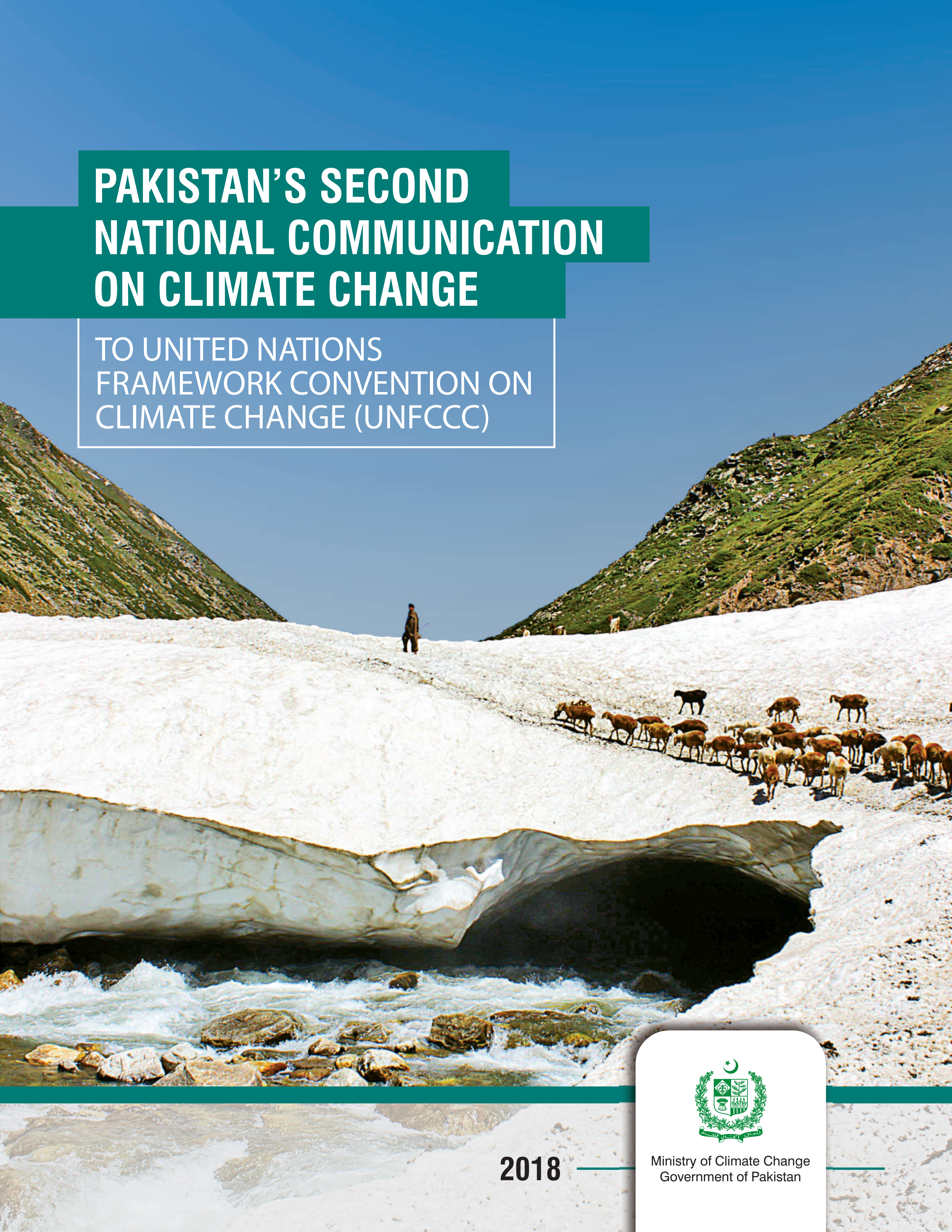
PAKISTAN'S SECOND NATIONAL COMMUNICATION ON CLIMATE CHANGE

TO UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)



2018

Ministry of Climate Change
Government of Pakistan

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Preface

Pakistan ratified the United Nations Framework Convention on Climate Change (UNFCCC) in June 1994 and was among the first South Asian countries which realized the need to control the anthropogenic contribution to global climate change and need to respond effectively to its adverse impact. Under Article 4(1) of the UNFCCC, each party is required to submit, periodic, *'National Communications reporting inter alia an inventory of Greenhouse Gas (GHG) emissions by sources and removals by sinks, a general description of measures taken or envisaged to implement the Convention, and any other information considered relevant to achieving its objectives'.* Pakistan submitted its Initial National Communication (INC) in 2003.

The Paris Climate Agreement in 2015 is seen as a landmark development, which has been a strategic milestone to develop a unanimous agreement worldwide to address the challenge of climate change. The Agreement has been instrumental in galvanizing actions to address the issue of climate change. After the Agreement, all the countries have submitted plans to implement their Nationally Determined Contributions (NDCs) to cut CO_2 emissions. Currently, 197 parties to the Convention have submitted their NDCs and 150 have ratified the Agreement.

In May 2011, the Global Change Impact Studies Centre (GCISC) started undertaking preliminary stocktaking and stakeholders' consultation for this purpose. The work started by reviewing the relevant documentations and identifying the relevant stakeholders. The consultations took three forms: correspondence, personal meetings, and workshops.

A 'National Workshop on Stocktaking of GHG Inventory Development in Pakistan' was held in June, 2011. Stakeholders suggested the strengthening of the GHG Inventory development mechanism so that the up-gradation of the inventory may be ensured on a regular basis. The issues of data availability, data authenticity, sustainability and periodicity of GHG- Inventory in connection with the country- specific emission factors were discussed.

Later, a two day second national workshop of this preliminary activity, was also held at the Pakistan Academy of Sciences, Islamabad in July, 2011. Participants focused on gaps identification of the previous and ongoing efforts, selection of priority areas for future research, capacity building and technology transfer needs and identification of national institutions that can contribute to the preparation of Pakistan's Second National Communication. (Findings of the working groups are annexed as 'Annexure- A').

Foreword

The effects of climate change are very much evident in Pakistan, with the multitude of threats, ranging from the melting of glaciers, floods, drought, sea level rise, and spread of diseases. These climate change impacts pose severe threats to our ecology, society, economic activity and are considered a major developmental challenge and threat to national security. All available scientific evidence points to the fact that Pakistan is expected to face these challenges in future, unless serious efforts are made by the international community to curb emissions.

In order to contribute to the global efforts, Pakistan intends to make efforts to delink economic growth from carbon growth to keep its emissions trajectory at the lowest possible level so it can play its part as a responsible country. All our development plans are being cautiously executed to keep our carbon footprint low so that we can engage in climate compatible development pathways. Adapting to climate change remains amongst the topmost priorities of the Government of Pakistan as the nation remains at the forefront even amongst the most impacted countries.

Integrating climate change concerns into overall development planning, initiating on ground action in priority sectors of agriculture & livestock, water resources, disaster management, forestry and human health, in a coordinated way is our political commitment. The present government is paying earnest attention to address the climate-related issues and has been undertaking concerted actions to cope with the policy and institutional challenges. The Government is committed to take all possible steps towards making all development climate resilient.

Pakistan's Second National Communication (SNC) on Climate Change has been prepared after rigorous research and analytical work and presents the case of Pakistan's unique vulnerabilities. SNC encompasses the challenges associated with integrating these concerns with policies and further translation into actions while touching finance, technology, capacity and awareness raising on climate change.

The process adopted for the preparation of SNC relies on the existing research and analytical competence of nodal national institutions dealing with the various thematic areas of the national communication. Institutional coordination and flow of information have been strengthened to make the reporting process more consistent and coherent. The Ministry of Climate Change has put an effective institutional structure in place to ensure the continuity of the national reporting process under the UN Framework Convention on Climate Change.

I congratulate the officials of the Ministry of Climate Change for successfully compiling the extensive information in its present form and as per obligatory reporting requirements of the Convention. My sincere appreciation goes to all the contributing authors and experts for devoting their time to complete the requisite analysis and the stakeholders for their support in reviewing the content. This document is a valuable resource and I expect that it will be used as reference material for designing all related programmes and implementing them on ground.

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Acronyms

ADB	Asian Development Bank
AEDB	Alternative Energy Development Board
AFD	Agence Francaise de Developpement
AJK	Azad Jammu and Kashmir
APTMA	All Pakistan Textile Mills Association
ARE	Alternate Renewable Energy
ASAD- PAEC	Applied System Analysis Division- Pakistan Atomic Energy Commission
ASHRAE	The American Society of Heating, Refrigerating and Air- Conditioning Engineers
BAP	Biodiversity Action Plan
BRESL	Barriers Removal Efficiency Standards and Labeling
BRT	Bus Rapid Transport
CAGR	Compounded Annual Growth Rates
CAS	Centers for Advance Studies
CBD	Convention on Biological Diversity
CBDR	Common But Differentiated Responsibilities
CCS	Climate Change Scenario
CDD	Cooling Degree Days
CFLs	Compact Fluorescent Lamps
CPEC	China- Pakistan Economic Corridor
CPEIR	Climate Public Expenditure and Institutional Review
CPI	Cleaner Production Institute
CSA	Climate Smart Agriculture
CSOs	Civil Society Organizations
DCPs	Data Collection Platforms
DDMUs	District Disaster Management Units
DISCOs	Distribution Companies
DMP	Drainage Master Plan
DOC	Degradable Organic Carbon
DRM	Disaster Risk Management
DSSAT	Decision Support System for Agrotechnology Transfer
EDB	Engineering & Development Board
EIA	Environmental Impact Assessment
EMDS	Electric Motor- Driven Systems
ESM	Environmentally Sound Management
ESTs	Environmentally Sound Technologies
EU	European Union
FAO	Food and Agriculture Organization
FATA	Federally Administrated Tribal Area
FCPF	Forest Carbon Partnership Facility
FFC	Federal Flood Commission
FFD	Flood Forecasting Division
FICCP	Framework for Implementation of Climate Change Policy
GB	Gilgit- Baltistan
GCF	Green Climate Fund
GCISC	Global Change Impact Studies Centre
GCMs	Global Circulation Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS/ RS	Geographic Information System/ Remote Sensing
GLOFs	Glacial Lake Outburst Floods
GMRC	Glacier Monitoring Research Center
GTS	Global Telecommunication System
HDIP	Hydrocarbon Development Institute of Pakistan
HKH	Hindu Kush Himalayan
HRS	Heat Recovery Systems
IBIS	Indus Basin Irrigation System
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIMOD	International Centre for Integrated Mountain Development
IEE	Initial Environmental Examination
IEP	Integrated Energy Plan
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRS	Indus River System
IRSA	Indus River System Authority
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
KP	Khyber Pakhtunkhwa
LCD	Liquid Crystal Display
LEAD- Pakistan	Leadership of Environment and Development- Pakistan
LED	Light Emitting Diodes
LHW	Lady Health Worker
LNG	Liquified Natural Gas
LPG	Liquefied Petroleum Gas
LUCF	Land- Use- Change and Forestry
MODIS	Market- Oriented Deposit Insurance Scheme
MOIP	Ministry of Industries, Production
MSW	Municipal Solid Waste
NAP	National Adaptation Plan
NARC	National Agriculture Research Council
NCCP	National Climate Change Policy
NCV	Net Calorific Value
NDCs	Nationally Determined Contributions
NDMA	National Disaster Management Authority
NDMO	National Disaster Management Ordinance
NDP	National Development Plan
NEECA	National Energy Efficiency & Conservation Authority
NEPRA	National Electric Power Regulatory Authority
NEQs	National Environmental Quality Standards
NEU	Non- Energy Use
NGO	Non- Governmental Organization
NIO	National Institute of Oceanography
NMVOC	Non- Methane Volatile Organic Compound
NSUSC	North Sindh Urban Services Corporation Limited
NTDC	National Transmission and Dispatch Company Ltd
NTWC	National Seismic Monitoring & Tsunami Early Warning Centre
NUST	National University of Science and Technology
NWFC	National Weather Forecasting Centre
OXFAM	Oxford Committee for Famine Relief
Pak- EPA	Pakistan Environmental Protection Agency

PARC	Pakistan Agriculture Research Council	SDPI	Sustainable Development Policy Institute
PCRET	Pakistan Council of Renewable Energy Technologies	SFM	Sustainable Forests Management
PCRWR	Pakistan Council of Research in Water Resources	SIHP	Snow and Ice Hydrology Project
PDMA	Provincial Disaster Management Authority	SLR	Sea level Rise
PEPA	Pakistan Environmental Protection Act	SME	Small and Medium- sized Enterprises
PEPCO	Pakistan Electric Power Company	SUPARCO	Space and Upper Atmosphere Research Commission
PFI	Pakistan Forest Institute	SWD	Solid Waste Disposal
PISD	Program for Industrial Sustainable Development	T&D	Transmission and Distribution
PMD	Pakistan Metrological Department	TCWC	Tropical Cyclone Early Warning Centre
PNSSP	Pakistan National Student Satellite Programme	TNA	Technology Needs Assessment
POPs	Persistent Organic Pollutants	TWEIP	Tube- wells Efficiency Improvement Program
PSMA	Pakistan Sugar Mills Association	UET	University of Engineering & Technology
PSWC	Pakistan Space Weather Centre	UIB	Upper Indus Basin
PTA- NZ	Pakistan Tanners Association North Zone	UNEP	United Nations Environment Programme
PTA	Pakistan Tanners Association	UNFCCC	United Nations Framework Convention on Climate Change
PTPS	Pakistan Transport Plan Study	UNIDO	United Nations Industrial Development Organization
PV	Photo Voltaic	USAID	United States Assistance for International Development
R&D	Research and Development	VFD	Variable Frequency Drive
RE&EE	Renewable Energy and Energy Efficiency	WAPDA	Water and Power Development Authority
REDD	Reducing Emissions from Deforestation and Forest Degradation	WASAs	Water and Sanitation Authority
RNE	Royal Netherlands Embassy	WWF	World Wide Fund for Nature
SAARC	South Asian Association for Regional Cooperation	ZSD	Zoological Survey Department
SBP	State Bank of Pakistan		
SDGs	Sustainable Development Goals		

Units

cft	cubic feet	MTOE	Million tonne of oil equivalent
p. a.	per annum	MAF	Million Acre Feet
FY	Fiscal year	MW	Megawatt
^{0}C	degree Celsius	MMCFD	Million Cubic Feet per Day
CO_2- eq	carbon dioxide equivalents	TOE	Tonne of oil equivalent
Gg	gigagram (=1,000 metric tons)	tonne	Metric tonne (=1,000 kg)
Gg CO_2- eq	gigagram of CO_2- eq.	TJ	Tera Joule
GW	gigawatt (=1,000 MW)	ha	hectares
GWh	gigawatt hour	mm	milimeters
hectare	(=10,000 square meters)	m^2	square meters
km	kilometer	m^3	cubic meters
kWh	kilowatt hour		

Executive Summary

Pakistan's Second National Communication (SNC) contains the updated information until the year 2015 about the consolidated efforts undertaken by Pakistan in different thematic areas related to climate change mitigation and adaptation. Chapter 1 builds up the context by briefly describing the National circumstances since the Initial National Communication (INC). Chapter 2 documents the GHG inventory with the anthropogenic emissions and removals from key sectors including waste, land-use- change and forestry, agriculture, industrial processes and energy sector. Industrial processes includes mining, chemical and metal production whereas the energy sector entails the manufacturing, transportation and energy industries of the economy. Energy use in residential, commercial and agriculture is also incorporated in the energy sector inventory of the GHG. The chapter concluded with listing the energy intensity from 1994 to 2015. It is prudent to summarize that despite the expanding population, with ever growing energy and water demand, the total emissions (in kilograms of CO_2- eq) per $GDP (in USD of 2010) of Pakistan was 1.88 kilograms of CO_2- eq in comparison to 1.9 kg eq in 1994. This itself presents the meagre portion of Pakistan in terms of the anthropogenic cause of climate change as contrast to the collective but unevenly distributed share of responsibility at Pakistan. Regardless of Pakistan's very small contribution to GHG emissions, its role as responsible member of the global community in combating climate change is highly appreciable, and can be seen from large scale projects such as the Billion Tree Tsunami, which restores 350,000 hectares of forests and degraded land to surpass Bonn Challenge commitment. Chapter 3 remains the backbone of this report with modeled results related to temperature and precipitation changes projected for 2020, 2050 and 2080. It is prudent to mention here:

"The future climate projections developed by using state- of- the- art climate models indicate higher temperature rise over northern parts of Pakistan when compared with southern parts. The projected temperature increment along the coastal belt of the country are comparatively lesser and are in the range of 3 to 4 °C. In case of precipitation, an increase is projected over northern parts of the country compared to the southern counterpart.

These changes, invariability and expected erratic climate conditions are then trickled down to scope the effects on crop development, underground and river water inflows, health sector, natural ecosystems, coastal management, livestock and others. Such key vulnerable sectors are identified and highlighted in Chapter 3. Chapter 4 postulates the options and challenges associated to the mitigation of current and projected GHG emissions. From the perspective of projected emissions for a growing economy, Pakistan's Intended Nationally Determined Contributions (INDC) were aligned with the expected GDP growth scenarios as well as with the respective policies, plans and sectoral growth targets set by various ministries and other government entities. Due importance has been given to mitigation efforts in sectors such as energy, transport, industries, urban planning, forestry and land- use, agriculture, livestock and waste in Chapter 4. These overlapping thematic areas and the vulnerable sectors identified in Chapter 3 are then integrated into Climate Change Considerations into Social, Economic and Environmental Policies in Chapter 5. Such integrations are big wins for Pakistan in terms of Strategy (National Climate Change Strategy), Plan (Climate Change and National Development Plan) and Policies (National Climate Change Policy, 2012). Furthermore, appropriate actions relating to disaster preparedness, capacity building, institutional strengthening and awareness raising in relevant sectors have also been part of this document. Inclusive and equitable measures with a focus on the most vulnerable segments of the society is at the forefront of Pakistan's response to the threat of climate change.

Chapter 6 provides an update on Research, Technology Transfer and Systematic Observation. It identifies the lack of technical equipments in particular, and capacity building needs in general, as effective tools to combat the affects of climate change. Recent trends of extended droughts and intense heatwaves coupled with the floods including glacial lake outburst floods; the writing is on the wall for the people and institutions of Pakistan with over USD 18 billion loss to the economy in just five floods (2010- 2014).

Discussion of technology requirement and capacity building, stated in Chapter 6, is complimented with the need assessments of key sectors of energy/ power, transport, agriculture, water, forestry and waste management in Chapter 7 while also discussing environmentally sound technologies and their development and transfer as well as related capacity building needs. Such technological and other capacity building needs that are then articulated in Chapter 8 titled ‘Constraints, gaps, and related financial, technical & capacity needs’. It sought collaborations from international community and also briefly lists the ongoing such collaborations via bilateral and multi- lateral institutional framework.

In noting the advances made in this NC, it is also important to recognise its limitations. Considering such limitations and the uneven effects of climate change on vulnerable segments of the population, massive international investments are required to reduce emissions from projected scenarios. Pakistan’s adaptation need is between USD 7 to 14 billion/ annum whereas Pakistan qualifies for being one of the most promising carbon investment markets in the world as it has low abatement cost coupled with an enabling regulatory regime for prospective climate- resilient investments.

Anticipating the future challenges, Government of Pakistan’s strategies are aimed at saving the lives of the people from the vagaries of climate change, promoting development for the overall wellbeing of the nation and honoring the international commitments as responsible global citizens to reduce emissions and prevent climate change. Towards this end, the government has taken following steps:

- Establishment of Prime Minister’s Committee on Climate Change
- The launch of 10 Billion Tree Tsunami
- The launch of Clean & Green Pakistan - the program envisages addressing five components: plantation, solid waste, liquid waste/ hygiene, total sanitation and safe water
- Efforts to Increase the Share of Renewable Energy up to 30% in the Energy Generation Mix
- Promotion of net-metering regime
- Development & Launch of Mandatory Energy Labeling Regime for LED Lights, AC and Refrigerator
- Promotion of Solar Power Irrigation Systems
- Efforts for the gradual wiping-out of single use plastics
- Formulation of NDC implementation roadmap
- Formulation of Electric Vehicle Policy
- Launch of Ecosystems Restoration Initiative (ESSRI)

Contents

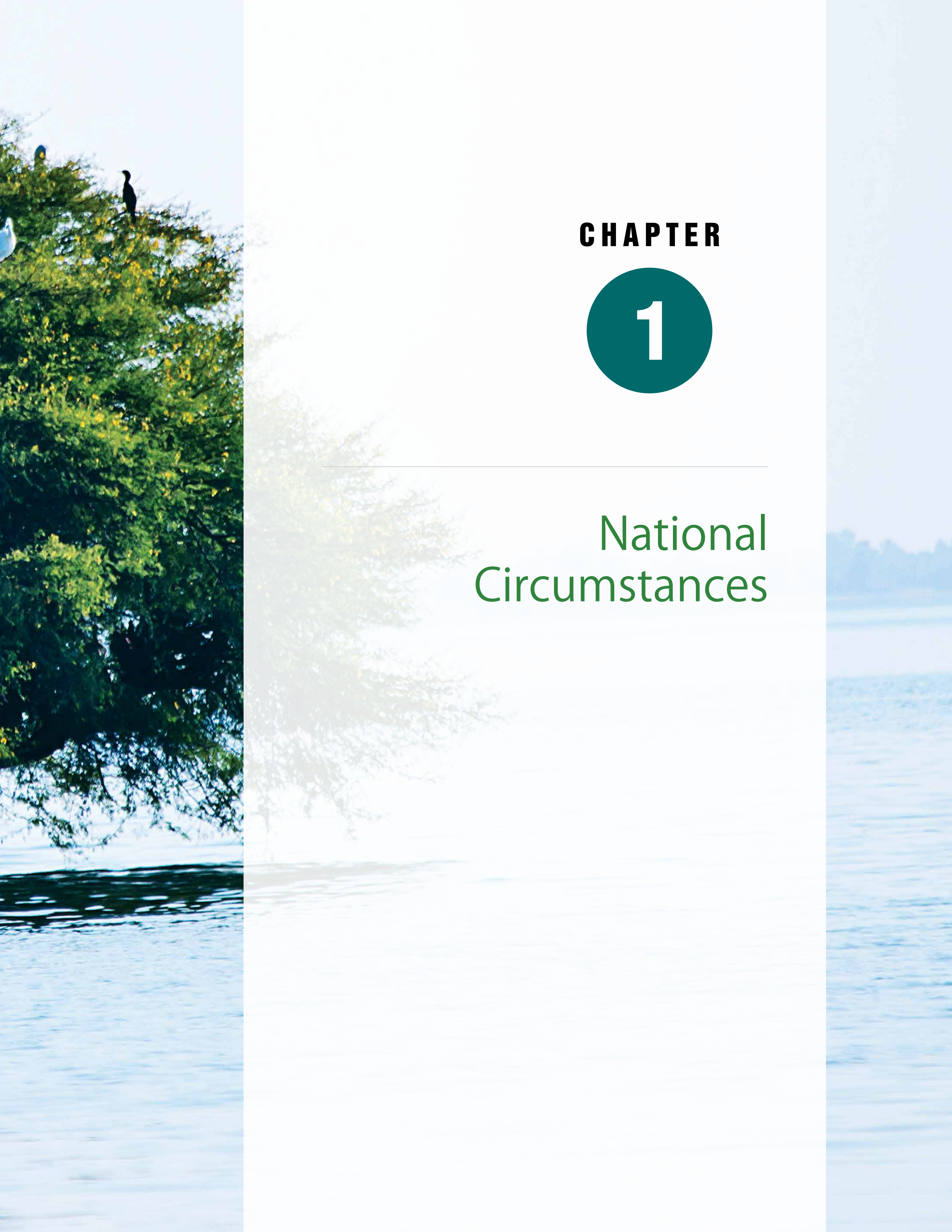
CHAPTER 3

CHAPTER 4

CHAPTER 5

List of Figures

List of Tables



CHAPTER

1

National Circumstances

National Circumstances

1.1 Geography

Pakistan is blessed with four seasons and almost all the landscapes, including plains, deserts, forests, hills, and plateaus from the coastal areas of the Arabian Sea in the south to the Karakoram Range in the north. The country overlaps with both the Indian and the Eurasian tectonic plates. In the west, it shares its borders with Afghanistan and Iran, in the east with India, and in the north with China.

With 796,096 square kilometers of land, Pakistan is the 36th largest country by area. K2 the second highest peak globally is also located in Pakistan. The longest river is Indus, which originates from the Tibetan plateau, and runs through the entire length of Pakistan and merges into the Arabian Sea near Karachi, a port city in Sindh province.

The country is located between 23 degrees north to 37 degrees north longitude, and 61 degrees east to 77 degrees east latitude.

1.2 Climate

Diversity in climatic conditions along the length and width of Pakistan offer multiple dividends. In the south and southwest areas, there are places where temperature rises as high as 50- 54 °C in summers whereas in northern and northwestern Pakistan, it falls below freezing- point in winters.

