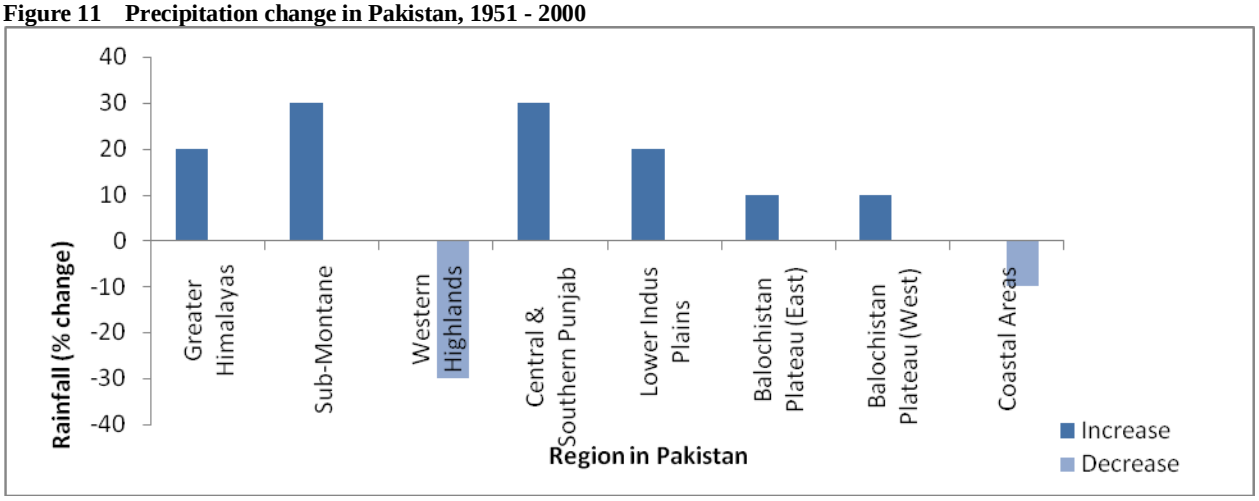
The WesternHighlands, Sub-montane and Lower Indus Plains Regions have witnessed a decline in mean annual temperatures during the period 1951 – 2000. All other regions show a warming trend (figure 10). The precipitation trend (% change per year for 1951 –2000) shows a decline in rainfall in the WesternHighlands and Coastal Areas. All other regions show an increase in rainfall (figure 11).[78]

Figure 10 Temperature warming and cooling 1951 - 2000



Source: Khan 2009.

Figure 11 Precipitation change in Pakistan, 1951 - 2000



Source: Khan 2009.

Climate change, water scarcity, agricultural productivity and natural disasters

Given the trends mentioned above, the country must prepare itself for the impacts of climate change. The Planning Commission's Task Force on Climate Change identified the following as the most pressing threats that Pakistan faces as a consequence of climate change:

- Increased monsoon variability.
- Recession of glaciers in the Hindu Kush-Karakoram-Himalayan (HKH) region that would threaten Indus River System water flows.
- Rising snowlines and glacial melt that will reduce the capacity of natural reservoirs.
- Loss in reservoir capacity from the increased siltation of large dams.
- Reduction in agricultural productivity and power generation because of water and heat stress in arid and semi-arid regions.

- Adverse impact on coastal agriculture, mangroves and fish breeding grounds because of the intrusion of saline water into the Indus Delta.
- Higher risk of droughts and floods.
- Increasing vulnerability of coastal areas due to greater cyclonic activity because of the higher temperature of sea surfaces and sea level rise.

As is clear from above, the country's greatest adaptation related challenges lie in the areas of water, agriculture and disasters. Changes in the spatial and temporal patterns of precipitation, temperature, snow fall and glacier melt and runoff stress water supplies (box 3) and agricultural productivity. For example, the timing of the summer monsoon rains has shifted forward, beginning in June and ending in August (instead of occurring July through September), with severe implications for the *Rabi* (winter) crop that depends on these rains.[79]Eleven of the twelve years between 1995-2006 ranked among the warmest years since 1850 in Pakistan and the greater frequency of heat waves over most land areas has caused drought like conditions in many agricultural areas with serious consequences for food security. The magnitude of the impact is illustrated by a study that estimates thattemperature increases between 1 and 4° C are associated with a 9 to 30 per cent decline in irrigated wheat yields in semi-arid areas in Pakistan.[80]

Box 3 Climate change and hydrological regimes in the Upper Indus Basin (UIB)

The UIB stretches from northeastern Afghanistan to the Tibetan Plateau and is the primary source of water for the Indus Basin Irrigation System. Three hydrological regimes exist in the UIB:

- Catchments at high altitudes such as the Hunza and Shyok Rivers, which together account for more than one fourth of the inflow into the Tarbela Dam, are largely glacier-fed. Summer runoff here during July to September is highly correlated with summer temperatures and uncorrelated with winter precipitation. A 1° C fall in temperature is associated with decreases in summer runoff of 16 and 17 per cent for the Hunza and Shyok Rivers, respectively. Mean summer temperatures recorded at climate stations have fallen by about 1.2° C in the UIB from 1961 to 2000, and have led to an average decrease in summer runoff from these two rivers of about 20 per cent. Moreover, in stark contrast to the glacier retreat witnessed in the Eastern Himalayas, some glaciers in the UIB are thickening and expanding.
- Catchments at middle altitudes such as the Astore and Kunhar Rivers are largely snow-fed and summer runoff is mainly determined by precipitation in the preceding winter. Here, higher temperatures are associated with an increase in evaporative losses and reduced summer runoff. According to one estimate, runoff here decreases by about 18 per cent for a 2° C rise in temperature. On the other hand, a 10 per cent increase in mean winter precipitation increases the runoff at Astore by about 5 per cent.
- At foothill catchments such as Khan Khwar runoff is determined by liquid precipitation in winter and during the monsoon.