Figure 1:

Map of Pakistan

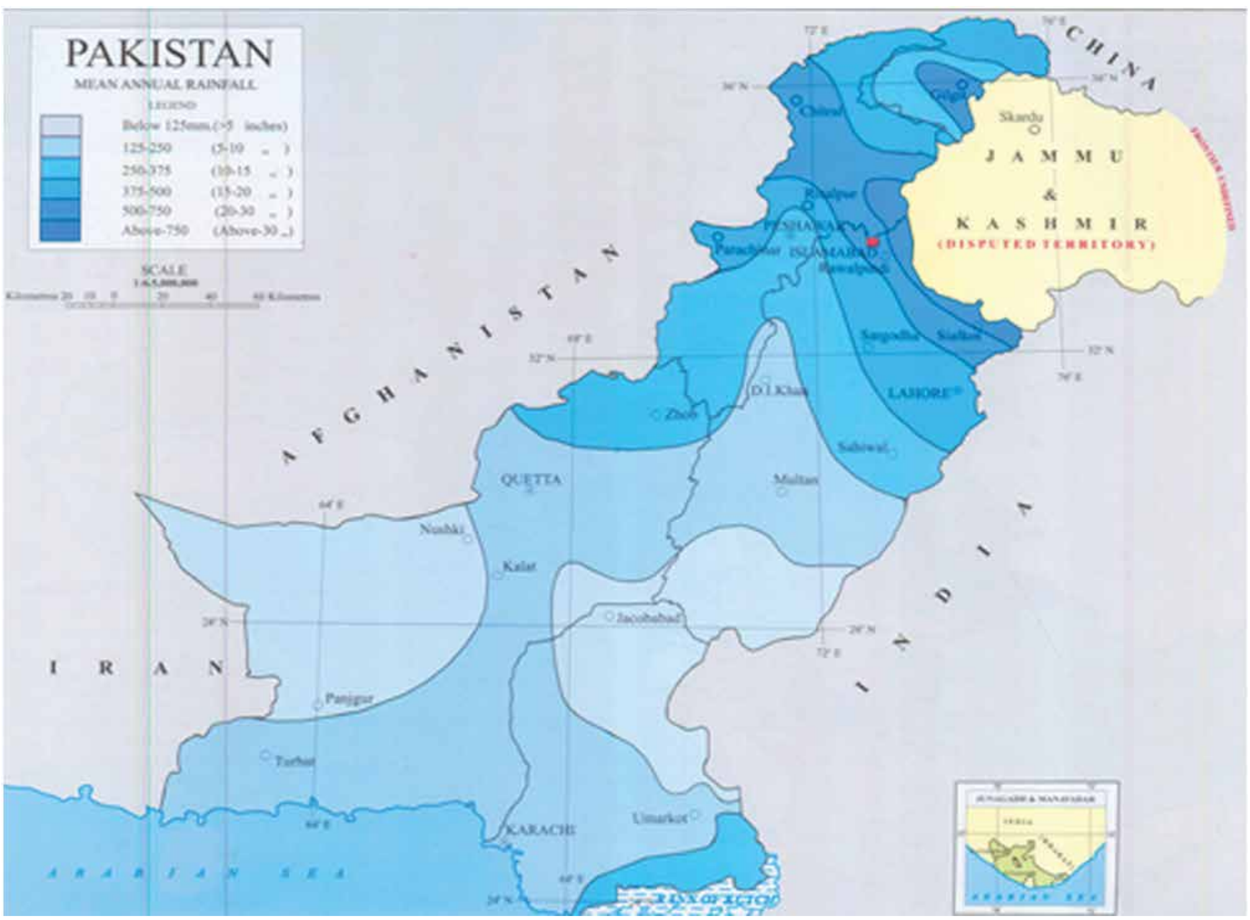
The average annual precipitation amounts to about 280 mm, varying between some 1600 mm in the northern sub- mountainous region/ northern Punjab and about 50 mm in the south of the country, with southern Punjab and upper Sindh getting about 100 mm per annum. On the basis of Pakistan Meteorological Department data (1961- 1990), about 34.1% of the land is classified as hyper arid, 28.8% as arid, 30.8% as semi- arid, 3.6% as sub- humid, and 2.8% as humid to very humid. There was an increase of 0.6 °C during the past century in conformity with the average global temperature increase.

However, during the period between 1981- 2005, the decadal mean temperature rise over Pakistan was 0.39 °C as compared to 0.177 °C for the globe as a whole (Sheikh *et al.,* 2009a), which implies that the warming over Pakistan was twice as fast as the global mean temperature rise. The climate change projections based on Global Circulation Models (GCMs) also indicate that the average temperature over Pakistan will increase during the current century at a pace faster than that of the average global temperature (Islam *et al.,* 2009b). Besides, the projections indicate that the northern half of the country above 31° N will experience more warming than the southern part.

Pakistan, for the last several years, has been rated among the top in the list of the countries most affected by climate change, and is highly vulnerable to its devastating impact due to its diverse geographical and climatic features. Its climate varies from arid to semi- arid with a great diversity in temperature and precipitation. The country has predominantly agriculture-based economy and is particularly vulnerable to climate change, as the agriculture sector is highly sensitive to the changing patterns of climate in terms of time and location. Similarly, some of the world's largest glaciers, including 70- km long Siachen and 63- km long Biafo that feed the Indus river and some of its tributaries are susceptible to such erratic patterns. These

Figure 2:

Map of Pakistan showing the annual mean precipitation



glaciers are also receding rapidly due to global warming. Consequently, water, food and energy securities of the country are under serious threat. In the recent past, the country also faced large floods, extended droughts and intense heatwaves. Changes in the physical processes responsible for the climate system dynamics under global warming scenario sometimes appear as occurrence of extreme events of unprecedented intensity causing irreversible loss to the natural resources. The present era of rapid climate change demands for reliable future climate projections for policy and decision makers, better resource management, sustainable economic activity and technological advancement. In nutshell, Pakistan is ranked one of the top most vulnerable countries to climate change. Analysis of the 1996- 2015 data of damages caused by hydro- meteorological extreme events, German Watch, a Germany-based think tank, declares Pakistan the seventh most vulnerable country to climate change in the world (Kreft, Eckstein & Melchior, 2016).

1.3 Population

Pakistan is sixth most populous country in the world with an estimated population of 191.7 million in 2015, growing at 1.92% per annum (See Table 1). It is expected that Pakistan will attain fifth position in the world in terms of total population in 2050. About 40% of the population lives in urban areas whereas rural areas constitute the rest of 60%. An overall population density is 231 people per sq. km. About 60% of the total population lies in the age group of 15-59 years with sizeable youths.

Table 1:

Selected Demographic Indicators of Pakistan

	2014	2015
Total Population (millions)	188.02	191.71
Urban Population (millions)	72.50	75.19
Rural Population (millions)	115.52	116.52
Total Fertility Rate (TFR)	3.2	3.2
Crude Birth Rate (per thousand)	26.4	26.1
Crude Death Rate (per thousand)	6.90	6.80
Population Growth Rate (percent)	1.95	1.92
Life Expectancy (Years)		
Male	66.9	67.3
Female	64.9	65.2

Source: Ministry of Finance, 2015

Pakistan hosts massive number of refugees from Afghanistan as well as internally displaced persons (IDPs) due to war on terror. Frequent floods in the monsoon and drought in the dry seasons are normal phenomena with huge recurring social and economic costs to the country. Pakistan's demographic history spreads out from the Indus Valley Civilization to the division of Indian subcontinent to the modern era of parliamentary democracy.

1.4 Economy

In 2014- 15 the total labour force is 61.04 million out of which 57.42 are employed. The share of employment in agriculture sector is 42.3% with the share of transport/ storage & communication at 5.4%. The share of manufacturing stood at 15.3%. Unemployment rate reported was 5.9% (Economic Survey of Pakistan, 2015- 16).

The per capita income in 2014- 15 was USD 1,512 compared to USD 492 in 2002- 03. The main factors responsible for this increase were relatively high growth rate of Gross Domestic Product (GDP) until 2007, lower growth in population, and stable exchange rate. However, Pakistan's economic performance was affected from 2007 onwards due to devastating floods, internal security hazards, and the energy crisis. As a result, during the last five years, the average economic growth rate was only 2.6% per annum. During 2014- 15, the GDP grew at 4.24%, up from

0.4% in 2008- 09 but lower than 4.4% in 2011- 12 (Ministry of Finance, 2015).

Deterioration in the power sector has been the main constraint for economic growth in recent years: The average annual growth rates of Power Generation and Primary Commercial Energy Supplies during 2007- 2012 were- 0.6% (minus sign with 0.6) and 1.3% respectively, as against 6.3% and 6.0% respectively in the previous 5- year period (HDIP, 2008 & 2013). As the power outages are shaving off annually about 2% economic growth, the GDP growth has been stuck at a level, which is only half of the potential level of about 6.5% per annum based on Pakistan's long- term trend (Ministry of Finance, 2013). With concrete and sincere efforts of the government, almost 12% growth has been observed in real value addition of electricity generation & distribution and Gas distribution during FY- 2015 and FY- 2016 which in turn helped the real GDP growth of 4.7% during FY- 2016. Government of Pakistan is also pursuing to enhance gas production in order to meet the increasing demand of energy in the country (Economic Survey of Pakistan, 2015- 16).

At present, Pakistan's export earnings correspond to about USD 25 billion, which is equivalent to about 10% of GDP, with agriculture products (mainly rice, cotton yarn and textiles) being the major export items. On the other hand, the country's imports consume nearly USD 45 billion, equivalent to about 18% of GDP. Oil imports account for about 35% of the total imports bill and consume nearly two- thirds of the country's exports earnings, which is a serious burden on the national economy (Ministry of Finance, 2013). Government has improved relations with International Financial Institutions. The country has witnessed the resumption of policy lending from the World Bank and Asian Development Bank, which was suspended for lack of a stable macroeconomic framework before June 2013. The government's three- year Extended Fund Facility Program with the IMF effectively institutionalizes the government's economic policy objectives. Pakistan has successfully completed eleventh reviews with IMF. All international financial institutions are appreciating performance of the economy of Pakistan and forecasting improvement in economic situation over time (Economic Survey of Pakistan, 2015- 16).

Table 1 (First):

Sectoral share in Gross Domestic Product (GDP) at constant basic prices

No	Sector/Industry	2005- 06	2006- 07	2007- 08	2008- 09	2009- 10	2010- 11	2011- 12	2012- 13	2013- 14	2014- 15 (R)	2015- 16 (P)
												(%)
A.	Agricultural Sector (1 to 4)	23.01	22.55	21.87	22.55	22.03	21.68	21.63	21.42	21.10	20.80	19.82
	1. Crops (i+ii+iii)	9.93	9.83	9.26	9.71	9.07	8.84	8.79	8.60	8.49	8.24	7.38
	i) Important Crops	5.82	5.87	5.36	5.79	5.44	5.33	5.53	5.35	5.51	5.27	4.67
	ii) Other Crops	3.33	3.22	3.25	3.25	2.94	2.90	2.59	2.63	2.39	2.37	2.25
	iii) Cotton Ginning	0.78	0.74	0.65	0.66	0.69	0.61	0.67	0.62	0.59	0.61	0.46
	2. Livestock	12.06	11.75	11.59	11.81	11.95	11.92	11.94	11.91	11.73	11.73	11.61
	3. Forestry	0.45	0.44	0.46	0.47	0.46	0.46	0.45	0.47	0.46	0.39	0.41
	4. Fishing	0.56	0.53	0.55	0.56	0.56	0.45	0.45	0.44	0.43	0.44	0.43
B.	Industrial Sector (1 to 4)	20.95	21.38	22.09	20.87	21.04	21.22	20.95	20.36	20.45	20.61	21.02
	1. Mining and Quarrying	3.30	3.35	3.29	3.20	3.21	2.96	3.00	3.00	2.93	2.92	2.98
	2. Manufacturing (i+ii+iii)	13.81	14.26	14.42	13.76	13.60	13.45	13.23	13.38	13.58	13.56	13.60
	i) Large Scale	11.71	12.16	12.29	11.50	11.26	11.04	10.76	10.84	10.98	10.91	10.90
	ii) Small Scale	1.15	1.18	1.22	1.32	1.40	1.46	1.53	1.60	1.66	1.73	
	iii) Slaughtering	0.94	0.92	0.91	0.94	0.94	0.95	0.94	0.94	0.94	0.93	
	3. Electricity generation & distribution and Gas	1.43	1.18	1.54	1.35	1.53	2.43	2.37	1.68	1.61	1.73	1.85
	4. Construction	2.42	2.58	2.84	2.55	2.69	2.38	2.36	2.30	2.34	2.39	2.58
	Commodity Producing Sectors (A+B)	43.96	43.93	43.96	43.41	43.07	42.90	42.59	41.78	41.56	41.40	40.84
C.	Services Sectors (1 to 6)	56.04	56.07	56.04	56.59	56.93	57.10	57.41	58.22	58.44	58.60	59.16
	1. Wholesale & Retail trade	19.74	19.80	19.93	19.26	19.12	18.84	18.44	18.41	18.54	18.29	18.27
	2. Transport, Storage & Communication	12.44	12.60	12.66	13.25	13.30	13.15	13.24	13.29	13.27	13.37	13.29
	3. Finance & Insurance	3.67	3.79	3.84	3.45	3.26	3.01	2.95	3.08	3.09	3.16	3.25
	4. Housing Services (OD)	6.54	6.45	6.39	6.62	6.71	6.74	6.75	6.77	6.76	6.76	6.71
	5. General Government Services	5.51	5.36	5.12	5.39	5.67	6.24	6.67	7.17	7.08	7.14	7.58
	6. Other Private Services	8.15	8.07	8.11	8.61	8.87	9.13	9.36	9.50	9.70	9.88	10.06
D.	GDP {Total of GVA at bp (A+B+C)}	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Pakistan Statistical Yearbook, 2015

1.5 Natural Resources

Pakistan has been endowed with huge mineral potential including precious metals, dimension stones, industrial minerals, rock salt, and coal. However, there has been very limited exploration by using modern managements, adequate capital and appropriate technical know- how. As such, the mineral sector contributes only a meager 3% to the national GDP. A major constraint is that most of the mineral deposits are concentrated in Balochistan and whatever minerals are being produced, their production has been affected by law and order situation, absence of necessary infrastructure, and lack of technical capacity of mining. As such the actual production is far below the potential. There is a need for the development of technologies for processing different indigenous ores to extract products of high commercial value that can play a dominant role in economic uplift, employment generation and exports. A number of initiatives to this effect are now being taken by the government (Ministry of Finance, 2013). Since the discovery of Thar coal field, several areas of Sindh have attained significant importance in their stratigraphic settings and natural resources potential such as bentonite, granite and celestite etc. It was quite difficult in the past to have a quick and easy access to these sources of information, mainly because of absence of a reliable data base (Economic Survey of Pakistan, 2015- 16).

1.5.1 Energy Sector

Primary commercial energy supplies in Pakistan comprises of oil, natural gas, coal, hydro and nuclear electricity. The primary energy supplies of the country during fiscal year 2014- 15 increased by 5.11% and reached 70.26 MTOE as compared to 66.85 MTOE during the same period last year. The overall contribution of gas in primary energy supplies of the country, during 2014- 15, was the highest with 29.98 MTOE (42.66%) followed by the Oil 24.97 MTOE (35.54%), Hydro Electricity 7.75 MTOE (11.03%), Coal 4.95 MTOE (7.05%), Nuclear Electricity 1.39 MTOE (1.97%), LPG 0.46 MTOE (0.65%), Imported Electricity 0.11 MTOE (0.15%), LNG Imported 0.47 MTOE (0.67%) and Renewable Energy 0.19 MTOE (0.27%).

Oil Reserves

The balance recoverable reserves of crude oil of the country as on 30th June 2015 were 384.407 million barrels while the production during fiscal year 2014- 15 was recorded as 34.49 million barrels. The total oil refining capacity of the country as on 30th June 2015 was 18.92 Mt (million tonnes) per year while the total crude oil processed in the refineries of the country was 12.41 mt. The total import of the crude oil of the country during 2014- 15 was 8.33 mt with cost amounting to USD 4581.14 million while during 2013- 14 the total import of crude oil was 8.04 mt with total cost of USD 6572.68 million. The consumption of petroleum products (furnace oil, light diesel oil, high speed diesel and motor spirit) within the power sector was recorded as 9.00 million tonnes during 2014- 15 while during 2013- 14 it was recorded as 9.01 mt.

Gas Reserves

The balance recoverable reserves of natural gas of the country as on 30th June, 2015 were 20.26 trillion cft. while the production during fiscal year 2014- 15 was recorded as 1,465,760 million cft. The consumption of natural gas in power sector during 2014- 15 was recorded as 371,562 million cft. while during 2013- 14 it was recorded as 349,535 million cft. The total network for distribution of natural gas in Pakistan as on 30th June, 2015 was 153,642 km. The total number of natural gas consumers in Pakistan, as on 30th June, 2015 was 7.692 million of which the share of domestic, commercial and industrial consumers were 7.6 million, (77455) and (10606), respectively.

Coal Reserves

The estimated total coal reserves of the country as on 30th June, 2015 were about 186 billion tonnes while production of coal during 2014- 15 was recorded as 3.71 million tonnes. The total coal imported during 2014- 15 was 5.00 million tonnes, with cost amounting to Rs. 52762 million. The total coal consumption in power sector during 2014- 15 was 151,180 tonnes as compared to 160710 tonnes, same period previous year. The electricity generated through coal during fiscal years 2013- 14 and 2014- 15 was 112 GWh and

102 GWh respectively.

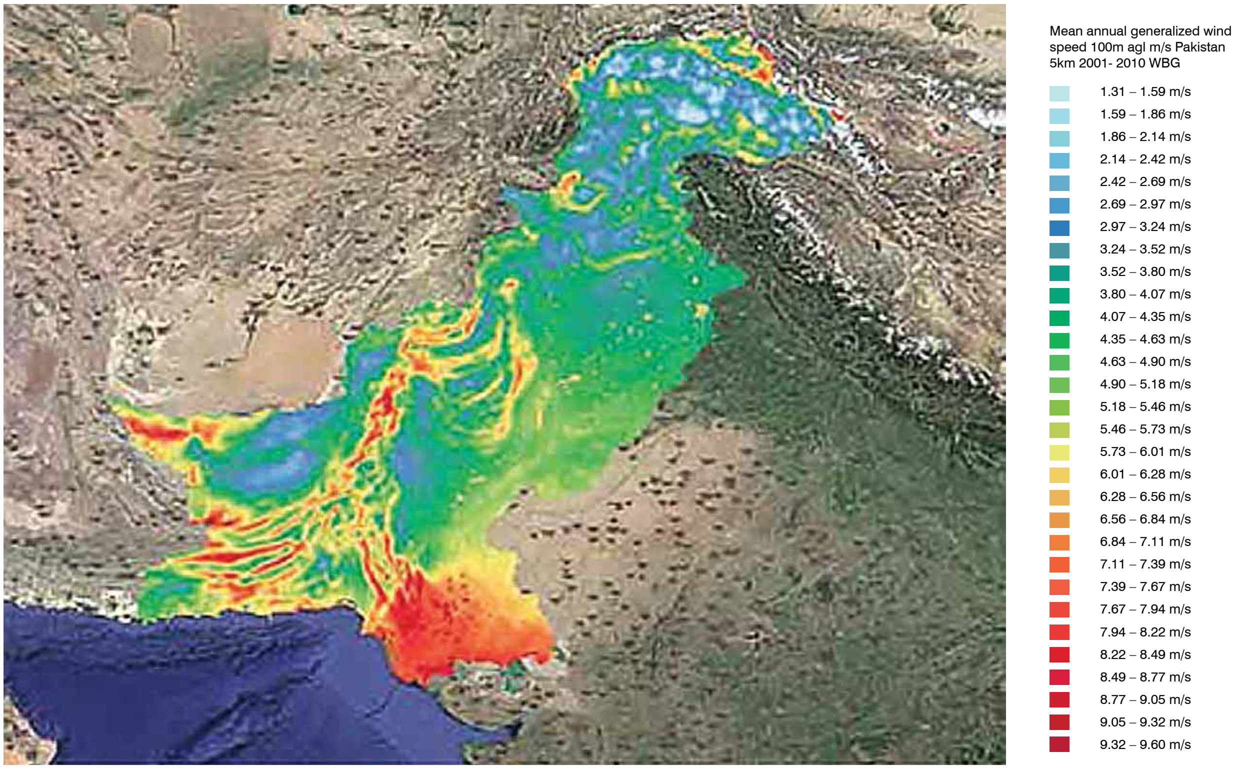
Alternative Energy Sources

a. Wind

The US National Renewable Energy Laboratory created a wind map of Pakistan based on satellite data. This provided a starting point for wind development as it identified many parts of the country that could have commercially exploitable wind potential. The theoretical potential for wind power in Pakistan estimated in this map is about 340 GW, but this estimate does not consider technical and economic constraints. The World Bank- ESMAP initiative is producing a more precise wind atlas of Pakistan based on ground-level wind speed measurement using wind masts of various heights at different locations. With an approximate theoretical potential of over 50 GW, the Gharo- Keti Bandar wind corridor in southern Pakistan was prioritised by the government at the very beginning of renewable energy development in the country. This is due to its good resource potential and relative proximity to major load centres and the national grid (AEDB, 2013). At the moment, all the installed wind power in Pakistan is in this corridor. The Figure below displays the wind energy resource map prepared using satellite data from 2001 to 2010 showing wind speeds at a height of 100 meters.

Figure 3:

Pakistan wind energy resource map



Source: IRENA (n.d.), Global Atlas for Renewable Energy, using data from World Bank- ESMAP

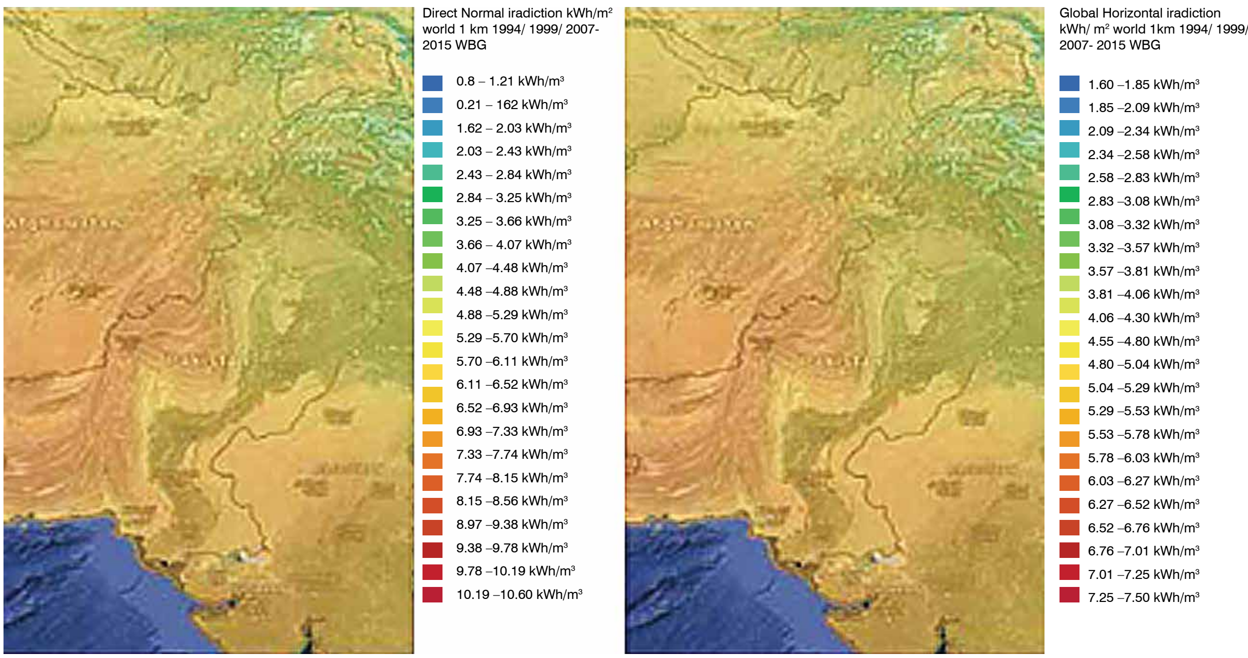
Disclaimer: Geographical boundaries IRENA (n.d.) Global Atlas for Renewable Energy, using data from World Bank- ESMAP

b. Solar

Pakistan has good solar irradiation, and the southern and southwestern parts of the country record greater irradiation levels than the northern

Figure 4:

Pakistan Solar Energy Resource Maps



Notes: Left represents direct normal irradiance, right represents global horizontal irradiance.
Source: IRENA (n.d), Global Atlas for Renewable Energy, using data from World Bank- ESMAP.
The boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA and Pakistan.

Pakistan. Balochistan in the southwest is the site of the country's maximum annual global horizontal irradiance at just over 2300 kWh per square meter (m^2). The estimated values only decrease gradually as one moves up towards the northeast of the country and still exceed 1500 kWh/ m^2 per year in more than 90% of the land area (World Bank- ESMAP, 2014). This consideration is integrated into the upfront tariffs for solar PV power generation, which differ in the northern and southern parts of the country. Figure 4 shows the solar irradiance maps of Pakistan.

c. Biomass/ Waste Energy

The biomass feedstock available from industrial processes includes maize husk, rice husk, corn cob and bagasse. By contrast, biomass feedstock from agricultural residue includes, for instance, rice straw, sugarcane trash, wheat straw, cotton stalk and maize stalk. Table 2 summarizes the technical and theoretical potential of all these sources. However, existing economic use of agricultural residue (e.g. as animal fodder, natural fertilizer) can reduce its availability for energy, particularly in winter, while loss of agricultural land to real estate development may further reduce availability.

Table 2:

Biomass feedstock potential

		Theoretical potential (000 tonnes/ year)	**Technical potential** (000 tonnes/ year)
Indutrial biomass feedstock	Maiz husk	526	57
	Rice husk	4360	1841
	Corn cob	789	86
	Bagasse	11030	3915
agricultural biomass feedstock	Rice straw	21800	9203
	Sugarcane trash	4413	1566
	Wheat straw	52335	8260
	Maiz stalk	2988	327

Source: World Bank Group (n.d). "World Bank Open Data", http://dataworldbank.org/

d. Primary Energy Supplies

The primary energy production of the country consists of oil, gas, coal, nuclear electricity net generation (converted to Btu using the nuclear plants heat rate); and conventional hydroelectricity net generation (converted to Btu using the fossil- fueled plants heat rate). The primary commercial energy supplies by source from 2010- 11 to 2014- 15 is given in Table 3:

Table 3:

Primary Energy Supplies by Source (MTOE)

Fiscal year	Unit	Gas	Oil[1]	LNG Import[2]	LPG[3]	Coal	Hydro Electricity[4]	Nuclear Energy[4]	Renewable Energy[2]	Imported Electricity[5]	Total	Annual Growth rate
2010-11	MTOE	30.68	20.67		0.34	4.35	7.59	0.82		0.06	64.52	2.27
	% share	47.55	32.04		0.53	6.74	11.77	1.27		0.10	100	
2011-12	MTOE	32.03	19.96		0.32	4.29	6.81	1.26		0.07	64.73	0.32
	% share	49.49	30.83		0.50	6.62	10.52	1.94		0.10	100	
2012-13	MTOE	31.14	20.97		0.31	3.86	7.13	1.09		0.09	64.59	-0.21
	% share	48.22	32.47		0.48	5.98	11.03	1.68		0.14	100	
2013-14	MTOE	30.96	23.01		0.36	3.59	7.61	1.22		0.10	66.85	3.5
	% share	46.32	34.42		0.54	5.37	11.38	1.82		0.15	100	
2014-15	MTOE	29.98	24.97	0.47	0.46	4.95	7.75	1.39	0.19	0.11	70.26	5.11
	% share	42.66	35.54	0.67	0.65	7.05	11.03	1.97	0.27	0.15	100	

Source: Pakistan Energy Yearbook, HDIP, Islamabad

e. Final Energy Consumption

Final energy is a form of energy available to the user following the conversion from primary energy. Gasoline or diesel oil, purified coal, purified natural gas, electricity, mechanical energy are different forms of final energy. The final energy consumption by source from 2010- 11 to 2014- 15 is given in Table 4:

Table 4:

Final Energy Consumption by Source (MTOE)

Fiscal year	Unit	Gas[6]	Oil[7]	LPG	Coal[6]	Electricity[8]	Total	Annual Growth rate
2010- 11	MTOE	16.78	11.25	0.50	4.03	6.28	38.84	0.19
	% share	43.20	28.97	1.30	10.36	16.17	100	
2011- 12	MTOE	17.62	11.62	0.48	4.06	6.25	40.03	3.05
	% share	44.02	29.03	1.20	10.14	15.62	100	
2012- 13	MTOE	17.52	12.22	0.53	3.66	6.25	40.18	0.40
	% share	43.60	30.41	1.31	9.11	15.56	100	
2013- 14	MTOE	16.28	12.72	0.59	3.45	6.79	39.82	-0.91
	% share	40.88	31.94	1.47	8.65	17.06	100	
2014- 15	MTOE	15.76	13.85	0.76	4.63	6.99	41.98	5.44
	% share	37.53	32.99	1.80	11.03	16.65	100	

Source: Pakistan Energy Yearbook, HDIP, Islamabad

1 Excluding petroleum products exports and bunkering.
2 LNG Imports and Renewable Generation reported for the first time in FY 2014-15.
3 Include imports and production from field plants.
4 Converted @ 10,000 Btu/kWh to represent primary energy equivalent of hydro and nuclear electricity as if this was generated by using fossil fuels.
5 WAPDA importing electricity from Iran since October, 2002.
6 Excluding consumption for power generation.
7 Excluding consumption for power generation and feedstock.
8 @ 3412 Btu/kWh being the actual energy content of electricity.

1.5.2 Water Sector

Water, which is one of the most important national resources, is increasingly becoming scarce. 93% water resources are used in agriculture, 5% in domestic sector and only 2% in industrial sector. The domestic and industrial sector use is projected to be increased to 15% by 2025. However, water share in agriculture is expected to decrease because of competing non- agricultural demands. Pakistan's Indus Basin Irrigation System (IBIS) is the world's largest contiguous irrigation system that comprises three large dams, 85 small dams, 19 barrages, 12 inter- river link canals and 45 canal commands.

Water resources are inextricably linked with climate; hence, the climate change has serious implications for Pakistan's water resources. The freshwater resources in Pakistan are mainly based on snow and glacier melt and monsoon rains, both being highly sensitive to climate change. The average annual flow of Indus River System (IRS) is around 142 Million Acre- Feet (MAF) of which 104 MAF is diverted to the canal network, while major portion of the remaining balance of around 35 MAF outflows to the sea. Fortunately, Pakistan has a large useable groundwater aquifer, which is largely recharged from the surface flows and rains.

Vulnerability from extreme weather events is growing due to the ever- increasing population, socio- economic issues and environmental degradation.

The country- specific climate projections strongly suggest the following future trends in Pakistan.

- Decrease in the glacier volume and snow cover leading to alterations in the seasonal flow pattern of IRS
- Increase in the formation and burst of glacial lakes
- Higher frequency and intensity of extreme climate events coupled with irregular monsoon rains causing frequent floods and droughts
- Greater demand of water due to increased evapotranspiration rates at elevated temperatures

1.6 Agriculture & Livestock

1.6.1 Agriculture Sector

Agriculture is central to human survival and is probably the single human enterprise most vulnerable to change in climate. Agriculture is the lifeline and the single largest sector of Pakistan's economy. It contributes 21% to the GDP, employs 45% of the labour force and contributes about 70% to the export earnings. In Pakistan, it is greatly affected by erratic weather and could be harmed significantly by long- term climate change.

It has been increasingly realized that climate change is the most important factor that is likely to affect productive resources and ultimately the agriculture production in a number of ways. During FY- 2016, cotton production stood at 10.074 million bales as compared to 13.960 million bales in FY- 2015 and registered a drastic decline of 27.8%. These impacts include but are not limited to:

a. Shortening length of growing period

The duration of crop growth cycle is related to temperature; an increase in temperature will speed up crop growth and shorten the duration between sowing and harvesting. This shortening could have an adverse effect on productivity of crops and fodder for livestock. Subsequently the economic wellbeing of the labor is affected as well since they are daily wage employees.

b. Changes in river flows

The Indus River System gets about 80% water from the Hindu- Kush- Himalaya glaciers. Increasing atmospheric temperatures are expected to increase glacier melt. IPCC (2007) projected that glacier melt in Himalayas would cause increased rivers flows during the next few decades and then followed by decreased river flows, as the glaciers recede.

c. Increased crop evapotranspiration

Increased atmospheric temperature would cause higher water evaporation from soil and from plant leaves. These higher evapotranspiration losses would mean that plants would need more water to maintain optimum growth.

d. Land degradation

The deterioration of productive agricultural land areas due to water logging and salinity is causing major threat to food security in the country. Soil erosion due to water and wind is universally recognized as a serious threat to productive agriculture land areas. Water and wind erosion is the direct consequence of climatic parameters of high intensity rainfall, wind- velocity and higher temperatures. The northern mountainous region suffers from unfavourable soil and moisture regime, thereby causing soil erosion. Similarly, arid regions of the Punjab (Cholistan), Sindh (Tharparker) and Balochistan (Chaghi Desert and sandy coastal areas) are affected by wind-erosion.

e. Extreme weather events

According to IPCC (2007), the frequency and intensity of extreme weather events such as floods, heavy precipitation events, droughts, cyclones, etc. are expected to increase in future. Such extreme events can also affect food security.

1.6.2 Livestock Sector

Livestock is the largest component of agriculture sector, its contribution in the agriculture sector stood at 58.55% while it has share of 11.61% in the GDP. This sub sector is widely contributing in poverty reduction among the masses; this sub sector has great potential of growth as all necessary inputs for its development are available sufficiently in Pakistan. The livestock is relatively stable and have consistent growth trend as compared to other subsectors of agriculture. (Economic Survey, 2015- 16). Fishery is a sub-sector of livestock that also plays a significant role in achieving food security.

Since agriculture & livestock sectors are heavily dependent on the vagaries of nature, it is highly vulnerable to climate change phenomena. Climate change will impact food security in the country mainly through reduced crop productivity, adverse impact on livestock health and increased agricultural production losses because of extreme weather events. This will necessitate the agriculture and livestock sectors, particularly in rain- fed areas, to adapt to these climatic changes. Since the agriculture sector is heavily dependent on the water sector, a number of adaptation actions identified in the preceding section are equally applicable to the agriculture sector and will generally not be repeated.

1.7 Forestry Sector

Pakistan is a country with one of the low forest covers in the world, which is mainly due to the arid and semi- arid climate in most parts. It has 0.03 hectare of forest per capita compared to the global average of one hectare. According to the Forestry Sector Master Plan (1992), natural forests consist of 4.2 million ha (4.8%), irrigated plantations occupied 103,000 ha (0.11%) while rangelands covered 28.50 million hectares (32.40%) out of the total land area (87.98 million ha) of Pakistan. Unfortunately, no recent studies or surveys are available to exactly determine the current forest cover in the country. However, total area under forests in the country is 4.34 million ha (5%) out of which 3.44 million ha are state-owned while the tree cover on farmlands and in private forests is 0.78 million hectares (0.88%). Furthered by the increased rate of deforestation, the country's forest cover is alarmingly on the verge of disappearance. On average, an area of 31,658 ha (-0.75%) of natural forests is cleared or deforested each year in Pakistan (Food & Agriculture Organization, 2007).

The forests of Pakistan reflect great physiographic, climatic and edaphic diversities in the country. Following forest types are found in the country.

- Littoral and Swamp forests
- Tropical dry deciduous forests
- Tropical thorn forests
- Sub- tropical broad- leaved evergreen forests
- Sub- tropical pine forests
- Himalayan moist temperate forests
- Himalayan dry temperate forests

- Sub- alpine forests
- Alpine scrub forests

1.8 Disaster Preparedness

Pakistan is highly vulnerable, in varying degrees, to a large number of climate- related natural disasters. A large part of areas along rivers are prone to floods and river erosion, the coastline is prone to tropical cyclones and tsunamis, arid and semi- arid areas are vulnerable to drought and heat waves, and hilly areas are at risk from hill-torrent flash floods, landslides, etc. Heightened vulnerabilities to disaster risks are caused due to expanding population, urbanization and development within high- risk zones, environmental degradation and above all from climate change. As far as human vulnerability to disasters is concerned, the economically and socially weaker segment of population is the one that is most seriously affected. Climate change projections are scenario based, hence, contain some degree of uncertainties. Despite this, there are strong indications that in South Asia, particularly in Pakistan, climate change is intensifying the above- mentioned hazards. Pakistan is already experiencing climate change impacts that are too visible to ignore. Most natural hazards like floods, droughts, cyclones, etc. cannot be avoided or prevented. However, with appropriate adaptive and preparedness measures, along with proper climate- resilient development work in risk prone areas, their impact can be minimized.

1.9 Other Vulnerable Ecosystems

Pakistan covers a significant number of the world's ecological regions that support a rich variety of species contributing to the country's overall biodiversity. These valuable resources, however, are continuously depleting due to many factors, including unsustainable use whereas some species of important ecological functions are already on the verge of extinction. The loss, fragmentation and degradation of natural habitats are further declining which is affecting biodiversity in the rangelands, forests, deserts, freshwater and marine ecosystems. Deterioration of natural habitats has been taking place since long however, the present decline of these habitats in Pakistan has alarmingly increased. It is feared that the anticipated effects of climate change on biodiversity will further worsen. This continuous loss of biodiversity calls for immediate response and solid action towards the conservation of these resources.

The importance of conserving biological diversity, in the wake of climate change, has been repeatedly outlined in various policies, strategies, plans and programs in Pakistan. In 2000, the Ministry of Environment in collaboration with WWF- Pakistan and IUCN- Pakistan prepared a comprehensive Biodiversity Action Plan (BAP). In its preparation, academia and civil society were also consulted. The BAP provides a brief assessment of the status and trend of the existing biodiversity outlining strategic goals and objectives. It also identifies the plan of action, including coordination arrangements and implementation measures. The BAP is made up of 13 components corresponding to the specific Articles of Convention on Biological Diversity (CBD), which, under Article 6, requires parties (member countries) to develop national plans, strategies and programmes for conservation and sustainable use. Article 6 also implores to integrate such plans and strategies into relevant sectoral plans.

1.10 GHG Emissions contribution from different sectors

In Pakistan, GHG emissions are low compared to international levels of emissions. In 2008, Pakistan's total GHG emissions were 310 million tonnes of CO_2- eq. The break- up of these emissions is given in Table 5.

Table 5:

Total GHG emissions released in 2015

GHGs	Emissions (in thousand tonnes)
Carbon Dioxide (CO_2)	185,556
Methane (CH_4)	5,738
Nitrous Oxide (N_2O)	280
Oxides of Nitrogen (NOx)	754
Carbon Monoxide (CO)	5,734
Non- Methane Volatile Organic Compounds	804
Sulphur Dioxide	1,041

Source: National GHG Inventory

a. Agriculture and Livestock Sectors

GHG emissions from agriculture and livestock sectors accounted for about 39% of Pakistan's total GHG emissions in 2008. These emissions are essentially all Methane (CH_4) and Nitrous Oxide (N_2O), i.e. 79%, and 21% respectively and originated mainly from four sub- sectors: 1) Enteric fermentation in cattle (all in the form of Methane), 2) Rice cultivation, 3) Releases of Nitrous Oxide from agricultural soils/ Nitrous fertilizer, and 4) Manure management.

According to National GHG Inventory, 2008, GHG emissions from agriculture and livestock in Pakistan during 1994- 2008 grew at the rate of about 3% per annum. There is a pressing need to find ways to contain these emissions or at least to slow down their growth rate. These efforts will require technological innovations and financial resources and for that Pakistan would need the support of international community. To mitigate and minimize GHG emissions from agriculture and livestock sectors, the Framework for Implementation of National Climate Change Policy (NCCP) prescribes many measures, which are as follows:

- Develop and promote best management practices for methane and nitrogen management in agriculture and livestock sectors.
- Promote optimum use of chemical fertilizers and pesticides to achieve mitigation goals
- Arrange pest management training programmes for farmers
- Develop best practices of tillage and soil management that improve soil carbon storage
- Develop and introduce improved water management in rice paddy to control release of methane from agriculture soils
- Introduce low water dependent rice varieties
- Promote use of green manure in agriculture
- Identify and promote better manure storage & management practices
- Set- up system to control the illegal import of pesticides and apply quarantine measures at dry/ sea ports particularly in Balochistan
- Proper disposal of obsolete pesticides/ chemicals in Balochistan should be ensured
- Improve energy use efficiency in agriculture sector to reduce carbon emissions
- Develop and introduces low water dependent rice varieties
- Develop efficient bio- gas and manure digester for methane reduction and energy production.
- Undertake extensive review of existing research about mitigation option in agricultural sector to assess the value of investment in these programmes.
- Undertake detailed study to assess the possible threat of cultivation of bio- fuel crops on country's food security.
- Initiate cultivation of bio- fuel crops on limited pilot scale to assess its viability.
- Develop and introduce appropriate feedstock mixes and additives to reduce methane production from enteric fermentation/ digestion in cattle.

b. Forestry Sector

Climate change and forests are linked with each other, so better forest management is a key to deal with the hazards of climate change. Forest trees trap and store carbon dioxide (CO_2), playing a major role in mitigating climate change. Contrarily, when these forests are cut down or destroyed and burned, they can become sources of CO_2, the major greenhouse gas considerably responsible for climate change. Forests could be better used in combating climate change. This can be achieved by preventing forests from being cut down and through afforestation and reforestation of non- forested lands. Global carbon retention that could be the result of reduced deforestation, increased forest re-growth and more agro- forestry and plantations could make up for about 15% of carbon emissions from fossil fuels over the next 50 years (Food & Agriculture Organization, 2015).

Pakistan's forests, if not cut down and managed sustainably, can equally contribute to combat climate change by absorbing enormous amount of CO_2. Such objectives can be achieved through devising appropriate strategies and frameworks with assistance from the international community. Reducing Emissions from Deforestation and Forest Degradation (REDD) is an opportunity offered by the UNFCCC providing incentives to developing nations for saving their forests and use them as 'sinks' to absorb atmospheric CO_2. One of the major highlights of action in this thematic area is the campaign of Billion Tree Tsunami, which was launched in 2014, by the government of Khyber Pakhtunkhwa (KP), Pakistan, as a response to the challenge of global warming. Pakistan's Billion Tree Tsunami plans to restore 350,000 hectares of forests and degraded land to surpass its Bonn Challenge commitment.

c. Industries

In past two decades, growth of industrial sector remained focus of government policies, which resulted in improved performance of this sector in past decade. Industrial sector started revival and recorded growth at 6.80% in 2015- 16 as compared to 4.81% in 2014- 15 (Ministry of Finance, 2016). Economic Survey of Pakistan, 2015- 16 reports that the industrial sector has contributed 21.02% in GDP; and proved as a major source of tax revenues for the government while contributing significantly in the provision of job opportunities to the labour force. The major industries in Pakistan include textile, fertilizer, sugar, cement, steel and large petro- chemical plants.

Highest growth reported in large manufacturing sectors with about 80% share in overall manufacturing. These industries contribute about 6% to the total GHG emissions due to the industrial processes in use in addition to being responsible for more than a quarter of the emissions attributed to the energy sector.

d. Urban Planning

Like many other countries of the world, Pakistan is also witnessing a fast pace growth in urban population. Pakistan is the most urbanized nation in South Asia and its urban population has increased from 43.0 to 72.5 million between 1998 to 2014 and is expected to become predominantly urbanized by the year 2025. At present about 47% of urban population lives in the nine cities (Table 6), having population exceeding one million each. The primary factor in this conglomeration is increase in rural- urban migration. As such there is a need to address the existing challenges of large urban centers while planning ahead for the continued migration towards cities (Ministry of Climate Change, 2015).

Urbanization is linked to a chain of environmental problems including urban sprawl, land- use-change, increased demand for transportation and energy and resultant air pollution. Pakistan faces serious environmental problems in the urban areas with negligible green patches. Environmental degradation is further accelerated with the climate change impacts which are leading to increase frequency and occurrence of natural disasters. These environmental problems create an immediate threat to health as well as human welfare and thus leads to poverty. These could easily jeopardize continuous economic growth and sustainable development in Pakistan. Climate change leads to a range of socio- economic implications for urban planning. Sustainable town/ urban planning is a process by which adaptation to climate change impact is possible in the urban areas. The effects of climate change and the process of urbanization has complex nexus. It is expected that extreme events as well as gradual changes will, in many cases, contribute to the increasing level of climate change vulnerability in the urban areas because of inadequate institutions and a lack of infrastructure at high population density locations. In particular, rural to urban migrants often have no choice but to live on land that is already densely populated or in a location that is particularly prone to disasters.

Table 6:

Population of Major Cities of Pakistan from 1981- 2010

City	1998 Census	1981 Census	CAGR (%)	2010
Karachi	9,339,023	5,208, 132	3.49	13,386,730
Lahore	5,143,495	2,952,132	3.32	7,214,954
Faisalabad	2,008,861	1,104,209	3.58	2,912,269
Rawalpindi	1,409,768	794,834	3.43	2,013,876
Multan	1,197,384	732,070	2.93	1,610,180
Hyderabad	1,166,894	751,529	2.62	1,521,231
Gujranwala	1,132,509	600,993	3.79	1,676,357
Peshawar	982,816	566,248	3.29	1,386,529
Quetta	565,137	285,719	4.09	871,643
Islamabad	529, 180	204,364	5.7	972,669

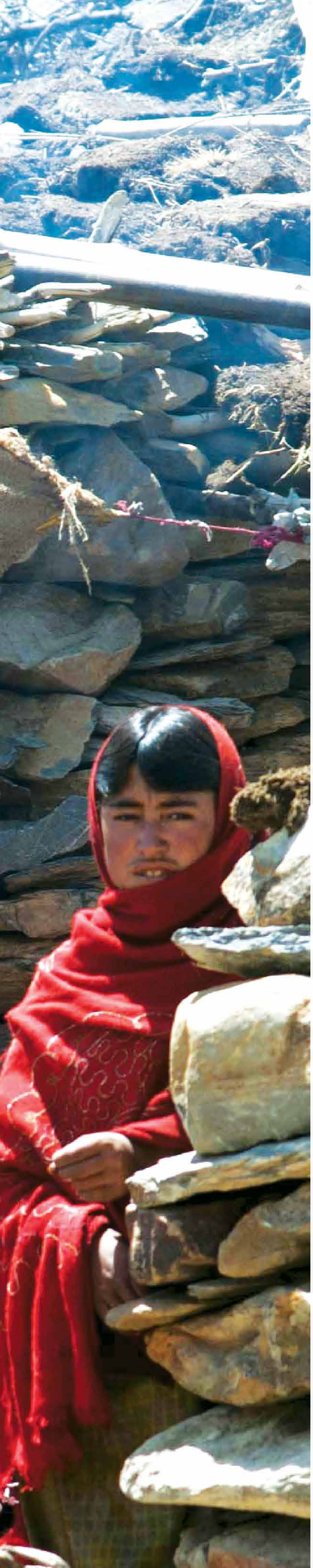
Source: Ministry of Climate Change- UN- Habitat, 2015

The extent to which a particular urban center is vulnerable to climate change is influenced by different factors. The location of towns affects the types of climate hazards to which they are exposed, and whether they are prone to be affected by high temperatures, erratic precipitation patterns, sea level rise or more frequent or intense extreme events. However, more importantly, vulnerability of an area and its residents depends upon its socio- economic context and the adaptive capacity of stakeholders and institutions to address the challenges of climate change.

1.11 Climate Change and Priorities of the Present Government

Being cognizant of the fact that climate change is the biggest challenge faced by the world and not only that its impacts are being felt in the country but Pakistan is among the countries most affected by it and that the nation has suffered/ suffering from a succession of climate related disasters including GLOFs, droughts, heat waves, new diseases and epidemics and threats from melting glaciers and changing monsoon patterns, the present government is fully committed to addressing climate change and have expressed this commitment in national as well as international forums. Government of Pakistan's strategies are aimed at saving the lives of the people from the vagaries of climate change, promoting development for the overall wellbeing of the nation and honoring the international commitments as responsible global citizens to reduce emissions and prevent climate change. Towards this end, the government has taken following steps:

1. Establishment of Prime Minister's Committee on Climate Change
2. The launch of 10 Billion Tree Tsunami
3. The launch of Clean & Green Pakistan- the program envisages addressing five components: plantation, solid waste, liquid waste/ hygiene, total sanitation and safe water.
4. Efforts to Increase the Share of Renewable Energy up to 30% in the Energy Generation Mix.
5. Promotion of net-metering regime
6. Development & Launch of Mandatory Energy Labeling Regime for LED Lights, AC and Refrigerator.
7. Promotion of Solar Power Irrigation Systems.
8. Efforts for the gradual wiping-out of single use plastics
9. Formulation of NDC implementation roadmap
10. Formulation of Electric Vehicle Policy
11. Launch of Ecosystems Restoration Initiative (ESSRI)



CHAPTER

2

National GHGs Inventory Information (2014-15)

National GHGs Inventory Information (2014-15)

In order to facilitate non- Annex I Parties in developing and reporting their GHG inventories as part of their national communications, the UNFCCC Secretariat has developed an Excel-based software, which incorporates all the elements of a national GHG inventory prescribed by decision 17/ CP.8. The software is based on the Intergovernmental Panel on Climate Change (IPCC) inventory software version 1.1 which uses the Tier 1 methodologies for estimating GHG emissions and removals for all source/ sink categories described in the Revised 1996 IPCC Guidelines for National GHG Inventories. It is further complimented by Good Practice Guidance (GPG). Since its release in 2005, most non- Annex I Parties have been using this software for developing their national GHG inventories.

Greenhouse Gas Inventory of Pakistan 2014- 15 follows the IPCC Revised 1996 Guidelines. It provides information regarding GHGs namely CO_2, CH_4, and N_2O emitted from the anthropogenic sources.