These findings suggest that variability in temperature and precipitation induced by climate change will have significant impacts on water availability, productivity and human security. However, these impacts will not be uniform across various parts of the UIB and the Western Himalayas.

Source: Fowler and Archer 2006 and Fowler and Archer 2005.

Moreover, climate change is inducing natural disasters that cause loss of life, damage infrastructure and further hurt food security by destroying thousands of hectares of crops. Apart from the droughts and heat waves discussed briefly above, climate change is also linked with the greater frequency and intensity of glacial lake outburst floods (GLOFs), cyclones, seawater rise and floods.

Faster glacial melt can lead to the accumulation of melted water on mountain tops, which can breach and flood over into surrounding settlements as GLOFs. In the first six months of 2008 alone, five

GLOFs occurred in Pakistan's Northern regions,[81] wiping away settlements and destroying agricultural fields. Tropical cyclones have also started to occur more frequently in the South Asian region and are usually accompanied by severe flooding. For example, the cyclone that hit Pakistan in 2007 was of an unusually high intensity, causing devastation in coastal and in-land areas of Sindh and Balochistan, and leading to losses worth US$ 327,118,000.[82] Sea level rise due to the disintegration of ice sheets further threatens coastal cities such as Karachi. Finally, the repeated havoc caused by floods across the country is impossible to ignore. The tragic floods of 2010 alone led to the deaths of more than 1,900 people, affected over 20 million and caused economic losses worth US$ 9,500,000,000.[83] Over the years, disasters have extolled tremendous costs in Pakistan in terms of trauma, deaths, the number of people affected and economic damages (table 6).

Table 6 Costs of disasters in Pakistan between 1900 and 2010

Disaster	No. of people killed	No. of people affected	Damages (000 US$)
Drought	143	2,200,000	247,000
Flood:			
Unspecified	7,284	20,671,883	1,170,030
Flash Flood	2,970	21,940,556	10,073,118
General Flood	4,520	19,883,171	1,225,030
Storm:			
Unspecified	184	2,988	N.A.
Local Storm	180	1,385	N.A.
Tropical Cyclone	11,532	2,599,940	1,635,036

Note: The numbers above only reflect the costs of disasters where at least one of the following conditions was met: ten or more people were reported killed; 100 or more people were reported affected; there was a call for international assistance; there was a declaration of a state of emergency.
Source: CRED 2011.

Impact of climate change on human security

The problems outlined above have a large impact on the poor, women, biodiversity, human health and future generations. Although the poor have been responsible for the fewest greenhouse gas emissions, they will be most exposed to irreversible losses of well being through climate change induced risks. They lack climate defense infrastructure, have little insurance, few savings, and will have to cope with shocks by migrating, reducing consumption, selling productive assets and putting off nonessential expenditures such as preventive healthcare. Such actions are likely to lock them into low human development traps and diminish their capacity to cope with pre-existing problems and future calamities. Moreover, climate variability induces the poor to manage their risks by engaging in low risk low return activities. In Tanzania, for example, poor families were found to specialise in drought resistant crops such as sorghum and cassava that provided food security but low financial gains. It is quite possible that in the future, farmers in Pakistan will also decide in favour of planting crops with lower returns to ensure their food security.

Prevailing social norms in Pakistan also mean that the gendered dimension of the impact of climate change is hard to ignore. Water shortages usually hurt women more than men because the former are typically responsible for collecting water for the family and droughts mean that they have to walk longer distances to collect it. The intra household allocation of resources favours men and in the event of falling agricultural productivity, it is often women whose nutritional intake is hurt most. In the aftermath of disasters such as floods, storms and landslides, men are often better equipped to save themselves because they can swim, climb trees and move to safer places faster and are given preferential treatment during relief operations. In some disaster prone regions of the country, such as parts of Azad Jammu and Kashmir, Khyber Pakhtunkhwa and Gilgit-Baltistan, a large proportion of the men work down country

and it is the women who suffer the most from catastrophes such as GLOFs and avalanches. Women are also less likely to have national identification cards than men and thus, even their access to state sponsored support is restricted once rescue operations are over and relief and rehabilitation efforts commence. Moreover, conservative attitudes prevent women from migrating and resettling in new areas that are less vulnerable to climate change.[84]

The extreme winter and summer temperatures induced by climate change also hurt both biodiversity and human health by increasing the coverage area of pests and diseases. For example, in 2006, 52 people died in Pakistan because of the outbreak of dengue fever,[85] a disease previously unreported in the country and possibly linked to climate change.

Finally, climate change raises serious equity concerns as future generations will have to deal with the consequences of actions taken today that they have no control over.[86]

Recommended responses and responsibilities

Natural resource management needs to take place at multiple levels to be effective, with the success of state policies ultimately depending upon the support from and response of individuals, communities, civil society and other regional and global actors. The following subsections outline steps that can be taken by the government to mitigate the challenges faced in the areas of environmental insecurities, energy scarcity and climate change and then highlight appropriate responses on the part of non-state actors.

State policies and programmes

Environmental security

Organisations and Programme Initiatives	Remaining Challenges and Recommendations to Address Gaps
National Conservation Strategy The Pakistan National Conservation Strategy (NCS) was developed in 1992 to meet the challenges of environmental protection and pollution control in the country and followed by the Pakistan Environment Protection Act (PEPA) in 1997. The main objectives of the strategy are the conservation of natural resources, sustainable development and improved efficiency in the use and management of resources. Energy policies include promoting efficiency and conservation as well as cogeneration, hydro, biogas, solar and new alternatives. The strategy also includes measures to control and limit pollution and incorporate environmental and sustainable development into educational curricula.	***Challenges*** First, sectors like industry, transport, energy and agriculture need technical support to be able to comply with regulations for environmental protection and pollution control. Second, environment protection agencies require capacity building to monitor environmental protection and pollution control in the country. It took five years to devise and include the PEPA in the legal system. However, its implementation remains problematic due to enormous obstacles in reporting ***Recommendations*** Provincial and federal EPAs need environmental lawyers to implement the PEPA through environmental tribunals. The EPAs also need to collaborate with government and/or academic science and technology departments for the scientific analysis of life support systems.
Pakistan Environmental Protection Act (PEPA) and Environmental Protection	***Challenges*** Ineffective environmental laws and enforcement

Agencies (EPAs) PEPA is the most significant environmental legislation in Pakistan. It requires industrial facilities to restrict their air emissions and effluents to the limits specified in the National Environmental Quality Standards and establishes penalties for noncompliance. It outlines the institutional framework for environmental protection in Pakistan, including creating the Environmental Protection Agency, responsible for ensuring compliance with the rules, standards and regulations set forth in this and subsequent environmental legislation. It delineates the duties and authority of Provincial Environmental Protection Agencies and requires Environmental Impact Assessments for public and private projects. It may also provide fiscal incentives, awards, tax exemptions, allowances, or subsidies for the promotion of the Clean Development Mechanism (CDM), including environmentally efficient activities, equipment or processes. ***Initial Environmental Examination (IEE) and Environmental Impact Assessments (EIA) for Public and Corporate Sector Development Projects*** TheIEE and EIA represent systems through which the government has control over all public and private sector economic activities that affect the environment. Through this system they can channel resources towards environmentally efficient economic development.	problems have caused delays in implementing the PEPA in its true sprit. Enforcement is very weak. Provincial and federal EPAs lack the on-ground infrastructure to implement the PEPA, IEEs and EIAs mainly due to capacity constraints of the Ministry of Environment. ***Recommendations*** Although the responsibility for protecting the environment falls on everyone in society, the government has to ensure that compliance with the PEPA is effective. The EPA will need to work with law enforcement agencies and technical research institutions in each province to implement the PEPA and train personnel to conduct IEEs and EIAs. Furthermore, environment is a cross-cutting theme. There are too many policies on the environment at present and the government should prioritise and focus on a few sectors such as air and water quality, forest regeneration, coastal areas and glacier studies.
Pakistan National Environmental Quality Standards (NEQS) This legislation regulates the air emissions and effluents of industry and other big polluters. The government uses the Self-Monitoring and Environmental Reporting System for Industries to implement the NEQS. The system supports the country's industry owners and operators to monitor and evaluate their environmental performance and report their data to the	***Challenge*** EPA needs to use the Self-Monitoring and Environmental Reporting System for Industries more effectively instead of auditing industrial estates to monitor their pollution levels. ***Recommendations*** Self assessments regarding NEQS by industries need to be made more transparent and provided to the EPA on a regular base. The NEQS need to be translated into other sectors of the economy like transport, energy and

EPA.	agriculture.
National Environment Policy 2005 The policy aims to promote sustainable management of resources for efficient economic growth, protection of the environment and honouring of international obligations. It concentrates on conservation and environmental protection in water, air, forestry, waste management and transport. It aims to promote mass transit and non-motorised transport as well as cleaner technologies, including natural gas (LPG), solar, hydroelectric and biogas.	***Challenge*** The mismanagement of existing natural resources, population pressure and natural causes like climate change remain important causes behind the degradation of life support systems in Pakistan. ***Recommendations*** With this policy, the government should encourage public participation in environmentally friendly practices through education and mass awareness campaigns. There should be grading standards for environmentally efficient durable products, to help consumers make informed decisions and focus on the environmental impact of their purchases.