2.1 An overview of National GHG Inventory Management and Preparation

The first GHG inventory developed for the fiscal year 1993- 1994 (herein called as 1994) was formally submitted to UNFCCC. Being part of the Initial National Communication of Pakistan, it was prepared by M/ s Hagler Bailly during 1999- 2003 with the support of Global Environment Facility (GEF) through United Nations Environment Programme (UNEP). It was prepared in the light of IPCC 1996 guidelines for the inventory development. Total estimated GHG emissions mentioned in 1994 inventory are 181.7 million tonnes of CO_2- eq (UNFCCC, 2003b). Sector-wise emissions estimates are: Energy, 47.2%; Agriculture, 39.4%; Industrial Processes, 7.3%; Land- Use- Change and Forestry, 3.6%; and Wastes, 2.5%.

Later, on the request of Planning Commission's Task Force on Climate Change, Applied System Analysis Division (ASAD) of Pakistan Atomic Energy Commission (PAEC) prepared the next GHG inventory of Pakistan for the year 2007-08 (herein called as 2008) in 2009 using 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The results are available in the form of a draft report. However, the inventory was not submitted to the UNFCCC. In this inventory, estimated GHG emissions are 309.4 million tonnes of CO_2- eq comprising sector- wise share of Energy (50.7%), Agriculture (38.8%), Industrial Processes (5.8%), LUCF (2.9%), and Waste (1.8%) (Ahmad *et al.,* 2009). In 2016, ASAD revised this inventory by using the Revised 1996 IPCC Guidelines instead of 2006 IPCC Guidelines. In the revised 2008 inventory, the estimated GHG emissions are 329.5 million tonnes of CO_2- eq comprising sector- wise share of Energy (51.1%), Agriculture (38.2%), Industrial Processes (5.6%), LUCF (2.8%), and Waste (2.2%) (Ahmad *et al.,* 2016).

Owing to the absence of any formal institutional arrangement in the country for the preparation of GHG inventory, Global Change Impact Studies Centre (GCISC) took the initiative in 2014 and developed its first GHG inventory for the fiscal 2011- 12 (herein called as 2012) by utilizing its indigenous capacities in the light of Revised 1996 IPPC Guidelines. Total GHG emissions estimated in 2012 inventory are 374.1 million tonnes of CO_2- eq. Sector- wise emissions were: Energy (45.8%), Agriculture (43.5%), Industrial Processes (5.2%), LUCF (2.6 %), and Waste (2.8%). This inventory was published by GCISC as research report (GCISC- RR- 19) in 2016 (Mir and Ijaz, 2016).

Table 7:

Estimated GHG emissions as of CO_2- eq.

No	Year	GHG Emissions as of CO_2- eq
1.	1994	181.7 million tonnes
2.	2008	309.4 million tonnes
3.	2012	374.1 million tonnes
4.	2015	329.5 million tonnes

Table 8:

Sector- wise share of GHG emissions (in %)

No	Sector(s)	1994	2008	2012	2015
1.	Energy	47.2	50.7	45.8	51.1
2.	Agriculture	39.4	38.8	43.5	38.2
3.	Industrial Processes	7.3	5.8	5.2	5.6
4.	LUCF	3.6	2.9	2.6	2.8
5.	Waste	2.5	1.8	2.8	2.2

In 2015- 16, GCISC started working on the national GHG inventory of Pakistan based on the latest data sets available as part of the Pakistan Intended Nationally Determined Contributions (INDCs) project executed by the Ministry of Climate Change through GCISC. INDCs is an initial official information channel to communicate Pakistan's efforts to respond to the climate change issues to the world community. It comprises inventory of Pakistan for the year 2014- 15 (herein called 2015) and is second such effort by the Centre. UNFCCC Non-Annex 1 National Greenhouse Gas Inventory Software, Version 1.3.2 was applied for the preparation of this inventory in accordance with Revised 1996 IPCC Guidelines, which employs Tier- 1 approach using default emission factors of Revised 1996 IPCC Guidelines depending on national circumstances and the availability of data the country for emission estimation. The main data sources used in this inventory are:

- Pakistan Energy Year Book, 2014- 15
- Agricultural Statistics of Pakistan, 2014- 15
- Economic Survey of Pakistan, 2015- 16

2.2 Greenhouse Gas Emissions in 2015

2.2.1 Activity Data, Emission Factors and Methodological Tier

IPCC Revised 1996 Guidelines have been applied in the preparation of the GHG inventory. The inventory includes five sectors including Energy, Agriculture, Industrial Processes, Land-Use- Change & Forestry, and Waste. The activity data have been taken from Pakistan Energy Year Book (2014- 15); Economic Survey of Pakistan (2016); Agriculture Statistics of Pakistan (2014-15); NEPRA State of Industry Report (2016); Country Report of Pakistan, UN Food and Agriculture Organization (FAO); National Forest and Rangeland Resource Assessment Study (2004); Pakistan Forest Institute, Peshawar; Supply & Demand of Fuel Wood & Timber for Household & Industrial Sectors & Consumption Pattern of Wood & Wood Products in Pakistan (2003- 2004) called MAANICS Report (2004); and Office of Inspector General of Forests, Ministry of Environment, Islamabad.

2.2.2 GHG Emissions in 2015- Summary

The total estimated emissions in terms of million tonnes of CO_2- eq. for the year 2015 shows an increase in total GHG emissions when compared with inventories of 1994, 2008, and 2012. The total estimated GHG emissions for the year 2015 are 408.1 million tonnes of CO_2- eq with 45.5% share of Energy, 42.7% of Agriculture, 5.4% of Industrial Processes, 2.5 of LUCF, and 3.8% share of Waste.

2.3 Energy Sector

2.3.1 Fuel Combustion (IA)

Fossil fuel combustion is a key element of the energy systems for most of the countries. When combustion of hydrocarbon takes place, CO_2 emissions are produced as a result of the oxidation of carbon in fuels during combustion.

Energy sector is considered one of the most important sectors contributing in GHG emissions. Generally, its contribution in CO_2 emissions is more than 90% while in total GHG emissions, it is 75%.

There are two major categories in the energy sector Fuel Combustion **(1A)** related activities:

1. Stationary Combustion
2. Mobile Combustion (Transport)

These two components include various source categories that emit GHGs.

Under Stationary Combustion category, following source categories are considered:

- **1A1:** Energy Industries, which include activities such as energy extraction, energy production and transformation, electricity generation, petroleum refining, etc.
- **1A2:** Manufacturing Industries and Construction, which include activities such as iron and steel production, non- ferrous metal production, chemical manufacturing, pulp and paper, food processing, beverages and tobacco, etc.
- **1A4:** Other Sectors such as Commercial/ Institutional, Residential, and Agriculture/ Forestry/ Fisheries.

Whereas under Mobile Combustion **(1A3),** the source categories include:

- Road transport (cars, light and heavy- duty trucks, buses, motorcycles, etc.)
- Rail Transport
- Domestic Aviation
- National Navigation
- Other transportation (e.g. gas pipeline transport)

Emissions from international transport activities - bunker fuels are estimated and reported separately. These estimates are excluded from the national totals as per Revised 1996 IPCC Guidelines.

2.3.2 Methodology, Activity Data, and Emission Factors

The Revised 1996 IPCC Guidelines have been applied to estimate the GHG emissions from the above- mentioned source categories. The activity data for the year 2015 in terms of consumption of various fossil fuel types has been taken from Pakistan Energy Year Book 2016- an annual energy statistics publication released by Hydrocarbon Development Institute of Pakistan (HDIP). The data in this year book is presented as top- down and is ideally suited for use in IPCC GHG emission estimation methodology. An extensive data from this publication has been taken to estimate carbon dioxide emissions from energy sector. The emission factors of fossil fuels, such as coal, oil, and natural gas are the most important considerations in estimating the GHG emissions from the combustion of these fuels.

In the absence of country- specific data, all emission factors for the calculation of carbon content, the default values for the fraction of carbon oxidized (0.995 for gas, 0.99 for oil and 0.98 for coal) have been taken from the IPCC guidelines for national GHG inventories. Default emission factors for CH_4, N_2O, NO_x, CO, and Non- Methane Volatile Organic Compounds (NMVOCs) by major technology and fuel types presented in the Revised 1996 IPCC Guidelines, Reference Manual- Volume 3 have been used. In general, suitable country- specific activity data and default emission factors under Tier 1 approach have been used for GHG emissions estimation. The values for the fraction of carbon oxidized may not represent the true situation in the country, as by and large the combustion processes in the country maybe inefficient and these values are, therefore, likely to be significantly lower.

The formula used for estimating total emissions for the country across all activities, technologies and fuels of individual estimates is presented below:

Emissions	=	$\sum (EF_{abc} \times Activity_{abc})$
EF	=	Emissions Factor (t C/ TJ)
Activity	=	Fuel Consumption (TJ)
a	=	Fuel Type
b	=	Sector Activity
c	=	Technology Type

The energy sector accounts for GHG emissions from fossil fuel combustion and fugitive emissions from the handling of fossil fuel. Fossil fuel combustion emissions constitute more than 90% of the total emissions from the energy sector. The CO_2 and non- CO_2 default emission factors for different fuel types and source categories used in the present estimations are provided in Table 9.

Table 9:

GHG emission factors used in the energy sector estimation

Category	Fuel	CO_2 (t/ TJ)	CH_4 (kg/ TJ)	N_2O (kg/ TJ)
1A1: Energy Industries	Diesel oil	73.2	3.0	0.6
	Furnace oil	76.5	3.0	0.6
	Coal local	94.0	1.0	1.4
	Natural gas	55.7	1.0	0.1
1A2: Manufacturing Industries	Gasoline	68.5	-	-
	Kerosene	71.0	-	-
	Diesel oil	73.2	2.0	0.6
	Furnace oil	76.5	2.0	0.6
	Coal imported	92.5	10.0	1.4
	Coal local	94.0	10.0	1.4
	Natural gas	55.7	5.0	0.1
1A3: Transport	Jet Kerosene	70.7	0.5	2
	Natural gas	55.7	50	0.1
	LPG	62.3	-	-
	Gasoline	68.5	20	0.6
	Diesel oil	73.2	5	0.6
	Furnace oil	76.5	5	0.6
1A4: Other sectors	Kerosene	71.0	10	0.6
	Diesel oil	73.2	10	0.6
	LPG	62.3	-	-
	Natural gas	55.7	5	0.1

Source: IPCC, 1996

2.3.3 An Overview of Greenhouse Gas Emissions from Energy Sector

Fossil fuel combustion- based emissions accounted for 93% of the total CO_2- eq., whereas contribution from fugitive emissions was 7% of the total emissions. Of the total 184 Mt emitted as CO_2- eq. in 2015, 89% was emitted as CO_2, 10% was emitted as CH_4, and only 1% was emitted as N_2O.

Figure 6:

Distribution of CO_2- eq. emissions (in Gg) across the energy sector in 2015

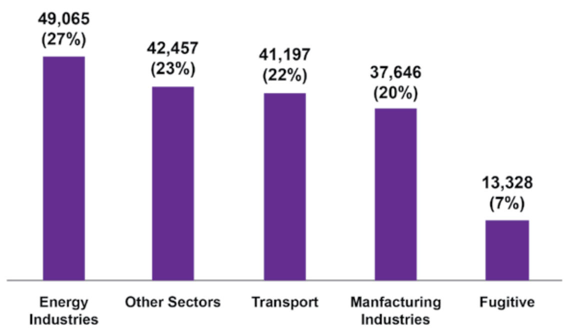
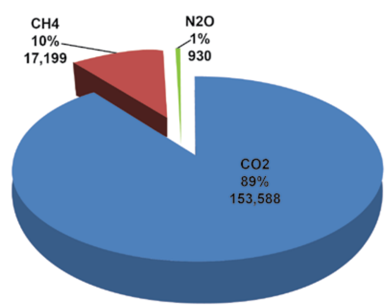


Figure 6:

GHG emissions distribution in the energy sector in 2015 (Gg CO_2- eq.)



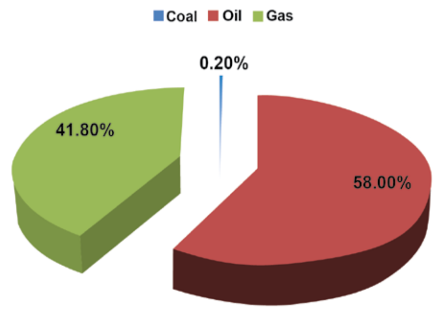
2.3.4 Energy Industries (1A1)

Energy industries release emissions produced as a result of fossil fuel combustion for electricity generation and solid fuel manufacturing. The natural gas used in gas processing plants has also been included in the category of electricity generation. However, information on the use of fossil fuels for solid fuel manufacturing is not available in Pakistan; so this category has not been included in the national totals. In 2005, the energy industries emitted 49.065 Mt CO_2- eq., which is 27% of the total GHG emissions from the energy sector. Of this, 49.013 Mt was emitted as of CO_2, 0.001 Mt as of CH_4, and 0.0001 Mt as of N_2O.

In 2015, Pakistan generated 106,966 GWh units of electricity (Hydrocarbon Development Institute of Pakistan, 2016) with a contribution of 63.4% from thermal, 30.4% from hydro, 5.4% from nuclear and 0.7% from renewables. The thermal energy mix for electricity generation was 0.2% coal, 41.8% gas, and 58.0% oil. (Figure 7).

Figure 7:

Fuel mix for electricity generation in Pakistan for 2015



The emissions estimation was done by applying the Revised 1996 IPCC Guidelines for preparing national GHG inventories by sources and removal by sinks. In this assessment, the emission factors for coal, oil, and gas are default factors taken from the Revised 1996 IPCC Guidelines. In 2015, Pakistan emitted 49.065 Mt CO_2- eq. which was 27% of the total CO_2- eq. emitted from energy sector. The CO_2- eq. emissions from the electricity sector constituted 49.013 Mt of CO_2, 0.021 Mt of CH_4, and 0.031 Mt of N_2O. Emissions reported from electricity generation include emissions from grid- based power plants using fossil fuels. The average value of Net Calorific Value (NCV) of solid and liquid fuel has been taken as 0.0420 TJ/ TOE while of gas, it is 0.0398 TJ/ TOE for estimating CO_2 emissions across all energy sub- sectors. However, the actual emissions from power sector may vary depending upon the actual value of NCV of fuel consumed in the sector. Research has/ is being carried out at various forums in Pakistan to compute emissions-factors for other different sectors.

2.3.5 Manufacturing Industries (1A2)

In 2015, manufacturing industries emitted 37.646 Mt CO_2- eq. and these emissions were 20% of the total CO_2- eq. emissions from the energy sector. GHG emissions from fossil fuel combustion in cement, iron and steel, chemicals, brick kiln, and other non- specific industries have been considered here. Of the total CO_2- eq. emissions from the manufacturing industries due to fossil fuel combustion, 37.490 Mt was emitted as CO_2, 0.063 Mt as CH_4, and 0.093 Mt was emitted as N_2O. It must be reiterated that capital goods sector has a multiplier impact on energy use. Therefore, there is a need to introduce energy audit of the present designs of capital goods sector. As a next step, plans are needed to reduce energy consumption to the level of international best practices.

In Pakistan, it is assessed that 59 billion fired bricks are produced yearly through various sorts of kilns, utilizing various types of fuels and fuel mix like indigenously produced lignite coal, rice husk, and other agricultural residues, rubber tires, plastics, and different industrial waste, which ultimately produce highly toxic gases. It is also measured that brick kiln sector consumes about 40% of the total extraction/ mining of around 4 Mt of locally produced coal, i.e., 1.6 Mt per annum (SAARC Energy Centre, 2012). Pakistan's fertilizer production capacity is over 6 Mt per year, and the main fuel used for fertilizer production is natural gas. In 2015, total fertilizer production of all kinds (urea, super phosphate, ammonium nitrate, and nitro- phosphate) was 6.2 Mt (Ministry of Finance, 2016). Pakistan's cement industry contributes considerably in the economy of the country. With 29 cement plants it contributes significantly to the national gross domestic product (Ministry of Finance, 2016). The major fuel consumption in the manufacturing of cement in Pakistan is coal and about 90% of the total coal requirement is being achieved through imported coal (Ministry of Finance, 2016).

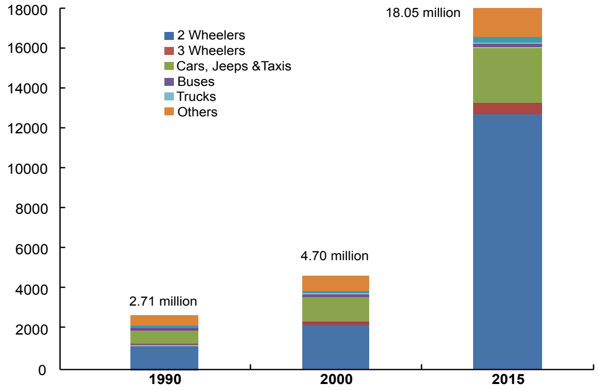
Steel use in 2015 was 7.1 Mt in Pakistan, with per capita utilization of 37.5 kg. Local production by Pakistan Steel Mills and Scrap Melters approximately falls in the range of 3 to 4 Mt (nearly 55%), while the remaining quantum of around 4 Mt (almost 45%) of steel a year is filled by import and ship breaking industries (World Steel Association 2015).

2.3.6 Transport(1A3)

Pakistan's transport system is one of the largest sectors of economy. All GHG emissions produced as a result of combustion of fossil fuel through road transport, aviation, railways, and navigation are included in the transport sector. It has been observed during the last two decades that demand for road transport services, holding share of 13% in Pakistan's GDP, has grown manifold (Ministry of Finance, 2016). In Pakistan, registered road vehicles have increased from 2.71 million in 1990 to 18.05 million in 2015 (Figure 9). Cars and two wheelers represent approximately 82% of the total road vehicles (Ministry of Finance, 2014). It consumes around 40% of the total liquid fuel consumed in the country. About 78% of fuel used in this sector is oil- mainly gasoline and diesel. Compressed natural gas (CNG) and electricity meets the remaining 22% requirements of the transport sector (Hydrocarbon Development Institute of Pakistan, 2016). The total GHG emissions from the transport sector in 2015 were 41.197 Mt CO_2- eq. This is 22% of the total CO_2-eq. emissions from the energy sector and is 10% of the total GHG emissions in 2015. Of the total CO_2- eq. emissions from the transport sector in 2015, 36.125 Mt was emitted as CO_2, 0.189 Mt CO_2- eq. as CH_4, and 0.090 Mt CO_2- eq. was emitted as N_2O.

Figure 8:

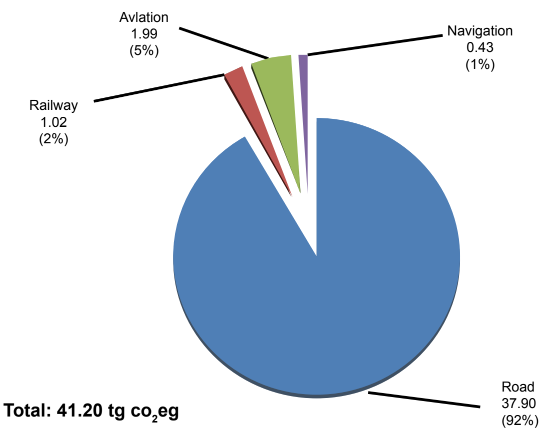
Growth in transport sector of Pakistan ('000 number of vehicles)



As shown in figure 9, the road transport sector released approximately 37.90 Mt CO_2- eq, which is 92% of the total emissions from the transport sector. In comparison, the aviation sector just emitted 5% of the total CO_2- eq. emissions. The rest of the emissions were produced by railways (2%) and navigation (1%) sectors. The international bunker fuels emissions (resulting from international marine and air transport) have also been assessed; however, these emissions are not considered in the national GHG totals as per IPCC Guidelines 1997.

Figure 9:

GHG emissions from transport sector



2.3.7 Other Sectors- Residential, Commercial, & Agriculture (1A4)

Cooking, lighting, space heating and cooling, refrigeration, and pumping activities are characterized in the residential, commercial, and agriculture sectors included in this category. The fuels consumed are electricity (for lighting, heating, cooling, and pumping), liquefied petroleum gas (LPG; for cooking), kerosene (for lighting and cooking), diesel (for generating power for pumping and lighting), and coal, charcoal, and fuel wood (for cooking). In the year 2015, these sectors together emitted 42.457 Mt of CO_2- eq, which is 23% of the total CO_2- eq from the energy sector. This excludes the GHG emissions due to grid use of electricity. Almost 60% of the total GHG emissions from the category 1A4 are from the residential sector (15.554 Mt CO_2- eq). The residential sector has a rural and urban spread, where it combusts both fossil fuel as well as biomass. Biomass still comprises a substantial amount of fuel mix used in rural Pakistan. CH_4 from biomass combustion in the residential sector is reported in the energy sector; however, CO_2 from biomass is reported as a memo item and is not included in the national totals in accordance with the IPCC Guidelines. The commercial, residential, and agriculture sectors also witness extensive use of captive power generated from diesel use. This source is scattered, and a systematic collection could not be carried out. The fuel consumption in these private generator sets could be substantial. Lack of data for this consumption is a gap area that requires further research and capacity to improve the inventory estimates in Pakistan.

2.3.8 Fugitive Emissions (1B)

The GHG emissions from the Fugitive Emissions **(1B)** category in the energy sector has been divided further into two main source categories: 1) Solid fuels (primarily coal mining) **(1B1),** and 2) Oil & natural gas systems **(1B2).** The dominant GHG emitted from all of these fugitive source categories is CH_4 although smaller amounts of CO_2 are also emitted from some sources.

For solid fuels, venting and disposal of coal- bed is the primary source of fugitive emissions. Most of these emissions occur at the mine with some residual emissions occurring from post- mining handling/ processing activities. The extraction, production, processing, or transportation of fuels involve substantial quantity of methane emissions to the atmosphere. Oil and natural gas systems are potentially very complex and diverse. Two major issues concerning the reported fugitive emissions from oil and gas systems are:

(i) the generally poor quality and completeness of available venting and flaring data;

(ii) the fact that much of the infrastructure contributing to equipment leaks is at minor facilities for which statistics are either unavailable or incomplete (e.g. well- site facilities and field facilities).

In 2012, fugitive CH_4 emissions for Pakistan were estimated at 13.27 Mt CO_2- eq. It constituted 89% of the total CH_4 emitted from the energy sector. Methane emissions from both surface as well as underground mining of coal were estimated by using IPCC default emission factors. Additionally, the estimates combine the emissions occurring through mining and post- mining events. The emission factors used for underground mining and post- mining are 18 and 2.5 m^3 CH_4/ t, respectively. The total estimated methane emissions from coal mining and handling in 2015 were estimated at 1.07 Mt CO_2- eq. On the other hand, in case of oil and natural gas industries, methane emissions took place because of leakages, evaporation, and accidental/ unintentional releases that occurred in the system (Harrison *et al.,* 1996). The factors used for estimating CH_4 emissions from oil and natural gas activities are taken as simple averages of IPCC default ranges, i.e. for oil production, transport, and refining 2.65 (0.3- 5), 0.745, 0.745 (0.09- 1.4) t CH_4/ PJ respectively; for gas production, and processing- transmission- distribution 71 (46- 96), 203 (118- 288) t CH_4/ PJ, respectively (IPCC, 1997).

Total methane emissions from oil and natural gas activities for the year 2015 were estimated at 12.20 Mt CO_2- eq. The activity data for estimating methane emissions from coal production and oil and natural gas activities is taken from Pakistan Energy Year Book 2015. The total coal production was 1.66 Mtoe while total oil and gas production was 4.63 Mtoe and 30.01 Mtoe respectively, in 2015 in Pakistan (Hydrocarbon Development Institute of Pakistan (HDIP) 2016).

2.4 Industrial Processes

2.4.1 Process Emissions

The industrial processes sector includes emissions from various processes. The emissions associated with the energy input are not regarded as industrial process sector emissions, therefore, are not included in the emission factor estimation. They are accounted for under source category 1A2- Manufacturing industries and construction in the energy sector. To avoid double counting, it is recommended that the Non- Energy Use (NEU) related emissions reported in the industrial processes sector should be calculated based on the use of reducing agents, particularly for the source categories in metal production.

According to IPCC, the source categories covered under industrial processes sector are:

2A: Mineral Products- Cement, lime, limestone and dolomite use, soda ash production, and glass.

2B: Chemical Industry- Ammonia, nitric acid production, carbide production, titanium dioxide production, methanol production, ethylene oxide,

2C: Metal Production- Iron and steel, ferro- alloys production, aluminum, lead, zinc, copper, and magnesium.

2.4.2 Methodology, Activity Data and Emission Factors

To estimate GHG emissions from the industrial processes, the Revised 1996 IPCC Guidelines have been used for each of the categories mentioned above. Activity data for industrial processes is taken from Pakistan Economic Survey (Ministry of Finance, 2016). This data includes production in mineral, chemical, and metal industries of Pakistan. Mineral industry includes production of limestone, cement, soda ash, and dolomite while chemical and metal industry includes production of ammonia, urea, iron, and steel. The total quantity of cement production in Pakistan during the year 2015 was 32.18 Mt while of limestone, dolomite, and soda ash were 1.59, 0.16, and 0.37 Mt respectively (Ministry of Finance, 2016). In 2015, the production of urea under chemical industry was 5.03 Mt while the amount of iron and steel produced under metal industry was 0.26 Mt (Ministry of Finance, 2016). The emission factors used are presented in Table 10.