Water scarcity and distribution

Organisations and Programme Initiatives	**Remaining Challenges and Recommendations to Address Gaps**
Water and Power Development Authority (WAPDA) WAPDA is controlled by the Ministry of Water and Power and was established for the coordinated development of water and power resources in Pakistan.	***Challenge*** Pakistan continues to suffer from inadequate water storage facilities. The problem is heightened when there is below average rainfall and is of particular concern to the farming community, which depends on the regular supply of irrigation water. ***Recommendations*** WAPDA should undertake infrastructure projects such as the Bhasha Dam in the Northern Areas and other long pending projects after weighing environmental concerns against economic returns. The Kala Bagh Dam could be redesigned as a barrage, giving it less height and hence, smaller water storage capacity, thus addressing concerns that a large dam could submerge agricultural lands. These projects will help ensure water supplies all year round and meet the acute shortage of electricity. Existing hydraulic infrastructure also needs extensive maintenance and rebuilding to improve efficiency and increase storage capacity. For example, the expedited desiltation of Tarbela Dam can help to increase water storage capacity

	at a fraction of the cost of building a new dam.
Indus Water Commission The Indus Water Treaty resolved the issue of water sharing between India and Pakistan. Two dams were to be built under the treaty, Mangla Dam on the JhelumRiver and Tarbela Dam on the IndusRiver. It also envisaged a few barrages, Marala and Qadirabad on the Chenab River, Sidhnai on the Ravi River, Rasul on the Jhelum River, Chashma on the Indus River and Mailsi on the Sutlej River.	***Challenge*** Any change in rainfall patterns and glaciermelt could significantly alter the availability of water in rivers. However, the treaty does not account for this possibility, leading to continuousdisagreements between Pakistan and India over the supply of water from the three western rivers. The fragility of the situation is apparent with most discussions between the commission's representatives failing to come up with positive outcomes for Pakistan. ***Recommendations*** There is a need to strengthen bilateral ties with India by conducting regular meetings of Indus Water Commission representatives to assess the quantity of water in the river tributaries and canal headworks on both Indian and Pakistani sides. A council of countries surrounding the Himalayas, including Bangladesh, India, Pakistan and China can be formed to conduct cooperative research on the accelerating effects of climate change in the region, particularly on the amount and distribution of water. OlafurRagnarGrimsson, the president of Iceland, suggested such an initiative.
IndusRiver System Authority (IRSA), Government of Pakistan IRSA was created to implement the historic Water Apportionment Accord agreed among Pakistan's provinces in 1991 and has the responsibility to distribute water amongst the four provinces of Pakistan.	***Challenges*** Pakistan is suffering from extremely dry conditions primarily because of El-Nino conditions prevailing in the Pacific Ocean that are expected to continue in the near future. The supply of water in the Rabi season of 2009-10 was six MAF lower than in 2008-09,[87] leading to disputes between Punjab and Sindh as some areas in Southern Punjab and districts in Sindh faced acute water shortages ***Recommendation*** IRSA will need to devise a formula to alter water supplies between certain districts in Punjab and Sindh to ensure the timely supply of irrigation water. This may affect the pattern of crops grown in these areas but will guarantee equitable supplies of irrigation water in both provinces.

Water and Sanitation Agency (WASA) WASA lies within the structure of the Urban Development Authorities and has the responsibility to ensure adequate water supplies for drinking and sanitation purposes. There are regional and city based WASA authorities and a number of projects are underway that deal with sewerage and drainage, bulk water supply, environmental improvement and rural water provision.	***Challenge*** Most large Pakistani cities continue to suffer from inadequate water quality and supplies. A large proportion of the population lives without any water supply pipelines or with inadequate water supplies in these pipelines. ***Recommendations*** Cities close to riverbanks or on coastal areas could receive filtered/de-salinised water through the WASA system. To ensure adequate water supplies for cities like Rawalpindi-Islamabad, water storage dams should be connected with the nearest river or canal systems, such as the Gazi-BarothaCanal. This will ensure water supplies even in drought years.

Water pollution

Organisations and Programme Initiatives	**Remaining Challenges and Recommendations to Address Gaps**
Federal and Provincial Environmental Protection Agencies (EPA) ***Water and Power Development Authority (WAPDA)*** ***Urban Development Authorities*** Authorities like the Lahore Development Authority (LDA), Karachi Development Authority (KDA), Capital Development Authority (CDA) Islamabad and similar municipal organisations in major urban centers in Pakistanhave the responsibility to plan, design, develop and maintain water supply, sewerage and drainage systems in cities. ***Pakistan Council of Research in Water Resources, Ministry of Science and Technology (PCRWR)*** PCRWR is a national organisation meant to promote and conduct research on all aspects of water resources.	***Challenges*** The biggest challenge facing Pakistan is the lack of adequate clean drinking water. The country's population and housing densities in residential neighbourhoods are increasing at a much faster rate than clean water supplies. The quality of existing water supplies is also far below WHO standards and is responsible for the spread of many diseases such as typhoid and diarrhea. ***Recommendations*** The Ministry of Environment in consultation with urban development authorities should devise a comprehensive plan to improve the quality of water provided to urban areas for drinking purposes. Water needs to be treated before being supplied to households, water supply pipes should lie at a reasonable distance from sewage lines so that dirty water cannot contaminate clean water supplies, the use of water supply pipes with high levels of lead should be discouraged and municipal and domestic wastewater should be treated before being released into water bodies. WAPDA, PCRWR and provincial irrigation departments should ensure that the water available for agricultural purposes meets safety standards

	and is free of toxic materials that could be harmful for agricultural productivity and human health.