Table 10:

GHG emission factors used in the industrial processes emission estimates

No.	Category	Gas	Emission factor used	Source
2A1	Cement production	CO_2	0.4985 t CO_2/ t cement produced	IPCC, 1996 Guidelines
2A2	Limestone use	CO_2	0.440 t CO_2/ t limestone used	IPCC, 1996 Guidelines
2A3	Dolomite use	CO_2	0.477 t CO_2/ t dolomite used	IPCC, 1996 Guidelines
2A4	Soda ash use	CO_2	0.415 t CO_2/ t carbonate	IPCC, 1996 Guidelines
2B1	Ammonia production	CO_2	1.5 t CO_2/ t urea produced	IPCC, 1996 Guidelines
2C1	Iron & steel production	CO_2	1.6 t CO_2/ t iron- steel produced	IPCC, 1996 Guidelines

Source: IPCC, 1996 Guidelines

The general approach for the estimation of industrial processes emissions is the application of the equation below:

$TOTAL_{ij}$ = Activity Data **x** Emission Factor

Where:

$TOTAL_{ij}$ = process emission (tonne) of gas i from industrial sector j

Activity Data= amount of activity or production of process material (AD) in industrial sector j (tonne/ yr)

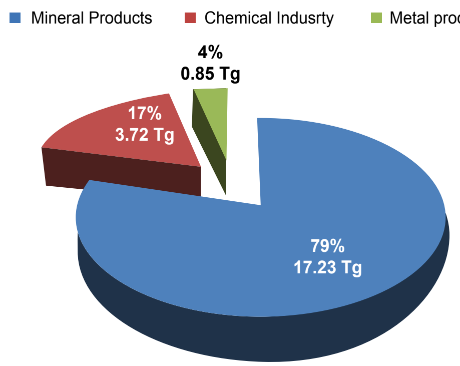
Emission Factor= emission factor associated with gas i per unit of activity in industrial sector j (tonne/ tonne)

2.4.3 Overview of Greenhouse Gas Emissions from Industrial Processes Sector

In 2015, the industrial processes sector in Pakistan emitted 21.8 Mt of CO_2- eq. as illustrated in Figure 10.

Figure 10:

GHG emissions from industrial processes by categories



The major contributor was mineral sector with 79% of the total CO_2- eq. emissions followed by chemical industry (17%) and metal production (4%). Minerals like cement production, soda ash, limestone, and dolomite use emitted 17.23 Mt CO_2- eq, out of which the cement production lead to an emission of 16.27 Mt CO_2- eq, limestone and dolomite use emitted 0.78 Mt CO_2- eq, and soda ash use emitted 0.18 Mt CO_2- eq. Chemical industry includes GHG emissions which are produced during the processes involved in the production of chemicals (such as ammonia). A total of 3.72 Mt CO_2- eq. was emitted by this sector in 2015. The emissions from metal industry are from production of iron and steel in Pakistan and a total of 0.85 Mt CO_2- eq. was emitted from this sector which is 4% of the total GHG emissions from this source category in the industrial process sector.

2.4.4 Mineral Industries (2A)

The focus of this category is on CO_2 emitted from calcination of carbonate materials in the production and use of a variety of mineral industry products. There are two broad pathways for the release of CO_2 from carbonates: (i) calcination and (ii) the acid- induced release of CO_2. The primary process resulting in the release of CO_2 is the calcination of carbonate compounds, during which a metallic oxide is formed through heating. The processes included here are the production of cement, limestone and dolomite use, soda ash production and use, and use of asphalt for road paving. The most important source of non- energy industrial process emissions is the cement production.

In 2015, CO_2- eq. emissions from the cement production was 16.27 Mt of CO_2, which is 93.9% of the total CO_2- eq. emissions from the mineral industries, followed by limestone and dolomite use (4.6%), soda ash production and use (1.1%), and use of asphalt for road paving (0.5%). With 29 cement plants and an annual production of cement over 44 Mt, Pakistan's cement industry contributes significantly in the country's GDP. The major fuel consumption in the manufacturing of cement is coal and about 90% of the total coal requirement is being achieved through imported coal (Ministry of Finance, 2016).

2.4.5 Chemical Industries (2B)

The chemical industry covers the production of ammonia, nitric acid, carbide, titanium dioxide, methanol, ethylene, etc. Ammonia is a major industrial chemical and the most important nitrogenous material produced. Ammonia gas is used directly in fertilizer production; heat treating and paper pulping; manufacturing of nitric acid, nitrates, nitric acid ester, and nitro compound; and in refrigeration system. In 2015, a total of 3.72 Mt CO_2- eq. was emitted by this sector. Pakistan's fertilizer production capacity is over 6 Mt per year, and the main fuel used for fertilizer production is natural gas. Total fertilizer production of all kinds (urea, super phosphate, ammonium nitrate, and nitro- phosphate) in 2015 was 6.2 Mt (ibid). Considering that ammonia production industry is a major emitter within the industrial processes sector, further efforts should be made to determine the emission factor of CO_2 from ammonia production process.

2.4.6 Metal Production (2C)

Steel use in 2015 was 7.1 Mt in Pakistan, meaning per capita utilization of 37.5 kg (World Steel Association 2015). Local production (Pakistan Steel Mills and Scrap Melters) falls in the range between 3 to 4 Mt (nearly 55%) approximately while the remaining quantum of around 4 Mt (almost 45%) of steel a year is filled by import and ship breaker industries (ibid). Pakistan Steel Mills produces about 1 million tonne steel per year whereas private sector is producing 30 million tonne (including billet, rebars, channel, angle, etc). The other requirements are fulfilled with ship- breaking and other steel products. The metal production processes together emitted 0.85 Mt of CO_2- eq. This includes emissions of CO_2 resulting from the production process of iron and steel.

2.5 Agriculture

The main GHG emissions from agricultural activities are methane (CH_4) and Nitrous Oxide (N_2O). The main sources of CH_4 emissions are enteric fermentation, manure management and rice cultivation. While N_2O emissions are mainly from agricultural soils due to the application of synthetic fertilizers, farmyard manure, and crop residue mixes after burning. The five main GHG emission source categories of agriculture sector are:

- Enteric Fermentation
- Manure Management
- Rice Cultivation
- Agricultural Soils
- Field Burning of Agricultural Residues

2.5.1 An Overview of Agriculture Sector Emissions

In 2015, The agriculture sector emitted a total of 174.56 million tonnes of CO_2- eq. of which CH_4 was 89.79 million tonnes and N_2O was 83.70 million tonnes. Emissions from agricultural soils constituted 45.5% of the total agricultural emissions, 45.1% emissions were from enteric fermentation, 6.5% of the emissions were from manure management, and remaining 6.7% emission were from rice cultivation and field burning of agricultural residues (Table 11 and Figure 11).

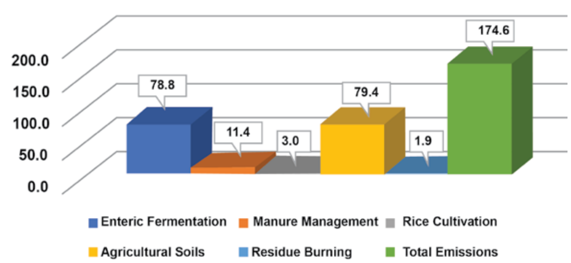
Table 11:

GHG emissions from agriculture sector in thousand tonnes of CO_2- eq.

Source Category	CH_4	N_2O	CO	Total
	89,796	83,700	1,068	174,564
Enteric Fermentation	78,792			78,792
Manure Management	7,413	4,030		11,443
Rice Cultivation	3,045			3,045
Agricultural Soils		79,360		79,360
Field Burning of Agricultural Residues	567	310	1,068	1,945

Figure 11:

CO_2- eq. emissions from Agriculture sector (million tonnes)



2.5.2 Enteric Fermentation

Livestock is an important component of Pakistan agriculture. It is one of the drivers of the socio-economic development of the country which contribute significantly to the rural economy as source of income and employment. On the other side, it contributes to climate change by emitting direct and indirect GHG emissions. The emissions from livestock are mainly from enteric fermentation and manure management.

Livestock source categories includes cattle, buffaloes, sheep, goats, camels, horses, mules, donkeys and poultry. All source categories except poultry emit CH_4 as by- product of fermentation process called enteric fermentation. This is digestive process of animals particularly ruminants in which microbes known as methanogenic bacteria ferment the food in the absence of oxygen. As a result, animal gains energy and CH_4 is released in the environment as a by- product.

Livestock population data of different livestock types with their respective emission factors are summarized in Table 12. Default emission factors for CH_4 emission estimation were taken from Revised 1996 IPCC Guidelines. These are based on default values for Asian, South Asian or Indian subcontinent region.

Table 12:

Livestock population estimates for 2014- 15 and CH_4 emission factors

Livestock Type	Number of Animals	CH_4 Emission Factors
	(in '000)	(kg/ head/ year)
Dairy Cattle	12167	46
Non- dairy Cattle	29084	25
Buffalo	33988	55
Sheep	29440	5
Goats	68420	5
Camels	1035	46
Horses	362	18
Mule & Asses	5216	10

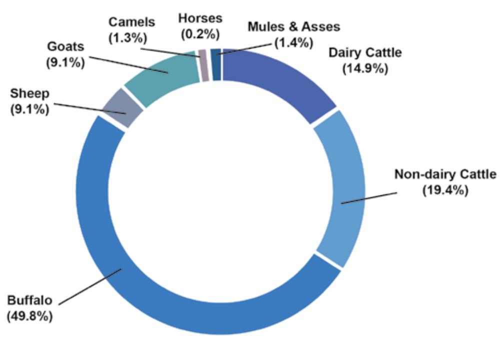
Using the default emission factors provided in Table 12, it is estimated that livestock in Pakistan emitted 78.8 million tons of CO_2- eq. of CH_4 emissions due to enteric fermentation. Buffalo is the single largest emitter of CH_4, emitting 39.3

million tons of CO_2- eq., which is 49.8% of the total CH_4 emissions from enteric fermentation. Emissions from cattle were 27 million tons of CO_2- eq. of which 15.3 million tons from non-dairy and 11.8 million tons are from dairy cattle constituting 19.4% and 14.9% of the total CH_4 emissions from enteric fermentation respectively.

Other livestock types, namely, goats, sheep, camels and others emitted 12.5 million tons of CO_2- eq. emissions constituting 15.9% of the total CH_4 emissions from this category (Fig. 12)

Figure 12:

CO_2- eq. emissions from enteric fermentation (million tonnes)



2.5.3 Manure Management

There is no systematic process of manure management in Pakistan. It is mainly converted into dung cakes used for fuel and other energy purposes in rural areas. The significant part of it goes to different animal waste management systems. The manure management practices vary in different areas of the country depending upon the need of the fuel type and animal manure as natural fertilizer for agricultural purpose. These manure management practices result in the emissions of both CH_4 and N_2O.

Livestock types, population data and respective CH_4 emission factors are summarized in Table 13. Default emission factors for CH_4 emission estimation from manure management were taken from Revised 1996 IPCC Guidelines. These are based on default values for Asian, South Asian or Indian subcontinent region.

Table 13:

Livestock population estimates for 2014- 15 and CH_4 emission factors

Livestock Type	Number of Animals (in '000)	CH_4 Emission Factors (kg/ head/ year)
Dairy Cattle	12167	6
Non- dairy Cattle	29084	2
Buffalo	33988	5
Sheep	29440	0.21
Goats	68420	0.22
Camels	1035	2.56
Horses	362	2.18
Mule & Asses	5216	1.19
Poultry	931000	0.023

Total emissions of 11.44 million tons of CO_2- eq. are emitted from livestock including poultry in Pakistan due to manure management, of which CH_4 is 7.4 and N_2O is 4.03 million tons of CO_2- eq..

Using the default emission factors provided in Table 13, it is estimated that livestock including poultry emitted 7.4 million tons CO_{2-} eq. of CH_4 emissions due to manure management. Buffalo is the single largest emitter of CH_4, emitting 3.56 million tons of CO_2- eq. which is 48.1% of the total CH_4 emissions. Emissions from cattle were 2.75 million tons of CO_2- eq. of which 1.53 million tons from dairy and 1.22 million tons are from non-dairy cattle constituting 20.7% and 16.5% of the total CH_4 emissions respectively. Poultry emitted 0.45 million tons constituting 6.1% of the total CH_4 emissions from manure management.

Other livestock types, namely, goats, sheep, camels and others emitted 0.648 million tons of CO_2- eq. emissions constituting 8.74% of the total CH_4 emissions from this category.

Manure management practices attributed to different Animal Waste Management Systems (AWAS) as prescribed in Revised 1996 IPCC

Guidelines result in N_2O emissions. These AWMS are Solid Storage and Drylot, Daily Spread, Pasteur Range & Paddock and others (Poultry). Out of total N_2O emissions of 4.03 million tons of CO_2- eq. from different AWMS, 3.41 million tons are from Solid Storage & Drylot and remaining 0.62 million tons are from other sources (poultry).

2.5.4 Rice Cultivation

The anaerobic decomposition of organic matter in flooded rice cultivation produces CH_4, which is released to atmosphere by diffusion through rice plants. This process is called methanogenesis. The annual CH_4 emissions from a given area of rice is a function of the crop duration, water regimes and organic soil amendments.

The CH_4 emissions from rice cultivation have been estimated by multiplying the seasonally integrated emission factor for continuously flooded rice without organic amendment from Revised 1996 IPCC Guidelines by the annual harvested area.

In 2014- 15, 2.89 million- hectare area was cultivated to grow rice using water management practices, where rice is intermittently flooded with canals or tube wells and aerated singly. It caused three million tonnes of CO_2- eq. of CH_4 emissions, which is 1.7% of the total agricultural emissions.

2.5.5 Agricultural Soils

Nitrification and denitrification are the processes that produce N_2O naturally in the soils. Aerobic oxidation of ammonium to nitrate by microbes is nitrification and anaerobic reduction of nitrate by microbes to nitrogen gas (N_2) is denitrification. In the reaction process of denitrification, N_2O is produced as a gaseous intermediate while as a by- product in case of nitrification that leaks into soils from microbial cells and eventually into the atmosphere.

Inorganic Nitrogen (N) in the soil is the main controlling factor in this reaction. Therefore, using the methodology in Revised 1996 IPCC Guidelines, N_2O emissions have been estimated from human- induced net N additions to soils through synthetic or organic fertilizers, animal manure, crop residues. Mineralization of N in soil organic matter following drainage/ management of organics soils, or cultivation/ land- use- change on mineral soils is also source of N addition to soils.

The N_2O is emitted both directly and indirectly from N inputs added through anthropogenic activities or N mineralization. Therefore, the total N_2O emissions are a function of sum of the both direct and indirect along with N added by animals.

Total annual N_2O emissions from agricultural soils of Pakistan are estimated to be 79.4 Mt of CO_2- eq. constitution 45.5% of the total emissions from agriculture sector. Soils of pasture range and paddock contributes 39.5 Mt CO_2- eq. of N_2O due to N added by grazing animals which is 49.7% of total N_2O emissions from agricultural soils. While direct N_2O emissions of 26.9 Mt of CO_2- eq. constituting 33.9% are followed by indirect N_2O emissions of 13 million tonnes constituting 16.4% of the total N_2O emissions from agricultural soils.

2.5.6 Field Burning of Crops' Residue

Field burning of agricultural residues is practiced in different agricultural areas of the country producing Carbon Monoxide (CO), CH_4, N_2O, NOx, and many other gases. In this report, only CH_4, N_2O and CO emissions have been reported.

The estimation of amount of biomass actually burnt in the field is an important step while calculating GHG emissions from crop residue burning. Using methodology in the Revised 1996 IPCC Guidelines, amount of biomass of four crops, viz. sugarcane, rice, wheat, and maize burnt in the fields was estimated for quantifying emissions due to this burning process. In this estimation process of emissions, national crop production data for the year 2014- 15 was taken from agriculture statistics of Pakistan while taking residue to crop ratio, dry matter fraction and fraction oxidized are default taken from the Revised 1996 IPCC Guidelines. Total emissions due to field burning of agricultural residues were found to be 1.9 Mt of CO_2- eq. constituting about

1.1% of the total emissions from agriculture sector. Out of the 1.9 million tonnes of emissions, 0.57 Mt of CO_2- eq. is CH_4 followed by 1.07 million tonnes of CO and 0.3 million tonnes is N_2O.

2.6 Land- Use- Change and Forestry

Pakistan is considered among the low forest cover countries with only five % of land area under forests. Among major forest types are conifers (including moist and dry temperate conifers), riverine forests, sub- tropical scrub forests, irrigated plantations, coastal mangroves, irrigated and non- irrigated farmland trees, and linear plantations (including urban and roadside plantations). Juniper, Deodar, Oak and Chilghoza forests, the world's most unique forests, are the native species. Besides, acting as sinks of GHG emissions, forests contribute significant ecosystem services by serving multiple benefits of physical and mental health of human beings because of their medicinal importance, soil erosion control, water regulation, control of infectious diseases and resilient safety nets. Forest is also an important source of livelihoods for the communities living there.

In Pakistan, the existing resources of forests are under immense pressure. They cannot even fulfil the domestic wood demands for the increasing population. The higher wood demand than the annual growth rates/ increment of forests has put this important natural resource at risk resulting in increased deforestation rate. Another reason of the lower forest covers, is dependence on the state- owned forests and farm/ community forests while ignoring shamilats, communal lands, Guzara and privately- owned forests. Rate of deforestation at national level is about 27,000 hectares per year mainly in private and community- owned natural forests. In addition to contributing to national GHG emissions, deforestation in watershed areas has negatively affected the quantity and quality of water at outlets. It has also triggered land degradation and biodiversity loss. In this regard, the 2014 launched Pakistan's Billion Tree Tsunami restores 350,000 hectares of forests and degraded land to surpass its Bonn Challenge commitment.

Table 14:

Province- wise forest areas by types of vegetation in 2005- 06 (thousand hectares)

Category	Punjab	Sindh	KPK	Balochistan	Gilgit- Baltistan	Azad Kashmir	Total
Conifers	58	-	760	125	315	408	1,666
Riverine	71	281	-	-	-	-	352
Scrubs	274	1	308	371	38	9	1,001
Irrigated Plantations	172	111	-	-	-	-	283
Mangroves	-	328	-	2	-	-	330
Irrigated including farmland trees	-	-	-	-	-	-	19,270
Non- Irrigated including farmland trees	-	-	-	-	-	-	1,900
Linear (Urban/ roadside) plantation	14	-	2	1	-	-	17
Range Lands	96	272	74	371	461	150	1,424
Mazri	-	-	24	-	-	-	24
Miscellaneous	84	-	750	-	-	-	834
	769	**993**	**1,918**	**870**	**814**	**567**	**27,101**

GHG emissions from LUCF sector involves estimation of carbon stock changes, CO_2 emissions by sources and removals by sinks and other non- CO_2 emissions. The IPCC has developed three GHG emission estimation guidelines for forestry and land- use sector. These guidelines include Revised 1996 Guidelines for LUCF; IPCC Good Practice Guidelines for Land- Use, Land- Use- Change and Forestry (LULUCF); and the recent 2006 IPCC Guidelines in which Agriculture, Land- Use and Forestry are combined under Agriculture, Forestry and Other Land Uses (AFOLU) category.

Pakistan used the Revised 1996 IPCC Guidelines for LUCF sector for the estimation of GHG emissions. LUCF sector contributes its marginal share of 10.4 Mt of CO_2- eq. to the total national GHG emissions for the year 2014- 15.

2.6.1 Methodology- estimating carbon stock changes

In Revised 1996 IPCC Guidelines, estimation of carbon stock changes is important because GHG emissions by sources and removal by sinks or the carbon stock change is the main source of GHG in LUCF sector (IPCC, 1996). Carbon stock changes are estimated by summing up the changes in stocks of all the carbon pools (forest types) in a given area over a period of time. These carbon stock changes are averaged to get annual stock changes.

2.6.2 Inventory estimation

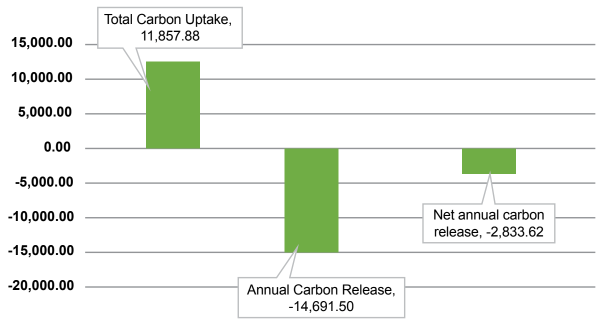
While estimating the GHG emission inventory for the year 2011- 12, Pakistan has adopted Tier- I approach where default emission and removal factors were used (IPCC, 1996). Activity data for different carbon pools has been taken from the following sources.

- Country Report of Pakistan 2005, Food and Agriculture Organization of the United Nations;
- Agricultural Statistics of Pakistan 2014- 15, Ministry of National Food Security and Research;
- Economic Survey of Pakistan 2014- 15, Ministry of Finance;
- National Forest and Rangeland Resource Assessment Study 2004, Pakistan Forest Institute;
- Supply & Demand of Fuel Wood & Timber for Household & Industrial Sectors & Consumption Pattern of Wood & Wood Products in Pakistan (2003- 2004) called as Maanics Report 2004, Office of Inspector General of Forests, Ministry of Environment;

The estimation of carbon stock changes (carbon emissions by sources and removals by sinks) for the inventory year 2014- 15, has been done on the basis of changes in forest and other woody biomass stocks (for the year 2014- 15) of the forest types present in the country. These forest types include conifers, riverine, scrub forests, irrigated plantation, mangroves, irrigated and non- irrigated farmland trees, and linear (urban/ roadside) plantation. The net carbon emissions or removals have been calculated on the basis of difference of total carbon uptake increment and annual carbon release (Figure 13).

Figure 13:

CO_2- eq. emissions from LUCF (thousand tonnes)



In 2014- 15, total carbon uptake was 11.9 million tonnes by forests of Pakistan as compared to 14.7 million tonnes of annual carbon release resulting in net CO_2 emissions of 10.4 million tonnes.

2.7 Waste

Methane (CH_4) is the main GHG emitted through waste management. Anaerobic decomposition of the solid waste by methanogenic bacteria results in the production and release of CH_4 in the atmosphere. Waste water also produces CH_4 through anaerobic handling or treatment along with N_2O from domestic waste water with protein contents. GHGs and their sources in waste sector include:

- Municipal solid waste disposal/ handling sites emitting CH_4
- Domestic waste water disposal/ handling resulting CH_4 and N_2O emissions
- Industrial waste water disposal/ handling producing CH_4 emissions

2.7.1 An Overview of GHG Emissions from Waste

In 2014- 15, the waste sector produced total GHG emissions of 15.65 million tonnes of CO_2-eq. of which 13.5 million tonnes was CH_4 and 2.2 million tonnes was N_2O (Table 15).

Table 15:

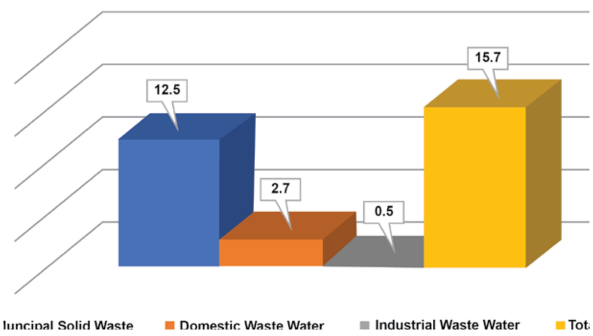
GHG emissions from the waste sector in thousand tonnes of CO_2- eq.

Source Category	CH_4	N_2O	Total
	13,482	**2,170**	**15,652**
Municipal Solid Waste Disposal	12,453		12,453
Domestic Waste- water Handling	546	2,170	2,716
Industrial Waste- water Handling	462		462

Municipal Solid Waste (MSW) is the dominant source of CH_4 emissions, which emits 79.6% of the total CO_2- eq. GHG emissions from waste sector. 6.4% of the CH_4 emissions were produced by domestic and industrial waste water handling. The remaining 13.9% emissions were produced as indirect N_2O emissions from waste water containing human sewage.

Figure 14:

CO_2- eq. emissions from Waste sector (million tonnes)



2.7.2 Municipal Solid Waste

In Pakistan, municipal corporations systematically collect urban waste and disposed it of at waste disposal sites. Its anaerobic decomposition results in CH_4 emissions. In rural areas, waste is neither collected nor dumped, but thrown to the fields by the rural people. MSW in urban Pakistan is disposed of in landfills by means of open dumping and burning.

The rate of generation and disposal of MSW varies in different cities. The estimation of CH_4 emissions from MSW at national level is uncertain due to lack of year- wise data on MSW generation. In the present methodology of GHG estimation, revised 1996 IPCC Guidelines have been used with default CH_4 emission factor (IPCC, 1996). In this methodology, total annual MSW generation has been estimated by multiplying MSW generation rate (which is 0.65 kg/ capita/ day) with urban population.