Air pollution

Organisations and Programme Initiatives	Remaining Challenges and Recommendations to Address Gaps
Urban Development Authorities **Departments under urban development authorities, such as the Lahore Development Authority's** Traffic Engineering Planning Agency (TEPA), are often responsible for road development and the smooth functioning of traffic and transport systems. ***Ministry of Environment*** ***National Energy Conservation Centre (ENERCON)***	***Challenges*** Pakistan is yet to pass legislation such as a National Clean Air Act to contain urban and indoor air pollution to safe levels. EPAs, municipalities, urban development authorities and local traffic police departments have inadequate staff, training and equipment to check and control vehicle emissions. Coordination among these institutions, academics, industries and local stakeholders is also almost nonexistent. ***Recommendations*** EPAs, municipalities, urban development authorities and local traffic police departments should: invest in fixed and mobile air quality monitoring stations to monitor current and predict future emission loads and types; provide technical training to staff for environmental impact assessments; improve the implementation of air pollution regulations such as industrial and vehicular emission standards; prioritise traffic flow plans and public transport development; introduce cleaner fuels with lower levels of pollutants such as sulphur and lead; and disseminate pollution index levels and weather reports throughout the country. The Ministry of Environment should spearhead efforts to establish a council of parties responsible for and interested in controlling air pollution such as federal and provincial EPAs, municipalities, urban development authorities and local traffic police departments, industry representatives and academics. The council should: assess the impact of air pollution on health, ecological systems and regional climate change; calculate the costs of abatement and control measures; establish acceptable emission standards; and coordinate the activities of various organisations for better emission controls.
Federal and Provincial Environmental Protection Agencies (EPAs)	***Challenges*** Local air quality is further exacerbated by trans-

Foreign Office ***Industries***	boundary air pollution, particularly from North West India. The Government of Pakistan does not have effective strategies for the joint management of trans-boundary pollution control with neighbouring countries like India and China. ***Recommendations*** EPAs, the Foreign Office and industry representatives from all neighbouring countries in the region, particularly India and Pakistan, must get together to enforce mechanisms to measure trans-boundary air pollution and find mutually agreeable means to curtail emissions. Polluting industries could be given a reasonable timeframe within which to reduce emissions and help with acquiring cleaner technologies. They should also be taxed to correct for the negative externalities such as health and environmental costs created by their emissions.

Shrinking forests

Organisations and Programme Initiatives	**Remaining Challenges and Recommendations to Address Gaps**
Forest Department, Government of Pakistan, National Forest Policy 2010 The policy seeks to launch a process to maintain and improve ecosystem functions and services through the sustainable management, protection, restoration, development and conservation of forests and allied natural resources, namely, watersheds, rangelands, wildlife and associated biodiversity.	***Challenges*** Although the policy is in place, its implementation must be accelerated to increase forest coverage and density in Pakistan. It has also not yet curtailed the influence of the timber mafia, which is responsible for the unsustainable harvest of forest products and the violation of the rights of many forest communities. ***Recommendations*** The capacity building of Forest Department officials is needed to train them to value the ecosystem, protection of biodiversity and carbon sequestration functions of forests, along with the market returns of timber. Existing laws and regulations must be enforced effectively so that the role of the timber mafia is eradicated and authorised timber dealers harvest forest products in consultation with the Forest Department. The policy should give due consideration to the social and economic conditions of communities living near forested areas. Traditional systems of community participation in the decision making and management of forests must be studied and

	best practices should be revived to regenerate and protect forests. The policy must also be gender sensitive by ensuring that women have equal access to and control over forest resources. The impact of the policy on the workload of women, for example, with respect to gathering forest products, must also be evaluated. The Forest Department must undertake the systematic data collection of forest biodiversity and ecosystems based on the reliable study of each forest block. This information must be computerised and stored for every district in each province. A move towards adopting geographical information systems (GIS) and remote sensing techniques could play a pivotal role in supporting forest policy making processes.
Pakistan Forest Institute (PFI) The mission of the Pakistan Forest Institute is to provide effective research, education and training for scientific management of forests, rangelands, wildlife, watersheds, environment protection, and biodiversity conservation in Pakistan and its status is being up-graded to a degree awarding institution.	***Challenge*** Forests in Pakistan face new challenges. Prolonged dry spells, decreasing rains during the monsoon and irregular snowfall in mountainous regions during the winter have increased the vulnerability of trees to widespread dieback, insect infestations, fungal disease and forest fires. The PFI remains ill-equipped to prepare the forest department workforce and others to deal with these challenges. ***Recommendation*** The PFI must train future foresters to prepare plans for disaster management, particularly forest fires, avalanches and landslides. It must also invest in more research on: a long term plan to increase tree canopy cover; the sustainable supply of timber to local markets and the identification and harvesting of non-timber forest products; the level of soil erosion and the type of vegetation required to remedy it; the possibility of sequestration through different plant species for carbon credits; and the role that the corporate sector can play in maintaining forests and in afforestation efforts.
Federal and Provincial Environmental Protection Agencies (EPAs)	***Challenge*** Inter-departmental coordination between EPAs and other agencies and departments such as the Forest Department remains poor, restricting them from benefiting from each others' expertise. ***Recommendation***

	Trees play a vital role in reducing air pollution and slowing down climate change.As such, EPAs should involve the Forest Department in urban tree plantation for carbon sequestration to help improve air quality in city centers. To this end, the Pakistan Clean Air Network and Clean Air Initiative for Asian Cities Centre could play a pivotal role in bringing together the Forest Department and EPAs.