2.7.3 Waste Water Treatment and Disposal

When waste water is treated or disposed of anaerobically, CH_4 is emitted. Various domestic, commercial and industrial sources produce waste water, which is treated on the site, collected at centralized plant for treatment or disposed of as untreated.

2.7.4 An Overview of GHG Emissions from Waste Water

In Pakistan, total emissions of 3.2 million tonnes are released from waste water sources in 2014-15, which is 20% of the total CO_2- eq. emissions from the waste sector. Out of the total emissions from waste water, 1 million tonnes is CH_4 and 2.2 million tonnes of CO_2- eq. is N_2O (Table 16).

Table 16:

GHG emissions from waste water sector in thousand tons of CO_2- eq.

Activity	CH_4	N_2O	Total
	1,008	2,170	3,178
Domestic	546	2,170	2,716
Industrial	462		462

2.8 Greenhouse Gas Emission Profile: Key Features

2.8.1 An Overview

In 2014-15, Pakistan emitted 406.5 million tonnes of CO_2- eq. with LUCF. All GHGs particularly CO_2, CH_4 and N_2O in terms of their respective global warming potentials are summed to get total national emissions in CO_2- eq. This chapter describes the emissions by gases for different sectors. Also, comparison of 2015 emissions with the 1994 emissions (communicated in Pakistan's Initial National Communication to the UNFCCC) has be presented.

2.8.2 Trends of GHG Emissions by Gas

Carbon Dioxide (CO_2)

In 2015, the total CO_2 emissions from Pakistan were 185,556 thousand tonnes compared to 94,572 thousand tonnes in 1994. In 2008, GHG emission estimates were 168,837 thousand tonnes, which increased to 178,805 thousand tonnes over the period of four years in 2012 Table 11).

Methane (CH_4)

The second largest GHG emitted in 2015 was CH_4. Total CH_4 emissions were 5,738 thousand tonnes compared to 2,891 thousand tonnes in 1994. In 2008, GHG emission estimates of CH_4 were 4,891, which increased to 5,109 thousand tonnes over the period four years in 2012 (Table 17).

Table 17:

National GHG Emissions in 1994, 2008, 2012 and 2015 by Gas (thousand tonnes)

Gases	1994	2008	2012	2015
Carbon Dioxide (CO_2)	94,572	168,837	178,805	185,556
Methane (CH_4)	2,891	4,891	5,109	5,738
Nitrous Oxide (N_2O)	37	118	260	280
Oxides of Nitrogen (NO_x)	410	755	770	754
Carbon Monoxide (CO)	732	1,154	3,127	5,734
Non- Methane Volatile Organic Compound (NMVOC)	657	285	443	804
Sulphur Dioxide (SO_2)	775	1,004	844	1,041

Nitrous Oxide (N_2O)

The Total N_2O emissions, third in series, were 280 thousand tonnes in 2015 compared to 37 thousand tonnes of N_2O emissions in 1994. In the estimates of 2008 GHG emissions, N_2O was 118 thousand tonnes, which increased to 260 thousand tonnes in 2012 (Table 17).

Other GHGs

Other GHGs included Oxides of Nitrogen (NOx), Carbon Monoxide (CO), Non- Methane Volatile Organic Compound (NMVOC) and Sulphur Dioxide (SO_2). These gases are considered minor or supporting GHGs, therefore, were not reported in 2015 estimates. In 2015, CO is the largest in this category emitted as much as 5,734 thousand tonnes followed by 1,041 thousand tonnes of SO_2, 804 thousand tons of NMVOC and 754 thousand tonnes of NOx (Table 17).

2.8.3 Trends of GHG Emissions by Sector

Energy

Energy sector remained the highest emitting sector, which released 184,002 thousand tonnes of CO_2- eq. in 2015 compared to 85,816 thousand tonnes in 1994. In 2012, the emissions from energy sector increased to 19,595 thousand tonnes than that of 18,541 thousand tonnes of CO_2- eq. in 2008 (Table 18).

Table 18:

National GHG Emissions in 1994, 2008, 2012 and 2015, by sector (thousand tonnes of CO_2- eq.)

Sectors	1994	2008	2012	2015
Energy	85,816	168,472	171,440	184,002
Industrial Processes	13,297	18,541	19,595	21,853
Agriculture	71,632	125,978	162,860	174,564
Land- Use- Change and Forestry (LUCF)	6,527	9,299	9,671	10,390
Wastes	4,454	7,243	10,554	15,652
TOTAL (Mt CO_2- eq.)	**181.7**	**329.5**	**374.1**	**406.5**

Agriculture

Agriculture sector, the second highest emitting sector concluded with 174,564 thousand tonnes of CO_2- eq. in 2015 compared to 71,632 thousand tonnes in 1994. In 2012, the emissions from agriculture sector increased to 162,860 thousand tonnes than that of 125,978 thousand tonnes of CO_2- eq. in 2008 (Table 18).

Industrial Processes

The third largest emitting sector of Pakistan was industrial processes which released 21,853 thousand tonnes of CO_2- eq. compared to 13,297 thousand tonnes in 1994. In 2008, the emissions from industrial processes were 18,541 thousand tonnes which increased to 19,595 thousand tonnes in 2012 (Table 18).

Waste

The fourth largest emitting sector of Pakistan is waste. In 2015, it released 15,652 thousand

tonnes of CO_2- eq. in comparison of 4,454 thousand tonnes in 1994. In 2008, the emissions from waste sector were 7,243 thousand tonnes which increased to 10,554 thousand tonnes of CO_2- eq. in 2012 (Table 18).

Land- Use- Change and Forestry (LUCF)

LUCF emissions contribution remained the lowest in 2015. It emitted 10,390 thousand tonnes of CO_2- eq. in comparison of 6,527 thousand tonnes in 1994. In 2008, the emissions from LUCF sector were 9,299 thousand tonnes which increased to 9,671 thousand tonnes of CO_2- eq. in 2012 (Table 18).

2.8.4 Comparison with 1994, 2008 & 2012 GHG Inventories

The 1994 GHG assessments are available in Pakistan's INC. Both the 1994 and 2015 GHG emission assessments for the years 1994 and 2015 had been done using IPCC guidelines for the preparation of national GHG inventories by sources and removal by sinks. A sectoral comparison of the emissions in 1994 and 2015 is provided in Table 19. The overall national emissions are growing at the rate of 3.9% from 1994 to 2015. Emissions from waste, agriculture and energy are growing at a faster rate with respect to others. The compound annual growth rates are 6.2%, 4.3% and 3.7% respectively. These are mainly associated with the growing food and energy needs for the increasing population. Emissions form industrial processes and LUCF sector are growing with compound annual growth rates of 2.4% and 2.2% respectively.

Table 19:

A comparison of emissions by sector between 1994 and 2015 (thousand tons of CO_2- eq.)

Sectors	1994	2015	CAGR (%)
Energy	85,816	184,002	3.7
Industrial Processes	13,297	21,853	2.4
Agriculture	71,632	174,564	4.3
Land- Use- Change and Forestry (LUCF)	6,527	10,390	2.2
Wastes	4,454	15,652	6.2
TOTAL (Mt CO_2- eq.)	**181.7**	**406.5**	**3.9**

2.8.5 Emissions Intensity (per capita emissions)

The estimated population of Pakistan in 2015 was 191.7 million. The per capita GHG emissions with LUCF were estimated to be 2.12 tonnes of CO_2- eq. In comparison, in 1994 when the estimated population was about 121.4 million, the per capita GHG emissions were 1.5 tonnes of CO_2- eq. The Gross Domestic Product (GDP) at the constant factor cost (in billion USD of 2010) was 215.9 billion USD in 2015 and the total emissions (in kilograms of CO_2- eq.) per $ GDP in USD of 2010 was 1.88 kilograms of CO_2- eq. In contrary, in 1994, the GDP was USD 95.4 billion and the total GHG emissions were accordingly 1.9 kilogrammes of CO_2- eq. per $ GDP (Table 20).

Table 20:

Total GHG emissions per capita and per $G DP (emission intensity) in 1994, 2008, 2012 and 2015 inventories

	1994	2008	2012	2015
Total GHG emissions (million tonnes of CO_2- eq.)	181.7	329.5	374.1	406.5
Population (million)	121.48	166.41	180.71	191.71
Total GHG emissions (tonnes of CO_2- eq.) per capita	1.50	1.98	2.07	2.12
GDP at constant factor cost (in billion USD) of 2010	95.4	169.8	188.7	215.9
Total GHG emissions (kilogram of CO_2- eq.) per $GDP in USD of 2010	1.90	1.94	1.98	1.88

2.9 Future Perspective

2.9.1 Emissions Factor- witching to Tier 2 & 3

So far Pakistan is using Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, following the decision 17/ COP8 (UNFCCC, 2003). In addition to the default IPCC, 1996 Revised Guidelines, IPCC Good Practice Guidance is also being used. Though the latest IPCC 2006 Guidelines for national GHG inventories are more elaborate and provide guidance for developing country- specific emission factors under certain GHG source/ sink sub categories, the lack of credible data remains the major constraint. Further the country- specific GHG emission factors (Tier 2 and 3) are not available which are essential to get the precise estimates of GHG emissions in the country. However, the studies are going on particularly for Methane emissions from rice and Forest Reference Emissions Levels (FRELs) are being developed. Still a lot needs to be done for the development of Tier 2 & 3 GHG emission factors.

2.9.2 Capacity Building & Institutional Setup

Accurate stocktaking of GHG emissions play a useful role for the policy makers to make more informed decisions and to meet the report obligations under UNFCCC. Currently, a coherent GHG- Inventory preparation system does not exist in the country, though five GHG- I preparation efforts have been carried out till 1994 and the sixth one is in the offing. A coherent and sustainable GHG inventory preparation system is direly needed for which Global Change Impact Studies Centre (GCISC) is carrying out efforts under the patronage of Ministry of Climate Change with the technical assistance of GHG Inventory and Research Centre (GIR), Korea.

As far as capacity in the preparation of GHG- I is concerned, only few professionals at GCISC are capable of developing the inventories using IPCC Guidelines. Further, GCISC has organized few trainings in this regard to train a mass of professionals. Establishment of a robust national inventory system for the preparation of GHG emission inventories at the national level is needed. A national GHG inventory system incorporating all the legal, institutional, and procedural elements will be useful in estimating, reporting, and archiving GHG emissions and sinks. Furthermore, capacity building of the existing national GHG experts on these elements, including the description of the procedures for preparing GHG inventories and the documents of data sources, methodological choice, assumptions, quality assurance, quality control (QA/ QC) measures, and legal and institutional mechanisms for ensuring periodic reporting of data is essential.

CHAPTER

3

Vulnerability and Adaptation Assessment

Vulnerability and Adaptation Assessment

3.1 Advances since Initial National Communication (INC)

The assessment of climate change impacts along with vulnerability and adaptation to climate change require a wide range of physical, biological, and socio- economic models, methods, tools, and data. These methods are improving gradually. Since the submission of Initial National Communication to the UNFCCC, Pakistan has taken a lot of climate- related initiatives, which have been discussed in detail in this Chapter.

3.2 Observed and Projected Climate Changes in Pakistan

3.2.1 Observed Climate Trends

Pakistan has four well- marked seasons: winter (December to March), pre- monsoon (April to May), summer or monsoon (June to September) and post- monsoon (October to November) (Sheikh *et al.,* 2009). Summer season is extremely hot and the humidity ranges between 25% to 50%. Daytime temperature approximately ranges around 40 °C and beyond in plain regions, while in northern areas it ranges around 15 °C. The average winter temperature ranges around 4 °C to 20 °C in the plain areas. Whereas, in northern mountainous region, mercury sometimes falls well below freezing- point, so temperature drops as low as - 50 °C (Chaudhry *et al.,* 2009; McSweeney *et al.,* 2010). Normal annual maximum and minimum temperatures are shown in Figure15 (C & D) respectively.

In summer, Pakistan receives rainfall from south Asian monsoon whereas in winter, rainfall is the result of western disturbances. Monsoon is a blessing, which transports water from the Bay of Bengal and the Arabian Sea to Pakistan. The seasonal march of monsoon (onset, number of rainy days, offset, etc.) is disturbed due to changing climate and its inter- annual variability (repeated drought/ flood events) is a serious challenge for the sustainable crop production. Pakistan's hydrological regime upstream and downstream is highly connected; if north receives surplus amount of water due to heavy rainfall or snow/ glacier melting, it immediately runs down to the low elevation plains of Sindh and the Punjab, flooding the cultivated lands and destroying the standing crops. In case of weak monsoon and less rainfall in the northern half, the agricultural plains of south suffer a lot due to intense heat, and higher water demands but less available water (Rasul, 1992; Zaman and Rasul, 2004). Pakistan receives rainfall of less than 250 mm annually, except in the southern slopes of Himalaya and the sub mountainous regions in the northern segment of the country, where annual rainfall ranges from 760 mm to

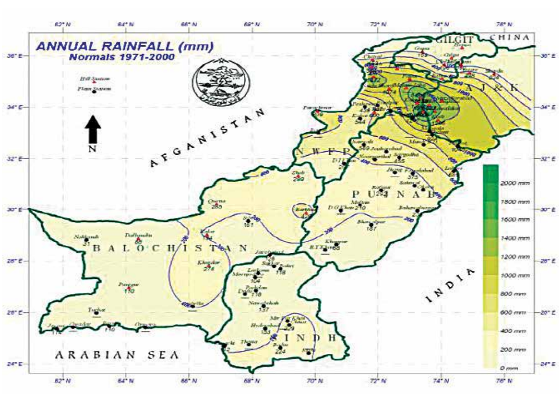
2,000 mm. Balochistan province is the driest part, which receives 210 mm on the average. Three- fourth part of the country receives rainfall less than 250 mm and 20% of it receives 125 mm (Chaudhry *et al.,* 2009). Normal annual rainfall is also displayed in Figure 15 (A).

Temperature

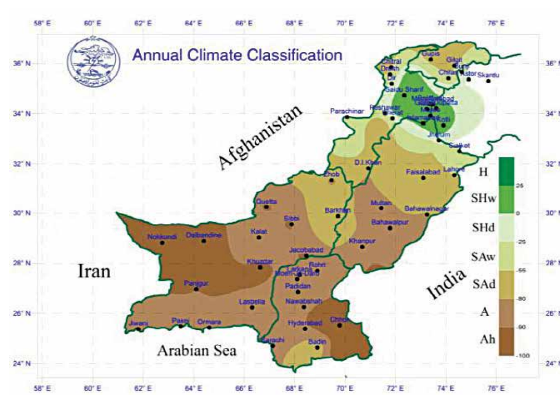
The time series of area weighted mean daily temperatures averaged over each year is shown in Figure 16. The analysis based on 56 stations covering the whole of Pakistan shows a sharp rise during the first decade of 21st century. However, the year 2005 was an exception when good summer and winter rains kept the temperatures in normal range otherwise this decade would have shown an irreversible rise in temperature (Rasul *et al.,* 2012). Since 1960, the year 1998 appeared to be the hottest year for Pakistan compared to the past due to severe El- Nino event, and the country's experience of a four year long drought due to inadequate summer rains.

Figure 15:

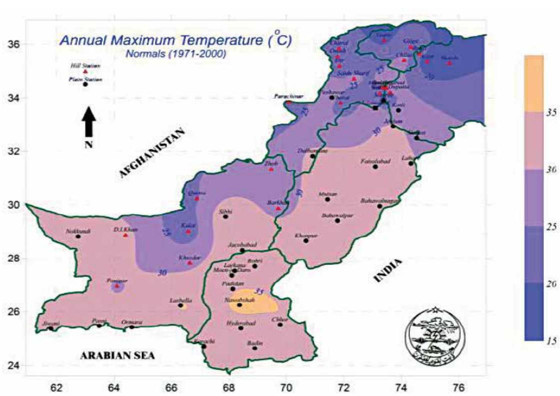
Climatic Normals of Pakistan



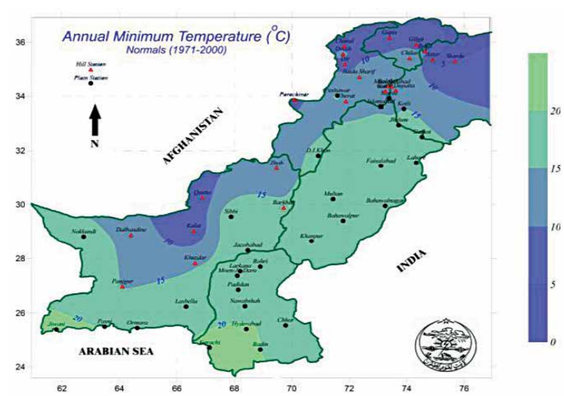
A: Annual Precipitation



B: Annual Climate Classes



C: Annual Maximum Temperature



D: Annual Minimum Temperature

Source: Country's experience of a four year long drought due to inadequate summer rains *et al.,* 2009

The minimum temperature, typically at night, and the maximum temperature, which is commonly the day's highest temperature, shows an increase in both summer and winter seasons almost throughout Pakistan (Afzaal and Haroon *et al.,* 2009). The analysis based on past temperature record shows that the winter season is greatly warmer when compared to the summer season, which indicates that the winter is shrinking and the summer expanding (Rasul *et al.,* 2012). Night temperatures show larger increase compared to the day indicating their negative impact on animals and crop production due to heat stress, increased water requirements, and higher rates of respiration. During the last decade, a mixed trend of maximum temperatures prevailed in summers. However, the minimum temperatures in summer over central parts of Pakistan pronounced warming trend while extreme north and south showed slightly cooling trend in some climatic zones. The coastal belt in general and the Indus delta in particular did not show any alarming warming or cooling trend. However, the changes in thermal regime taking place in the surrounding regions would ultimately affect the climatic conditions of the deltaic regions.

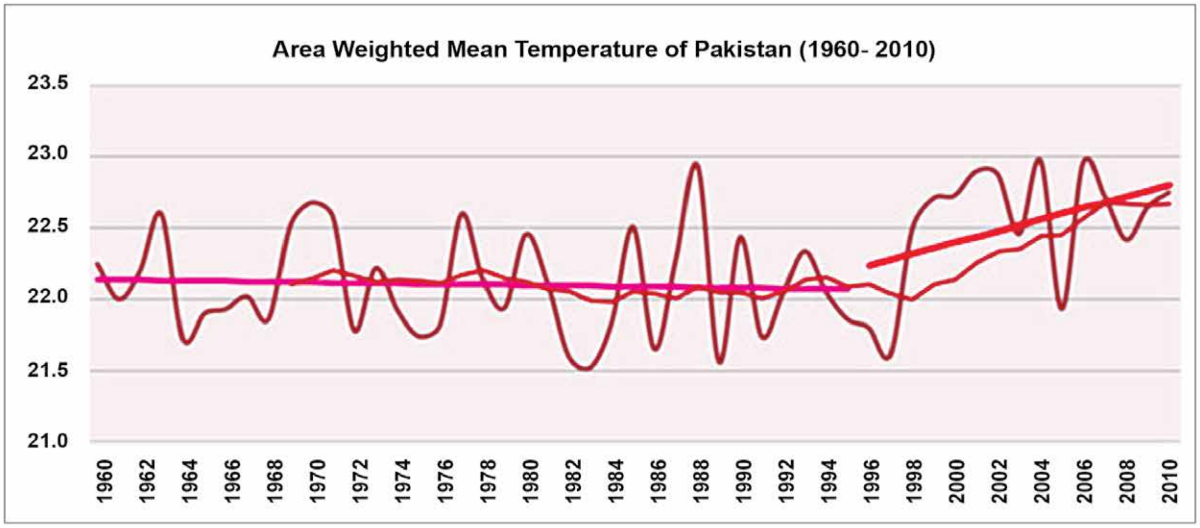
Precipitation

Winter and monsoon are two major rainy seasons in Pakistan. Monsoon contributes around 60% of the country's total annual precipitation. The precipitation in this season is generally associated with monsoon depressions (low pressure systems) formed over Bay of Bengal travelling westward and reaching Pakistan after crossing India. Another mechanism of monsoon precipitation is the southwesterly flow of moisture from the Arabian Sea, which gets activated in case of persistence of a depression. Both the phenomena reinforce the precipitation process after interaction and produce high intensity rainfall, i.e. heavy amount of water in a short interval of time (Das *et al.,* 2003; Rasul *et al.,* 2004).

Winter precipitation is linked with western disturbances, which are the troughs of westerly waves passing across the mid- latitudes. Under the influence of such waves, northern half of Pakistan (i.e. above 30 °N) receives fair amount of precipitation in the form of both snowfall and rainfall.

Figure 16:

Area weighted mean temperature over Pakistan

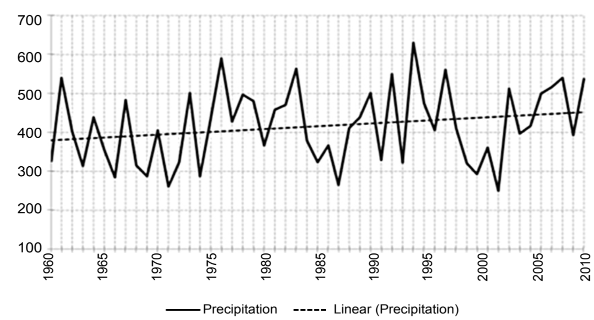


Source: Rasul *et al.,* 2012)

The southern half rarely gets winter precipitation as the system seldom penetrates this part of the country. However, in case of strong activity, the troughs of westerly waves extend sufficiently southward and sometimes yield good precipitation in Balochistan and Sindh. The winter precipitation is usually of low intensity as compared to that of summer. Hence, floods are not very common in winter. Solid precipitation accumulated over the northern mountains in winter along with glaciers melt feed the river flows in the summer season especially when dry and hot weather prevails in pre- monsoon period.

Figure 17:

Time series of precipitation over Pakistan



Source: Rasul *et al.,* 2012

Figure 17 shows temporal variations of precipitation in the recent past, i.e. 1960 to 2010 based on 56 meteorological stations covering whole Pakistan. The years falling under the trend line are graded as drought years, which have dominant frequency as compared to flood peaks with surplus amount of precipitation. The flooding years 1961, 1976 and 1994 are clearly visible from the precipitation peaks.

Climate change scenarios

The scientific community has incessantly been working on the development of new global, regional, and sectoral scenarios with the objective to explore the range of possible future climates and related physical changes that pose risks to human and natural systems. Climate change caused by human activities has resulted in a variety of research focusing on studying the past climate, predicting the future climate and quantifying the change in climate extreme events by using different climate models. Climate projections are descriptions of the modelled response of the climate system to scenarios of GHG and aerosol concentrations. Useful information about possible future climates and their impacts can be obtained using various scenario construction methods. The majority of scenario construction techniques depend upon results obtained from climate model simulations.

Future climate scenarios over Pakistan

The findings of the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) in connection with the Asian region show that sensitivity to climate change threats in agri- dependent economies (such as Pakistan) arises from their distinct geography, demographic trends, socioeconomic factors, and lack of adaptive capacity that when taken together, determine the vulnerability profile by perpetuating a vicious cycle of poverty (Hijioka *et al.,* 2014). The climate change projections of the AR5 for South Asia as a whole show that warming is likely to rise above the global mean and climate change will impact the glaciers' melting rate and precipitation patterns, particularly affecting the timing and strength of monsoon rainfall. Consequently, this will impact the productivity and efficiency of water-dependent sectors such as agriculture and energy as well as the wellbeing of workforce associated with these sectors.

3.2.2 GCM based Climate Projections

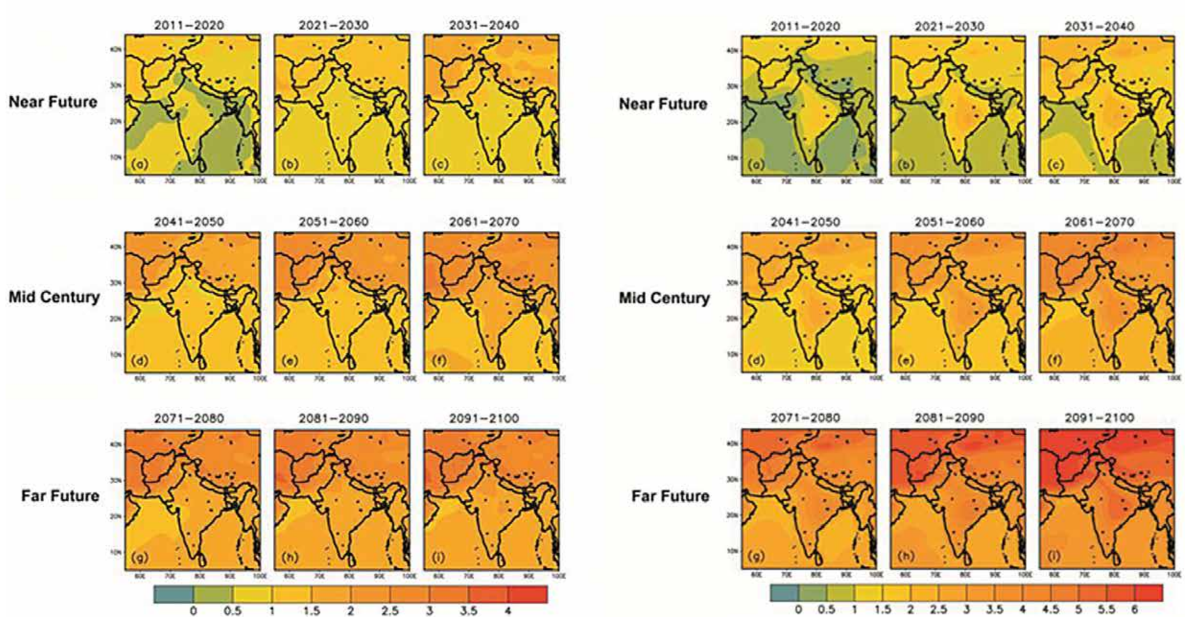
Climate models at different spatial scales and levels of complexity provide the major source of information for constructing climate scenarios. The widely applied method for developing climate scenarios for quantitative impact assessments is to use results from Global Circulation Models (GCMs) experiments. GCMs are the most appropriate tools available to study the changes in the earth's climate at large-scale (Houghton *et al.,* 2001; Moss *et al.,* 2010). Recent AOGCM simulations begin by modelling historical forcing by GHGs and aerosols from the late 19th or early 20th century onwards. Climate scenarios based on these simulations are being increasingly adopted in impact studies along with scenarios based on ensemble simulations and scenarios accounting for multi- decadal natural climatic variability from long AOGCM control simulations.

GCM based projections of future climate over Pakistan presented here include the results form latest set of experiments, i.e. Coupled Model Inter- Comparison Project Phase 5 (CMIP5) from IPCC- AR5. These simulations have been performed using Representative Concentration Pathways (RCPs). Future climate change projections over Pakistan under RCP 4.5 and RCP 8.5 have been discussed by Iqbal and Zahid (2014). Their study shows that significant temperature change is observed in northern and north western parts of the country. Projections have also been developed on decadal basis for three time- periods; near future (2011- 2040), mid- century (2041- 2070) and far future (2071- 2100) (Figure below). The findings show that the last decade of the century is the warmest than the early and mid- century time periods. For RCP 4.5 projected change in mean temperature is below 4 °C while under RCP 8.5, it is above 5 °C.

Ikram *et al.,* (2016) have presented projected changes in temperature and precipitation over Pakistan from CMIP5 GCM outputs under RCP4.5 & RCP8.5. The results show that temperature change under RCP 4.5 is 2.7 °C and 8.3 °C under RCP 8.5 by the end of this century. Seasonal cycle depicts that rise in temperature during winter is higher than summer. Temperature rise in future is more prominent over northern parts than southern parts. Annual increase in precipitation is about 3 to 4 mm/ day. There is a significant dipole like pattern in the summer precipitation with a northeastward shift in it and interdecadal variability in the magnitude of change. The increase in precipitation over monsoon belt is up to 4 mm/ day whereas; the decrease in precipitation is up to 2 mm/ day over southern parts of the country.

Figure 18:

Mean air temperature change (°C) from CMIP5 ensemble under RCP 4.5 (left) & RCP 8.5 (right) for 2011- 2100



Source: Iqbal and Zahid, 2014

The comprehensive analysis of thirteen GCMs for A2 scenario and seventeen GCMs for A1B scenario from IPCC- AR4 has been reported in GCISC research report GCISC- RR- 03 (Siraj *et al.,* 2009). The analysis has been performed for three time- slices 2010- 2039 (2020s, F1), 2040- 2069 (2050s, F2) & 2070- 2099 (2080s, F3). GCMs used in the study have been listed in Table 21.

The projected change in mean annual temperature and precipitation for A2 scenario is shown in Figure 19 (a). The results indicate that temperature rise by the end of 21st century ranges from 3 °C to 5 °C across the country. The projected warming is higher in the northern parts as compared to the southern parts. In case of precipitation, there is no significant change projected by the models for all the three future time-lines (2020s, 2050s & 2080s).

Table 21:

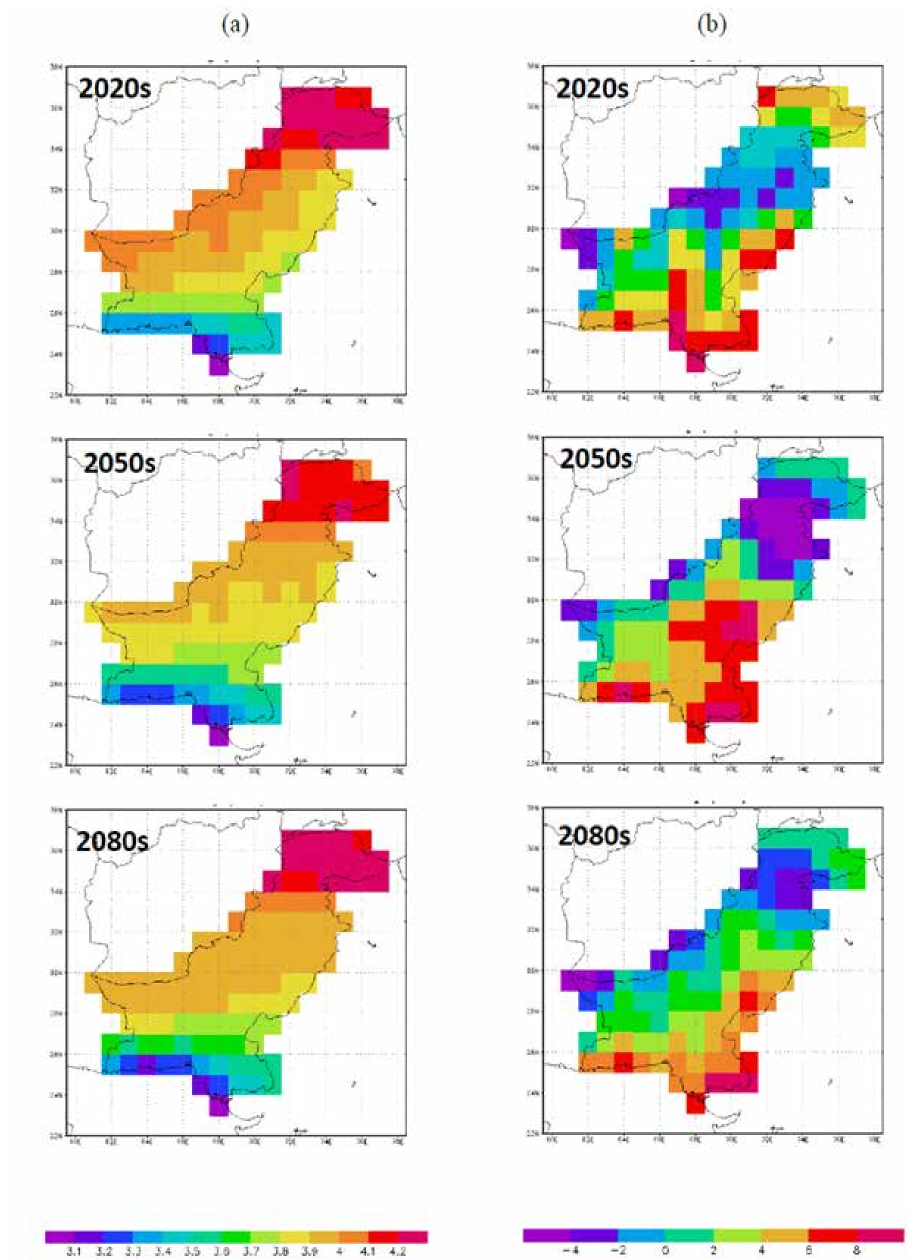
List of GCMs used in the report

Center	Center Acronym	IPCC ID with Key reference	Resolution
Centre National de Recherches Meteorologiques, France	CNRM	CM3 Salas- Melia *et al.,* (2006)	2.8° x 2.8°
Australia's Commonwealth Scientific and Industrial Research Organization, Australia	CSIRO	Mk3.0 Gordon *et al.,* (2002)	3.2° x 5.6°
Max- Planck- Institute for Meteorology, Germany	MPI- M	ECHAM5- OM Jungclaus *et al.,* (2006)	2.8° x 2.8°
Institute of Atmospheric Physics, China	LASG	FGOALS- g1.0 Yu *et al.,* (2004)	2.8° x 2.8°
Geophysical Fluid Dynamics Laboratory, USA	GFDL	CM2.0 Delworth *et al.,* (2006)	2.2° x 3.8°
		CM2.1 Delworth *et al.,* (2006)	1.25° x 2.0°
Goddard Institute for Space Studies, USA	GISS	AOM Russell *et al.,* (1995)	4.0° x 3.0°
		E- H Schmidt *et al.,* (2006)	4.0° x 5.0°
		E- R Schmidt *et al.,* (2006)	5.0° x 4.0°
Institute for Numerical Mathematics, Russia	INM	CM3.0 Diansky and Volodon (2002)	5.0° x 4.0°
Institut Pierre Simon Laplace, France	IPSL	CM4 Marti *et al.,* (2005)	3.75° x 2.5°
National Institute for Environmental Studies, Japan	MIROC	MIROC3.2 hires K- 1 Model Developers (2004)	1.125° x 1.125°
		MIROC3.2 medres K- 1 Model Developers (2004)	2.8° x 2.8°
Meteorological Research Institute, Japan	MRI	CGCM2.3.2 Yukimoto *et al.,* (2001)	2.8° x 2.8°
National Centre for Atmospheric Research, USA	NCAR	PCM Washington *et al.,* (2000)	2.8° x 2.8°
		CCSM3 Washington *et al.,* (2000)	2.5° x 1.4°
UK Met. Office, UK	UKMO	HadCM3 Jones *et al.,* (2004)	2.5°x 3.8°

Source: GCISC- RR- 03, 2009

Figure 19 (a):

Mean annual ensemble change of temperature (°C) and (b) precipitation (%) for A2 scenario over Pakistan



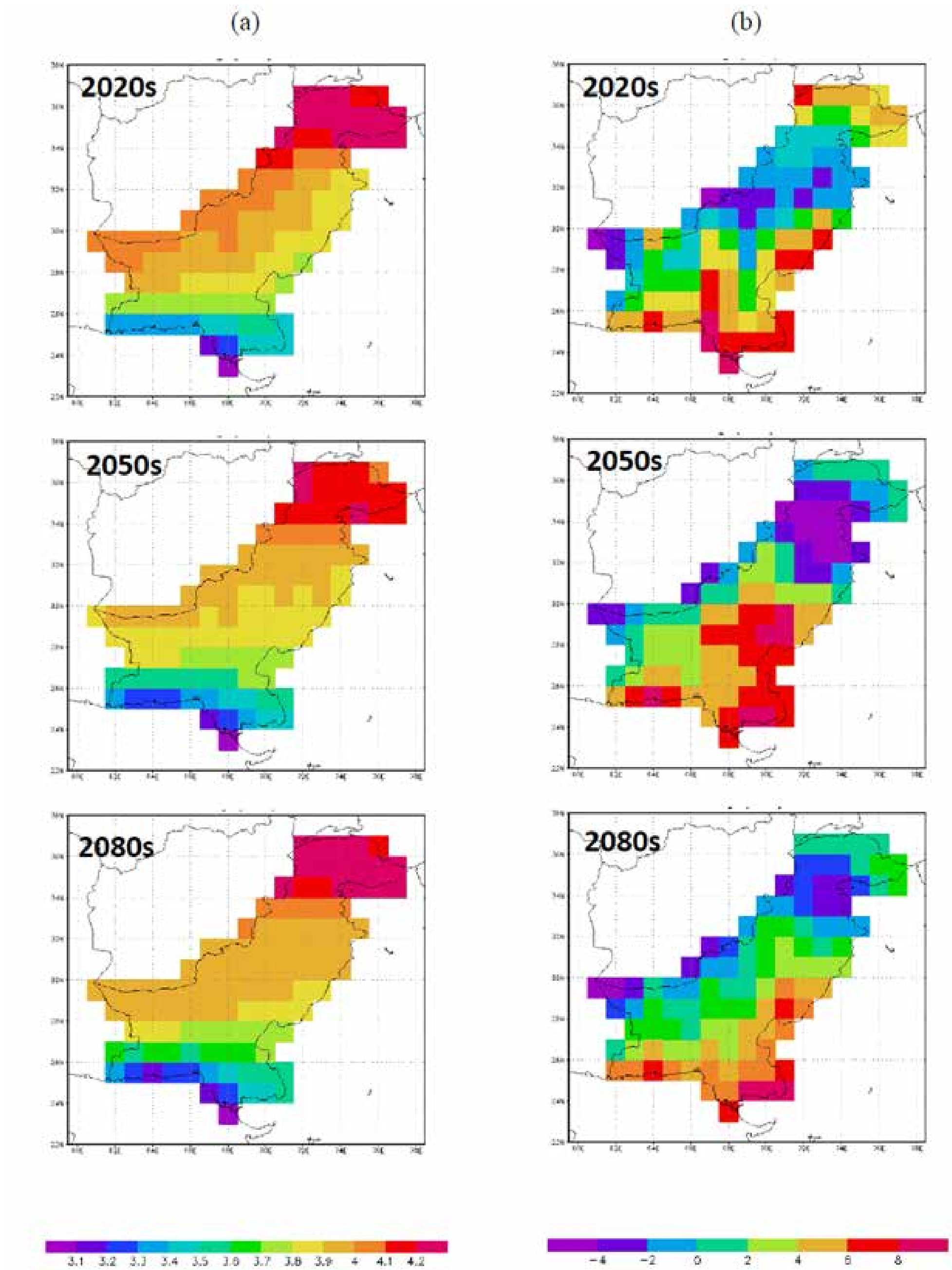
Source: GCISC- RR- 03, 2009

Disclaimer: Geographical boundaries shown above do not represent the official version of Pakistan and are taken from scientific resources

For A1B scenario (Figure 20), projected change in temperature is less as compared to A2 scenario. There is a rise of around 4 °C for northern region, while for coastal areas, the rise is about 3 °C by the end of 21st century. As far as precipitation is concerned, the models depict no significant change for the whole country.

Figure 20 (a):

Mean annual ensemble change of temperature (°C) and (b) precipitation (%) for A1B scenario over Pakistan



Source: GCISC- RR- 03, 2009.

Disclaimer: Geographical boundaries shown above do not represent the official version of Pakistan and are taken from scientific resources

Ensemble mean temperature change under A2 scenario is 4.38 °C while projected change for the same period but under A1B scenario is 3.87 °C. The spread in GCM simulated precipitation as seen in A2 scenario leads to higher uncertainty limiting the model's ability to predict this variable. The same is also evident from the results reported in Table 22.

Table 22:

Projected temperature changes (°C) over Pakistan

GCMs	A2			A1B		
	2020s	2050s	2080s	2020s	2050s	2080s
UKMO- HadCM3	1.14	2.49	4.39	1.12	2.58	3.85
PCM- NCAR	0.78	1.44	2.81	0.96	1.86	2.54
CCSM3- NCAR	1.32	2.35	4.02	1.40	2.65	3.11
MRI- CGCM2.3.2	1.09	2.27	3.71	1.36	2.54	3.48
ECHAM5/ MPI- OM	1.08	2.51	5.05	1.41	3.11	4.95
MIROC3.2 (hires)	1.55	2.86	4.65	1.55	3.03	4.47
IPSL- CM4	1.20	2.49	4.72	1.45	2.81	4.31
INM- CM3.0	1.81	3.24	4.92	1.98	3.25	3.95
GISS_ER	1.29	2.49	4.18	1.34	2.67	3.71
GFDL- CM2.1	1.64	2.93	4.95	1.77	3.25	4.37
GFDL- CM2.0	1.79	3.33	5.39	1.88	3.46	4.70
CSIRO- MK3.0	1.19	2.12	3.67	1.01	1.88	2.98
CNRM- CM3	1.12	2.50	4.47	1.40	2.55	3.67
GISS_AOM	---	---	---	1.18	2.36	3.15
GISS_EH	---	---	---	1.65	2.58	3.72
FGOALS- g1.0	---	---	---	0.89	2.11	3.09
MIROC3.2 (medres)	---	---	---	2.32	3.97	5.65
$(\bar{x} \pm \Delta x)$	1.31 ± 0.19	2.54 ± 0.31	4.38 ± 0.44	1.45 ± 0.09	2.75 ± 0.14	3.87 ± 0.20

Source: GCISC- RR- 03, 2009

Table 23:

Projected precipitation changes (%) over Pakistan

GCMs	A2			A1B		
	2020s	2050s	2080s	2020s	2050s	2080s
UKMO- HadCM3	14.70	22.37	9.63	10.73	4.72	11.46
PCM- NCAR	14.19	39.74	40.82	17.47	25.32	35.30
CCSM3- NCAR	13.90	23.90	35.04	14.98	18.45	26.76
MRI- CGCM2.3.2	16.33	17.06	15.36	-2.63	8.22	17.75
ECHAM5/ MPI- OM	-4.40	-3.32	-7.94	-10.32	-13.45	-22.03
MIROC3.2 (hires)	5.00	-3.22	10.73	0.75	-6.77	-3.96
IPSL- CM4	2.52	2.52	4.21	4.39	-7.13	-1.45
INM- CM3.0	-11.88	-4.84	-14.21	-12.70	-9.08	-21.14
GISS_ER	5.96	0.62	-7.48	2.02	-6.72	-6.46
GFDL- CM2.1	-10.16	-11.91	-22.47	-15.62	-18.42	-20.62
GFDL- CM2.0	-15.03	-23.18	-32.74	-10.58	-22.00	-25.95
CSIRO- MK3.0	2.60	6.77	5.06	1.44	8.15	4.44
CNRM- CM3	2.53	5.37	9.21	0.91	8.95	8.46
GISS_AOM	-	-	-	0.77	3.83	11.40
GISS_EH	-	-	-	-10.10	-8.69	-20.65
FGOALS- g1.0	-	-	-	-7.63	1.14	-3.75
MIROC3.2 (medres)	-	-	-	-5.84	-3.05	2.57
$(\bar{x} \pm \Delta x)$	2.79 ± 2.94	5.53 ± 4.63	3.48 ± 5.78	-1.29± 2.32	-0.97± 3.05	-0.4 ± 4.36

Source: GCISC- RR- 03, 2009

High Resolution Climate Scenarios

There are limitations that restrict the usefulness of GCM outputs for impact assessment studies. The community impacted by climate change has long been complaining about the insufficient spatial scale of climate scenarios produced from coarse resolution GCM outputs (Gates, 1985; Lamb, 1987; Robinson and Finkelstein, 1989; Smith and Tirpak, 1989; Cohen, 1990). The urge for information at higher spatial resolutions, on variability as well as changes in mean climatic conditions, has been there for a number of years (Smith and Tirpak, 1989).

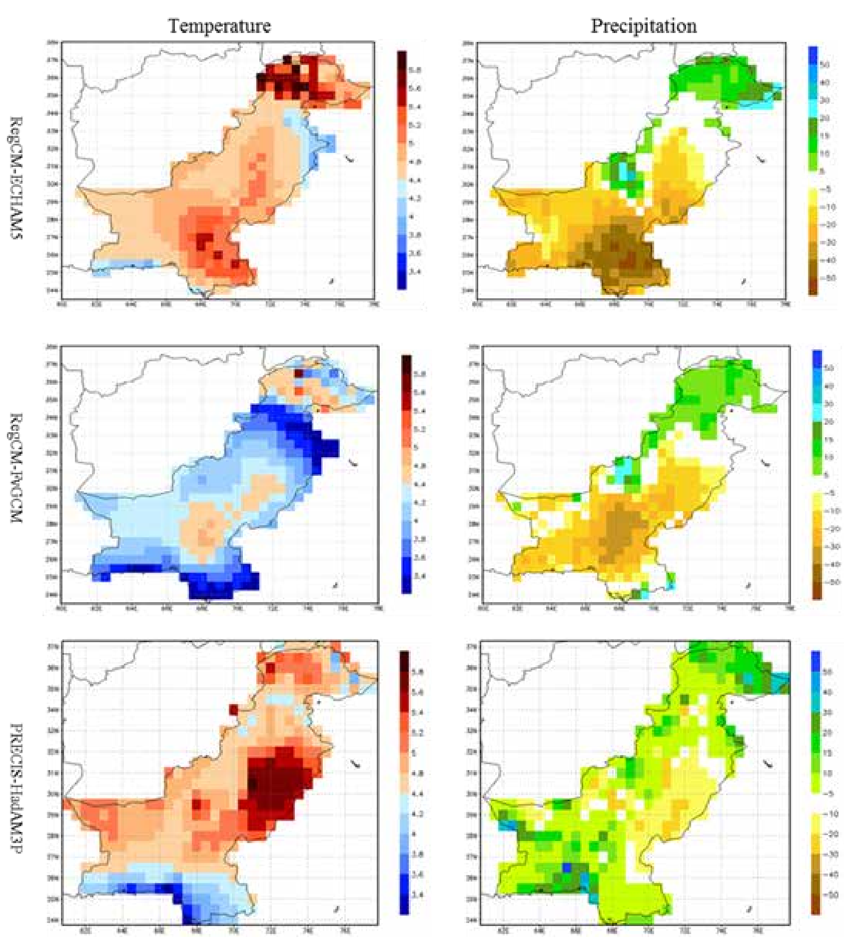
For developing high resolution climate change scenarios, Regional Climate Models (RCMs) provide a tool to dynamically downscale GCM simulations by superimposing the regional details. These high- resolution dynamic RCMs nested in GCM are becoming an increasingly important tool in climate research (Giorgi *et al.*, 2001). The regional climate modelling approach relies on the GCM to reproduce the large- scale circulation of the atmosphere while the regional climate model is to simulate sub- GCM scale regional distributions or patterns of climate, such as temperature, precipitation, and winds, over the region of interest (Giorgi and Mearns, 1991; McGregor, 1997; Giorgi and Mearns, 1999). The GCM provides the initial and lateral boundary conditions for driving the regional climate model (RCM). In general, the spatial resolution of the regional model is on the order of tens of kilometers. whereas the GCM scale is an order of magnitude coarser.

The results from two RCMs, namely PRECIS & RegCM, have been reported in GCISC- RR- 06 (Siraj *et al.,* 2009) & GCISC- RR- 08 (Mehmood *et al*., 2009) respectively. The model simulations performed at GCISC cover whole of south Asia at a horizontal resolution of 50 km for A2 scenario. PRECIS was driven by input data of HadAM3P GCM, while RegCM was forced by two GCMs ECHAM5 & FvGCM.

Table 22 and 23 presents results for projected temperature and precipitation changes simulated by PRECIS and RegCM. Spatial patterns indicate a rise of about 3° to 6 °C over Pakistan for ECHAM5 & FvGCM. The rate of change is higher in ECHAM5 as compared to FvGCM for the century 2100. The projected temperature changes simulated by HadAM3P is around 6 °C over central and southern Punjab whereas this change is comparatively less at the coastal belt and ranges between 3- 4°. ECHAM5 predicted an increase in precipitation of about 5- 20% in northern region while decrease in precipitation of about 5- 50% in southern region. There is no significant change observed over monsoon belt in the Punjab region by the end of century. FVGCM, projected changes of precipitation indicate an increase of about 5- 15% over northern parts whereas a decrease of about 5- 40% over rest of the country. Increase in projected precipitation (about 5- 50%) by HadAM3P is observed over the country by 2100.

Figure 21:

Projected future changes in mean annual temperature (°C) and precipitation (%) over Pakistan under A2 scenario



Source: GCISC- RR- 07 & 08, 2009

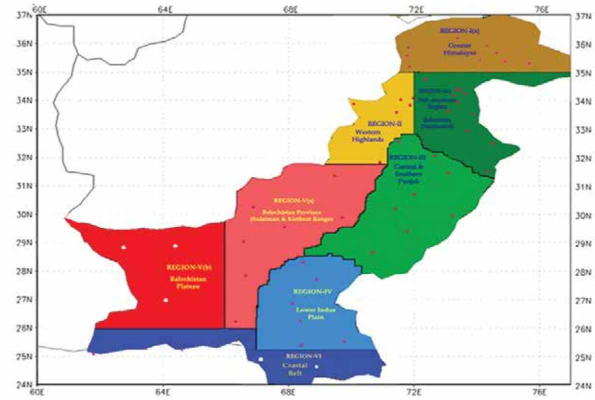
Disclaimer: Geographical boundaries shown above do not represent the official version of Pakistan and are taken from scientific resources

For impact assessments and policy makers, more precise analysis is performed & future projections of temperature and precipitation are worked out over various climatic zones (Figure 22) of Pakistan.

Projected temperature and precipitation changes simulated by PRECIS and RegCM for Pakistan and different climatic zones are documented in Table 22 & 23 respectively. Projected temperature changes by HadAM3P over 21st century indicates the high temperature rise over central and southern Punjab (5.42 °C) while a decrease in future projected precipitation is noted over this region. This contrasting result of temperature and precipitation projection is alarming for agriculture sector as this region of Pakistan is an important agriculture production zone. Temperature change over coastal belt of the country is less as compared to the other regions.