Energy security

Organisations and Programme Initiatives	**Remaining Challenges and Recommendations to Address Gaps**
Pakistan Water and Power Development Authority (WAPDA) WAPDA is the largest public utility of the country and is responsible for the generation, transmission and distribution of electricity, as well as the development of water resources and the provision of other services. ***National Energy Conservation Centre (ENERCON)*** ENERCON is an attached department of the Ministry of Environment and serves as the national focal point for energy conservation and fuel efficiency activities in all sectors of the economy, including industry, agriculture, building infrastructure and transport. ***Alternative Energy Development Board (AEDB)*** The AEDB was established as an autonomous body to implement various policies, programmes and projects in the field of alternative or renewable energy technologies. It aims to achieve a 10 per cent share of total electricity generation in Pakistan through renewable energies by the year 2015.	***Challenges*** Pakistan faces a massive power shortage at present and requires a continuous supply of cheap and abundant energy to continue its economic development. There are many structural flaws in the energy system: over-dependence on imported oil; limited financial support for new developments in the energy sector; massive transmission losses; and a weak implementation capacity in hydropower and renewable energy sectors. Pakistan's geographical location presents excellent conditions for harvesting wind and solar energy. However, the capital costs of such systems are very high and the technical capability to operate and maintain the systems after installation is also limited in the country. ***Recommendations*** Modernise power plants on a fast track basis to augment supplies and reduce the cost of power generation. Follow this with the upgradation and modernisation of the existing power transmission system to reduce losses. Efforts are also needed to improve electricity dues collection so that funds can be raised for system operations, maintenance and improvements. Conservation efforts and clean and renewable energy development must be expanded to reduce the country's dependence on imported oil and control environmental pollution. The government urgently needs to initiate research and development projects in wind, solar, biomass, biogas, micro-hydro, fuel-cell technologies and other renewable energy fields and strengthen existing research institutions. It must engage in

	the transfer of state-of-the-art know how on renewable energy technologies to local research institutions and private industries. The hydro thermal mix in electricity generation must improve from 30:70 to at least 50:50 by constructing more dams. Low-cost materials like fiberglass, aluminum sheets and iron glazing and indigenous manufacturing methods can be used to reduce the costs of a solar thermal electric system. The large-scale manufacturing of collectors and engine machines can also reduce system costs significantly. Further assistance from donors such as the Asian Development Bank, Global Environment Facility, United Nations Development Programme, United Nation Environment Programme and other sources must be sought for joint projects, seminars and awareness campaigns to promote energy conservation, efficiency and renewable energy development. Long-term contracts with neighbouring countries, such as a gas supply deal with Iran, must be pursued for the uninterrupted supply of energy.
Oil and Gas Regulatory Authority (OGRA) OGRA was established with the objective to foster competition, increase private investment and ownership in the midstream and downstream petroleum industry, protect the public interest while respecting individual rights and provide effective and efficient regulation. It also issues licenses to all concerns engaged in regulated activities in the natural gas, CNG, LPG and oil sector, determines the revenue requirement and prescribed prices of natural gas utilities, notifies producer gas prices, resolves complaints against licensees and determines petroleum prices per approved policy.	***Challenge*** The pricing of fossil fuels like petrol, oil, diesel and natural gas is done by OGRA. They need to reflect the true international prices of these commodities and local costs of exploration and royalties. In most cases, if oil prices go up in international markets, it is reflected in local Pakistani prices. However, there is no agreed mechanism between the petroleum industry of Pakistan and OGRA on how to reflect a significant price fall in the international market. ***Recommendation*** There is a need to improve the transparency of the process whereby OGRA reaches decisions on matters such as pricing. OGRA will have to take into confidence and acquire input from parties such as the industry that imports and refines petroleum products and the provinces that produce the bulk of fossil fuels.
National Electric Power Regulatory Authority (NEPRA) NEPRA regulates the electricity sector in Pakistan and strives to develop and pursue a regulatory framework to ensure the	***Challenge*** The electricity tariffs set by NEPRA are in the range where they make industrial products uncompetitive in international markets. The problem is that electricity is available from two

provision of safe, reliable, efficient and affordable electric power to consumers. It also facilitates the transition of the energy sector from a protected monopoly to a competitive environment where several power sector entities function in an efficiency oriented or market driven environment. This helps maintain the balance between the interests of consumers and service providers in unison with the broad economic and social policy objectives of the government.	main sources in Pakistan, hydro and fossil fuels. The source for hydropower lies within Pakistan and thus primarily conveys local costs of production. On the other hand, thermal electricity based on fossil fuels is dependent on local and imported fuel and its price is dependent on local costs of production and transportation, as well as the value of fossil fuels bought from international markets. ***Recommendation*** Pakistan must increase the share of locally based energy sources in its total energy mix to reduce its dependence on foreign fuels with high and volatile prices. The building of more hydropower stations and the exploration and development of local supplies of fossil fuels and renewable energy technologies can go a long way to meeting energy needs domestically.

Climate change

Organisations and Programme Initiatives	**Remaining Challenges and Recommendations to Address Gaps**
Ministry of Environment (MOE), National Climate Change Policy The Ministry of Environment in consultation with the United Nations Programme for Environment in Pakistan and the Core Group of Experts on Climate Change, is designing the National Climate Change Policy. This Policy will set preparatory guidelines for all sectors of the economy that could be affected by climate change.	***Challenge*** With the devolution process underway, action plans based on the National Climate Change Policy will have to be implemented through provincial branches of the MOE. ***Recommendation*** A climate change wing should be created at the provincial level so that all departments and ministries have access to information on how to prepare for climate change related events, and access funds to implement action plans based on the Policy. The MOE must also help coordinate the works of various agencies and work in collaboration with them to analyse significant issues, including: the Survey of Pakistan, GCISC and other research centers to collect data on temperature and precipitation changes in each ecological zone and their impact on agriculture and industry; provincial water and power authorities and meteorological departments to prepare data bases and inventories of glacier melt, precipitation, river flows and ground water aquifers; and the NDMA to develop locally relevant disaster management plans for different

	ecological zones, rural and urban areas.
Clean Development Mechanism (CDM) initiative, Ministry of Environment The Kyoto Protocol to the UNFCCC was adopted in 1997 and established the Clean Development Mechanism (CDM). The initiative allows Annex 1 countries to offset their emissions by investing in emission reduction projects in developing countries. These initiatives must be projects that would have not taken place without the support and incentives provided through the CDM. Under the criteria for CDM Projects, Pakistan shall allow unilateral, bilateral and multilateral CDM projects preferably in the following sections: energy, land use, agricultural and livestock practices, waste management, transportation and industrial processes.	***Challenge*** The Ministry of Environment's CDM Department must advise other government departments on what qualifies as clean technology so that future developmental projects can be initiated and paid for through the CDM. ***Recommendation*** The Government should collaborate with countries already engaged in "Best Practices" in priority sectors. It is vital to establish a knowledge bank on environmentally efficient technology and collaborative projects specifically focused on the "transfer of environmentally efficient technology to Pakistan". Only then will Pakistan be able to earn CDM funds and build a technological base for the sound environmental management of natural resources.
Pakistan Meteorology Department The Meteorology Department offers expertise and information on meteorological and geophysical matters with the objective of traffic safety in air, on land and sea. It provides weather forecasts, warnings and advisory services to the North Arabian Sea and territories falling within its area of responsibility, has the potential to forewarn the public of cyclones or tornadoes and predicts the amount of water in rivers from glacier melt. ***The Global Change Impact Studies Centre (GCISC) Pakistan*** The Centre was established in May 2002 as a think tank to help national planners and decision makers with strategic policy planning in consonance with the changing global environment. It focuses on areas such as climate, water, energy, food, agriculture, health, ecology and new technologies.	***Challenge*** Predicting climate shifts accurately, conveying the information in a timely manner and helping people address the challenges posed by climate change. ***Recommendation*** The Meteorology Department should develop focused links with targeted departments such as irrigation and agriculture related departments to provide real-time information and warnings of impending adverse weather, such as strong storms and floods. The Meteorology Department and GCISC should also join forces to calculate the extent of climate change within Pakistan during the next eighty to hundred years. If predicted climate shifts are significant, with drastic impacts on water and agriculture, GCISC could play a pivotal role in preparing the government and rest of the country to tackle and adapt to the changes.
National Institute of Oceanography (NIO) The Institute is a scientific research organisation located in Karachi. It was	***Challenge*** In order to adapt to climate change and to reduce the risk from natural disasters, there is a need to implement comprehensive and integrated

established in 1981 through a Government Resolution to conduct multidisciplinary research in oceanography in the coastal and offshore areas of Pakistan (an Exclusive Economic Zone of 24,000 km²). It works on ocean biology/productivity, marine chemistry and environment, physical oceanography/coastal hydraulics, marine geology and geophysics.	ecosystem approaches to manage sea and ocean coastal zones and aquaculture, by regular monitoring and reporting from this Institute. ***Recommendation*** The Institute should undertake assessments of local vulnerability and risk and build local-level ocean climate models. It should strengthen knowledge of the dynamics of biogeochemical, carbon and nitrogen cycles in aquatic ecosystems. This will support other concerned government departments to prepare for the impacts of global climate change on regional seas and oceans.

Disasters

Organisations and Programme Initiatives	**Remaining Challenges and Recommendations to Address Gaps**
National Disaster Management Authority (NDMA) The NDMA is meant to strengthen the government's institutional capacity for disaster preparedness, response and recovery.	***Challenges*** Pakistan is vulnerable to a host of natural and man-made disasters. However, the NDMA's capacity to prepare for and respond to these disasters is limited and often dependent on external funding and technical assistance. ***Recommendations*** The NDMA must invest in the capacity building of its staff and the adoption and use of modern technologies such as GIS that can help with rescue and relief efforts. Apart from developing the efficiency of responses needed in the immediate aftermath of disasters, it needs to: engage in more long-term efforts to relocate and rehabilitate victims of disasters; move people away from locations at a high risk of facing disasters *before* the event occurs; and help local communities in disaster prone areas develop evacuation, first aid and reconstruction plans. Satellite technology can also be applied for natural disaster management. There are several reasons for possible enhancement in the satellite technology for disaster management. Early warning and high-speed communications, together with effective and efficient satellite communications technologies facilitate disaster management. It is vital for preparedness and response operations for floods, earthquakes, droughts and desertification. The operational and communications

	system for natural disaster mitigation based on integrated satellite technology applications is needed for the establishment of the necessary infrastructure. These include satellite communications, satellite-based positioning, satellite meteorology and remote sensing (Earth observation). Improved weather and climatological information based on satellite meteorology is essential for weather watch over a region vulnerable to natural disasters. Satellite based disaster mitigation systems, integrated with conventional ground-based equipment are increasingly applied to provide inputs for natural disaster management. The most important application of satellite technology is in detecting and delivering early warnings of impending disasters and in disseminating this information to people likely to be affected. Satellite based disaster mitigation equipment can provide unbiased, synoptic and timely information on the nature and effect of disasters. Reliable estimates of disaster damage, the location and extent of disaster-affected areas and an assessment of the post-disaster situation, facilitates effective disaster mitigation measures. An effective flood control system relies on timely availability of accurate information on rainfall, river level, cloud cover, glacier melt and other data, in many cases over inaccessible areas. Data from satellites have been widely used to improve rainfall estimates for more accurate flood forecasting. Snow melt run-off has also been estimated in China, India, Mongolia, the Central Asian republics and Pakistan using remote sensing data. The data from geostationary meteorological satellites has been designed to provide real-time or near real-time information on typhoons and tropical cyclones and to assist in forecasting the movement of tropical cyclones. In several Asian countries; Bangladesh, China, India, Japan, Malaysia, Pakistan, Thailand and Vietnam, and in the Mekong river basin, the application of satellite technology has improved flood forecasting and disaster warning efforts. Remote sensing data identify flood risk areas as well as assess flood damages.

Roles and responses of non-state actors

At the individual and community level, people can help slow down environmental degradation and climate change by being more responsible consumers and citizens. Simple actions such as reducing the consumption of fuel and electricity, engaging in volunteer activities to clean up waste products in urban centers and ecologically sensitive zones such as beach fronts and forest lands and demanding more environmentally friendly practices by the state and corporations can go a long way towards curbing emissions and protecting the environment. Academic institutions, research centers and think tanks can engage in the detailed assessment of local environmental problems and help provide locally relevant solutions to these problems.

International environmental organisations such as the Worldwide Fund for Nature (WWF), the International Union for Conservation of Nature (IUCN) and Leadership for Environment and Development (LEAD) have the technical knowhow to initiate awareness building on issues of environmental significance. They can also engage in environmental impact assessments, efforts for mitigation and adaptation to climate change and arrange trainings and workshops to build local capacity to understand pressing challenges and the available means to solve them. For example, in the recent past, IUCN and LEAD Pakistan have been actively engaged in providing officials in the government of Pakistan and other members of civil society, such as journalists, information on climate change and what Pakistan's stance should be in the international negotiations on climate change.

International non-governmental organisations (INGOs) can also assist with the dispute resolution and management of cross-border environmental issues. For example, WWF Pakistan, with the funding support of the United Nations Environment Programme (UNEP) and the Global Environment Facility (GEF), is carrying out a project called *'The South-Asia Trans-boundary Water Quality Monitoring Project'* to reduce the pollution load of Hudiara Drain. The drain used to be a natural storm water nullah, but now carries municipal wastewater mingled with untreated industrial wastewater as it flows from Batala in Punjab, India, to join the River Ravi in Pakistan and disturbs the aquatic biodiversity and bird life dependent on the river's waters. WWF in both Pakistan and India is in contact with local authorities and major industrial units on the river system, to find cost effective environmental solutions. It provides them with environmental technical assistance besides identifying treatment and cleaner production options to reduce the pollution load of the Hudiara Drain.[88]

Together, actions such as the ones listed above can help mitigate some of the most pressing environmental challenges in the country and lead to synergies between the efforts of civil society and the government.

Notes

[1]World Bank 2006b.
[2]Rizvi 2001.
[3]World Bank 2006a.
[4]Chandio 2009 and Habib 2006.
[5]GOP 2008c.
[6]Hanif 2003.
[7]Revenga 2000.
[8]Khan, Tariq, Yuanlai and Blackwell 2004.
[9]The Kotri Barrage, also known as the Ghulam Muhammad Barrage, was opened in 1955. It is near Hyderabad and is nearly 3,000 feet (900 metres) long. It is the final constructed structure on the Indus River before it reaches the Indus Delta.
[10]Henry L Stimson Center 2009.
[11]Parvaiz 2008.
[12]UNFPA 2009.
[13]UNFPA 2009.
[14]Abbass 2009.
[15]WWF - Pakistan 2009a.
[16]Raza 2009.
[17]IUCN 2008 and WWF - Pakistan 2010b.
[18]Saif, Haq and Memon 2005.
[19]Anjum, Rehman, Anjum and Latif 2005.
[20]Government of Punjab 2007 and Pak-EPA/JICA 2001.
[21]Kahlown, Chang, Ashraf and Hussan 2003.
[22]World Bank 2006b.
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