Figure 22:

Climatic zones of Pakistan



Source: GCISC- RR- 01, 2009

Disclaimer: Geographical boundaries shown above do not represent the official version of Pakistan and are taken from scientific resources

Table 24:

Projected temperature changes (°C) over Pakistan & climatic regions simulated by PRECIS & RegCM

PROJECTED TEMPERATURE ΔT (°C)				
Climatic Regions	PRECIS- HadAM3P (2080s)	RegCM- ECHAM5		RegCM- FVGCM (2080s)
		(2050s)	(2080s)	
Pakistan	4.77	2.00	4.83	4.08
I (a): Greater Himalayas (Winter dominated)	4.83	2.53	5.32	4.37
I (b): Sub- montane region and Monsoon dominated	4.77	2.37	4.68	3.88
II: Western Highlands	4.67	2.35	4.71	3.89
III: Central & Southern Punjab	5.42	2.34	4.80	4.20
IV: Lower Indus Plains	4.61	2.46	5.12	4.33
V (a): Balochistan Plateau (East)	4.78	2.42	4.85	4.25
V (b): Balochistan Plateau (West)	4.73	2.43	4.67	4.20
VI: Coastal Belt	3.91	2.12	4.44	3.48

Source: GCISC- RR- 07 & 08, 2009

The simulation of projected temperature of ECHAM5 and FvGCM indicates that ECHAM5 projects more warming than FvGCM over all regions. The high rise in temperature is projected over greater Himalaya zone, i.e. 5.32 °C by ECHAM5 by the end of 2100. Precipitation is increasing over all zones except zone III, as simulated by HadAM3P. In 2050s, ECHAM5 predicts an increase in precipitation over zone I (a), I (b), II & III whereas rest of regions have a decrease in precipitation. FvGCM predict the same pattern for 2080s.

country, is rain- fed. Water is a critical resource for its sustained economic progress. In order to fully utilize the river water resources, the IBIS has emerged as the largest irrigation system in the world.

Water availability for agriculture in indus basin

There are three main sources of water availability in the Indus Basin:

Table 25:

Projected precipitation changes (%) over Pakistan & climatic regions simulated by PRECIS & RegCM

PROJECTED PRECIPITATION ΔP (%)				
Climatic Regions	**PRECIS- HadAM3P (2080s)**	**RegCM- ECHAM5**		**RegCM- FVGCM (2080s)**
		(2050s)	**(2080s)**	
Pakistan	3.99	39.56	44.98	30.81
I (a): Greater Himalayas (Winter dominated)	15.75	7.46	12.59	7.97
I (b): Sub- montane region and Monsoon dominated	7.46	3.63	6.95	5.32
II: Western Highlands	8.33	1.20	-0.65	3.67
III: Central & Southern Punjab	-12.06	2.15	12.62	12.79
IV: Lower Indus Plains	1.12	-14.08	-41.63	-24.99
V (a) : Balochistan Plateau (East)	4.26	-4.69	7.10	-13.84
V (b): Balochistan Plateau(West)	24.59	-8.06	-12.86	-14.53
VI: Coastal Belt	12.09	-11.85	-31.62	-5.77

Source: GCISC- RR- 07 & 08, 2009

3.3 Key Sectors and Scope of the Vulnerability Assessment

3.3.1. Agriculture sector

The agriculture sector provides food security in the Indus basin, the bread basket of Pakistan. It accounts for 19.5% of the Gross Domestic Product (GDP) in addition to employing 42.3% of the labour force (Economic Survey of Pakistan 2016- 17). The irrigated area covers about 80% of the total under cultivation and fulfils 90% of the country's food and fiber requirements. The remaining cultivated land, the larger part of which is located in the Potohar plateau, northern mountains and north- eastern plains of the

a. Rivers

The average annual flow of Western Rivers of Indus Basin is approximately 142 million- acre feet (MAF). About 104 MAF of this water is diverted for irrigation purposes and about 35 MAF outflows to the Arabian Sea.

b. Rainwater

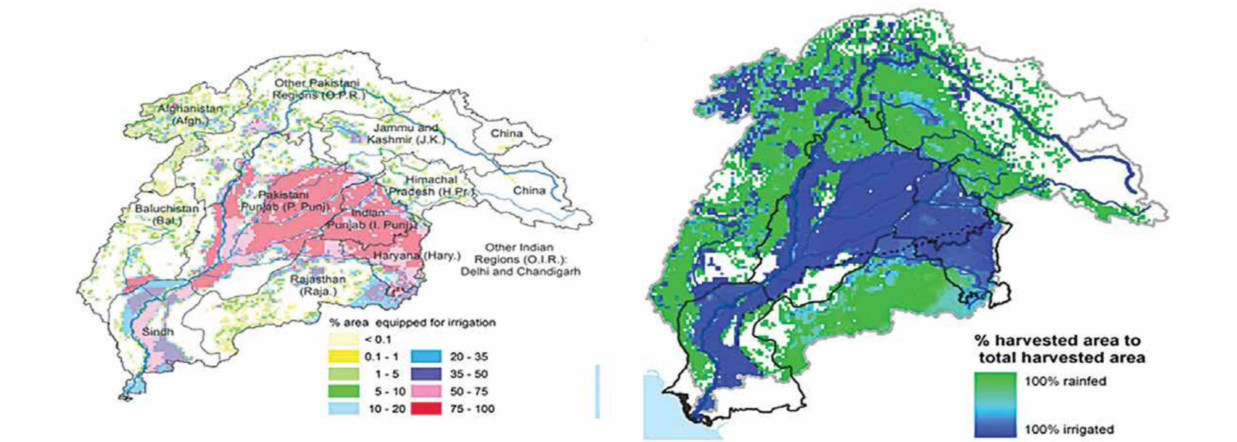
Another source of water is the rainfall. Irrigated areas of Indus Basin receive on average 40 MAF of water annually.

c. Groundwater

The third source of water is the groundwater. It fulfils approximately 40% of crop water requirements of the country.

Figure 23:

Agriculture within the Indus basin: (a) % of area equipped for irrigation (FAO- database, according to Siebert *et al.,* , 2005); (b) relative contribution (%) to total global harvested area by irrigated crops and rain fed crops, representation of MIRCA2000-



(a) (b)

Land- use in Pakistan

Out of a total geographical area of 79.3 million hectare (mha) of Pakistan, suitable area for agriculture is 31.2 mha. The area which is irrigated by all sources is 18mha and the total irrigated and Barani (rain dependent) area is 22.1 mha. However, the country has the capacity to bring 9.2 mha additional area under cultivation.

Rice, wheat, and maize are the main staple crops in this region, which require large amount of water and their production is highly vulnerable to changing climate (Chun *et al.,* 2016; Pros *et al.,* 2016). Water demand for irrigation is mostly fulfilled from rainfed and surface water reservoirs. Summer monsoon is the dominating climatological system in South Asia whereas snow- glacier melt is the main contributor to the river discharges in west originating from high mountains of Asia (Lutz *et al.,* 2014). These two water system plays a major role in the region in regulating the hydro- ecological systems during the warm and dry periods of the year (Bajracharya *et al.,* 2015; Moors & Stoffel, 2013). Any changes in the monsoon onset or melt water cycle will cause serious threats for food production in the region (Nibanupudi and Rawat, 2012). Agriculture is the main water consumer globally utilizing 70% of the total freshwater human demand where rainfed and irrigated agriculture are two major components with 40% and 60% contribution in total food production respectively (Boulay *et al.,* 2015; Portmann, Siebert & Döll 2010; Wada *et al.,* 2013). In South Asia, agriculture consumes 91% of its total available freshwater (Mukherji *et al.,* 2015; World Bank, 2013) with about 40% cropped area under irrigation whereas 60% dependent upon rains (Wani, Rockström & Oweis, 2009). Agriculture production is highly sensitive to water availability, environmental and climatic conditions. Uncertain climate patterns combined with other socio- economic challenges in the last decades have significantly affected the livelihoods of the people living in this region. Particularly rising temperatures, changing pattern of precipitation (timing and quantity), temperature extremes and shifts in monsoon cycle are unequivocal and already have significant impacts on hydrological and agricultural processes in the Himalayas (Gain *et al.,* 2011; Hijioka *et al.,* 2014; Immerzeel *et al.,* 2012; Rasul & Sharma, 2015).

Various studies have been conducted at global, regional and country level to assess the impacts of varying climate on water and food production under increased food demands. The effects of climate change on crop and terrestrial food production are evident in several regions of the world (Porter *et al.,* 2014). There are reports of more negative impacts of climate on agriculture yield particularly in the arid and semi- arid regions of South Asia (Field *et al.,* 2012; Shakoor*et al.,* 2015). Whereas, in some middle to high latitude areas, positive impacts of climate change on agriculture production has been observed (Hussain & Mudasser, 2007). The adaptations to climate change will reportedly bring more positive effects on the crops yield in South Asian countries in future but crops yield could reduce up to 30% if ongoing water and farm practices remain same.

Dwindling water situations, declining water quality and uncertain climatic changes call for improved efficiency and productivity of crop water use in response to the increasing food demand of the growing world population (Steduto *et al.,* 2012). To address issues of water scarcity and food security as affected by environment and management, various kinds of hydrological and crop simulation models have been developed in last few decades (Vanuytrecht *et al.,* 2014). Since, climate change is the main driver causing risks and uncertainties to the agriculture production, downscaled information form climate models in the form of future climate projections are fed into process based crop water simulation models to assess the impacts of changing climate on crop yield (Angulo *et al.,* 2013; Supit *et al.,* 2012). Coarse spatial resolution (200 to 300 km) of GCMs hinders the accurate evaluation of field scale assessments, therefore, different downscaling methods must be applied in order to produce detailed climate scenarios information's as input for impact models.

Food production system- risk from climate change

Recent climate modeling studies indicate that among subcontinent river basins, Indus and Brahmaputra are the most vulnerable due to which approximately 60 million inhabitants will be at food security risk by mid twenty first century. This situation will get worse with the rising impact of climate change, growing population pressures and increasing demands for irrigated agriculture that rely largely on glacial melt from Himalayan river basins (Immerzeel, Beek & Bierkens, 2010). IPCC report also confirmed that global warming effects have become more pronounced with more occurrences of temperature extremes, being felt at country-wide scale in most parts of South Asia in the 20th century and into the 2000s. Similarly, rainfall was also reported as highly variable with both increasing and decreasing trends and with more extreme rainfall and less week events in most of the sub regions of Asia.

Global food demand is projected to double by 2050 as compared to 2005 under a rapidly increasing world population with changing food-dietary habits (Chen *et al.,* 2016; de Fraiture, Molden, & Wichelns, 2010). This water and food supply is even more uncertain in Asia where warming patterns are higher than the global average with erratic and uneven precipitation trends. Sizeable change in climate pattern affects the water availability in upstream areas in Indus catchment with considerable effects on food security in downstream areas (Walter *et al.,* 2010). Considering the past hydro- climatic trends and raising water and food demands, political and scientific community attention has already turned towards the question whether sufficient water will be available in future to produce adequate amount of food (Biemans *et al.,* 2013; Moors & Stoffel, 2013). Under warm climatic conditions, inefficient irrigation efficiencies (less than 30% in South Asia) along with poor farm water management practices (Jägermeyr *et al.,* 2016), 30- 50% of water supplied for irrigation is lost in application and conveyance globally reducing water use productivity and consequently affecting crop yield (H. Biemans *et al.,* 2013; Fereres & Soriano, 2007; Jägermeyr *et al.,* 2015; Rohwer, Gerten, & Lucht, 2007). Similarly, a large part of water extracted for industrial, domestic and other purposes is not used efficiently, which is also causing threats to water security. To ensure future food production and to provide sustainable livelihood to two billion people in Asia by 2050 (H Biemans *et al.,* 2013; Carabine *et al.,* 2013; Hijioka *et al.,* 2014) adaptations to climate change are essential (Birkmann & Mechler 2015; Jägermeyr *et al.,* 2015).

Past trends in climatic variability and more erratic weather and climate patterns (floods and droughts) have influenced the surface water reservoirs. Less surface water availability in the rivers resulted in more groundwater extraction practices in several parts of the world, particularly in arid and semi- arid regions of Asia (Simons, Bastiaanssen, & Immerzeel, 2015; Wada, 2014). Large portion of the water withdrawal from ground reservoirs is supplied to agriculture sector globally to nurture the irrigation and food water demand. This intensified water abstraction, depleting the groundwater reservoirs more rapidly in most countries of Asia (i.e. Pakistan, India) and also in several other parts of the world which caused lowering of the water table (Habib, Anwer, & Hassan, 2015; Taylor, 2013; Tiwari, Wahr & Swenson, 2009). The complexity of risks posed by climate change and possible adaptations for crop production has called for integrated assessment and modelling (IAM) approaches linking biophysical and economic models (Ewert *et al.,* 2015). Integrated adaptation approaches to climate change at farm level and technological advancement at national and subnational levels are therefore important to reduce the negative impact of these challenges on water availability and food production, particularly during critical crop growth stages and specifically in temperate regions.

Modelling approach- Skills and resolution limitations

Various hydrological and crop models have been developed to assess the current and future vulnerabilities to water resources and food production under the increasing concern of climate change. Temperature and precipitation are two main drivers of these models to produce water and food projections. Owing to availability of sparse and sporadic observation data in mountains, climate models' output (regional or global) is often used to generate likely changes in the climatic variables, which are further used in crop and water models for simulating river flows and crop yields. For better future assessments, it is important to identify the climate prone sectors using higher spatial and temporal scale information to avoid heterogeneity in changes and uncertainties.

Uncertainties are also associated with the scale resolution used for assessing changes, i.e. uncertainties are higher at a large spatial scale (regional to global scale) whereas lower at small grid to basin scale (Liu *et al.,* 2013). Time specific basin scale assessments using high resolution hydro- climate data support scientists to understand the spatio- temporal response of water and food production under changing climate. These assessments help decision-makers and scientific community in identification of the appropriate adaptive measures for devising and implementation of future strategies.

Global Climate Models (GCM) are the basic tools frequently used to reproduce present climate as well as to generate future projections at global and regional scale (Jeong, St- Hilaire, Ouarda & Gachon, 2013; Sen, 2009). However, reliability of these projections depends on the ability of the models used to link all atmospheric and bio-physical processes (Hasson, Pascale, Lucarini & Böhner, 2015). Though large improvements have been made in recent Coupled Model Inter-Comparison Project Phase 5 (CMIP5) models compared to CMIP3 in terms of processes representation (Sperber *et al.,* 2012), the realistic representation of hydrological processes in global climate models is still a challenge because of the structural and computation limitations of these models,. More detailed and accurate water maps are often required by end users for future water planning (Eden & Widmann, 2014; Tebaldi & Knutti, 2007). However, large uncertainties in current and future water availability is projected by different global and regional hydrological models for different parts of the world depending on the use of GCMs and climate scenarios selection (Wada *et al.,* 2013). This uncertainty is even larger in the complex mountainous region of Asia (Hussain & Mudasser, 2007) where monsoon dynamics play an important role (Biemans *et al.,* 2009; D'Amato *et al.,* 2015; Lutz *et al.,* 2016). Selection of appropriate GCMs over complex topography and harsh environment of Hindu Kush Himalayan (HKH) region is quite challenging (Hasson *et al.,* 2015). Coarser resolution of GCMs produces less accurate results for capturing monsoon precipitation and discharge simulations based on temperatures and snow, and ice melting processes (Mathison *et al.,* 2015). Whereas, RCMs perform better as compared to GCMs (Akhtar, Ahmad & Booij 2008; Hassan *et al.,* 2015). For crop specific seasonal and farm level assessments, more detailed hydro- climatic information is essential. For this, different downscaling approaches (dynamical and statistical) have been used worldwide to bridge the gap between global climatic parameters and point level hydrological processes (Jeong *et al.,* 2013).

Crop Models- Development

The inherent sensitivity of agricultural production systems to climate change and extreme weather events make them highly vulnerable (Parry & Carter 1989; Reilly & Schimmelpfennig, 2000). Crop simulation models have been improved in structure and function to be able to address impact of climate change on crop growth, yield, crop water requirement and other management aspects. WOFOST model has undergone progressive application- based improvements in different versions since the time it was developed. Decision Support System for Agro- technology Transfer (DSSAT) (Jones *et al.,* 2003) is a processed base crop simulation model for over 42 crops (as of Version 4.6). The DSSAT model predicts yield as well as resource dynamics of agriculture production systems including water, carbon, nitrogen, also incorporates application for programmes for seasonal, spatial, sequence, crop rotation analyses and farm scale to regional scale assessments of climate variability and climate change (Hoogenboom *et al.,* 2015). The Agricultural Production Systems Simulator (APSIM) simulates biophysical process and economic impact assessment in response to climate risks and vulnerabilities (Kandulu *et al.,* 2012; Yu, Wang & Smith, 2008) APSIM modules simulate water balance (Ren, Sun, & Wang, 2016), Nitrogen (Chao *et al.,* 2016) and P transformations, soil pH, erosion and a wide range of management sub modules. Aqua Crop is a crop water productivity model developed by the Land and Water Division of Food and Agriculture Organization (FAO). The main outputs of AquaCrop are the yield and water use (Evaporation and transpiration) (Pasquale Steduto, Hsiao, Raes, & Fereres, 2009). Requires small number of input variables and relative few conservative crop parameters (Vanuytrecht *et al.,* 2014), uses canopy cover instead of leaf area index to define crop growth and development (Nielsen, Miceli- Garcia & Lyon, 2012).

Four kinds of uncertainties involved in modelling approaches are: natural uncertainties, data uncertainties, model parameter uncertainties, and model structure uncertainties (Pechlivanidis *et al.,* 2011). Continued efforts have been made to advance watershed modeling techniques keeping in view the climatic and socio- economic demands. Despite recent improvements in our ability to model climate dynamics with complex large- scale climate models, we still lack local to basin scale evaluation of complex bio-atmospheric processes.

Indo- Gangetic Plain (IGP) blessed by fertile alluvial soils, favourable climatic conditions and bounteous water sources acts as a bread basket for larger parts of Pakistan, India, Bangladesh and Nepal (Aggarwal *et al.,* 2004). Food & Agriculture Organization (2004) estimations reveal a reduction in cereal production of nearly 22Mt by 2030. A wide range of local and regional impact studies have assessed the effects of changes in climate and CO_2 on future crop productivity (Ewert *et al.,* 2015). IPCC studies confirm that rainfed agriculture of semiarid regions is likely to suffer from climate change both positively and negatively (Ratnakumar *et al.,* 2011). In the northern mountainous areas of Swat and Chitral districts of Pakistan, DSSAT model results indicate mixed scenarios (Hussain & Mudasser 2007). Future temperature increases of 1.5 °C and 3 °C would result in wheat yield reductions (by 7% and 24% respectively) whereas in Swat, contrasting results were observed, i.e. increases (by 14% and 23%) in Chitral district.

The IGP of south Asia showed large reduction in wheat yields projections, unless suitable management practices and varieties are adopted (Ortiz *et al.,* 2008). A methodological review and meta- analysis of data in 52 original publications revealed average changes in cereal production in South Asia of 16% for maize, 11% for sorghum by the year 2050s (Knox *et al.,* 2012), whereas no significant change has been observed for rice.

Climate change may prove beneficial for wheat farmers in parts of Pakistan. Warming temperatures may likely to allow at least two crops (wheat and maize) in a single year in hilly areas (Hussain & Mudasser, 2007). In the northern mountainous region of Pakistan, wheat yield was projected to increase by 50% with SRES A2 and by 40% with the B2 scenario, while in the sub- mountainous, semiarid, and arid areas, it is expected to decline by the 2080s (Iqbal & Arif, 2010).

An analysis with coupled hydrology and crop simulation model, i.e. LPJmL, over five south Asian river basins, namely (Indus, Ganges, Brahmaputra, Godavari and Krishna) with or without adaptation options, i.e. irrigation efficiency and reservoir storage capacity resulted in water shortage scenario in Indus and Ganges where reservoir storage capacity was not improved, positive results of increasing irrigation efficiency were observed for all the basins, moreover combination of both the strategies seems to be the best option (Biemans *et al.,* 2013).

Performance of two crop simulation models DSSAT and ATPSIM over Pakistan resulted in a mean reduction of 15.2 and 17.2% in rice yield by DSSAT and APSIM respectively. In wheat, mean yield reduction was 14.0% in DSSAT and 13.76% in APSIM. With the use of existing production technology there would be about 69-83% of farms projected as vulnerable to climate change with a poverty rate ranging between 33 and 38% (Hoogenboom *et al.,* 2015).

(Immerzeel *et al.,* 2010) assessed river flows of the Indus basin which is the largest irrigation system in the world. Upstream water reservoirs in Indus catchment are mainly fed by snow glacier melt and change in melted water supply and timing due to climate change could affect the whole irrigation system downstream. This change will have serious implications for food security in the region and could affect the livelihood of 60 million people in the region by reducing crops yield.

Water availability for crops will vary widely from- 12% to +24% in future under different climate change scenarios whereas crop yield and production impacts are negative across all scenarios, and net food imports will increase by 2050 (Zhu *et al.,* 2013).

Crop- water simulation models have undergone considerable improvements and progress in modelling climate change impacts on water resources and crops, but that progress contributed to a greater extent to the improved responsiveness of crop models to climate change factors. This also includes efforts to improve model representation of the extreme weather events. However, many other aspects related to climate uncertainties and risk management are less understood. Although shortcomings in the current methodology and tools for assessing climate change impacts on food and water security are identified and well described. These shortcomings mainly originate because of two reasons, firstly due to the lack of consideration and interest in the use of integrated assessment modelling approaches by incorporating several environmental and socio- economic dimensions and secondly due to limitation of inappropriate spatial scales of both the climate models and impact models.

In fact, there is a need to improve climate models by scaling them down to field scale resolutions so that their skills in realistically simulating impact of climate change on crop biophysical processes at field scale can be improved with efficiency. Similarly, impact models require to be scaled up from plot or field scale to regional and global scales. Crop models are often developed at the field scale. These models are calibrated using high resolution input data of climate, soil and management, etc. The upscaling of dynamic and process- based crop models from field scale to regional scale is achieved spatially, by aggregating soil and climate conditions in areas where these conditions are homogenous. Such spatial aggregation effects give rise to uncertainties in crop model responses. Quantification of uncertainties including weather, soil, and management inputs as well as model parameters is important to understand for scaling up regional assessments. Substantial progress is needed in different areas to address these limitations and a strong scientific coordination among climate and impact modelling community is desired that demands feedback mechanisms and promotion of interdisciplinary approaches.

3.3.2 Water Resource sector.

Key vulnerabilities of water resources to climate change and government response

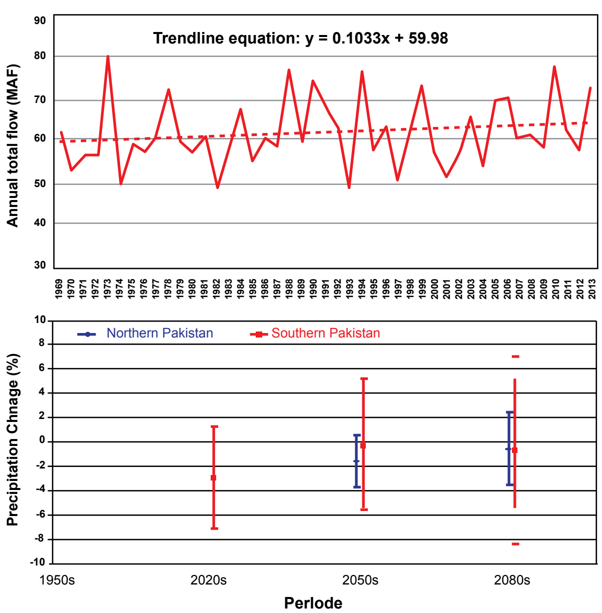
Like many other developing countries in the region, Pakistan's long- term water availability rest on continued flow from the rivers of the Indus Basin originating from the Hindukush-Karakoram- Himalayas region. It is indeed very difficult so far to reliably predict future changes in weather patterns at regional level or to assess the real impact of climate change on water resources. However, geographical location of Pakistan locates the country in heat surplus zone on the earth making it very high on vulnerability scale in terms of impacts of weather changes. Following are the key vulnerabilities of Pakistan related to its water resources.

Increased variability in river flows

In Pakistan, where inter- annual variation in precipitation is already very high, variability of river flows will further increase due to increase in the variability of monsoon and winter rains and decrease of natural reservoirs in the form of glaciers and perennial snow. According to IPCC's Fifth Assessment Report (2013), with the increase in temperature, the increase in frequency and intensity of extreme events is "very likely", i.e. 90% confidence. Data shows increased variability of Indus river flows upstream of Tarbela dam (i.e. before entering into the distribution network) whereas data presents future precipitation projections over Pakistan using 17 GCMs ensemble which shows that uncertainties are too large to reach a single conclusion.

Figure 24:

Pre- and Post- 1990 variability (standard deviation) of Indus River flows at Besham Qila



Source: Global Climate Change Impact Study Center, 2016

Glacier's retreat in the HKH

Glacier melting is a global concern and changes in glaciers are being determined in mountain ranges of all continents, but still there are multiple regions where one can find limited or only local information. The HKH region of upper Indus basin is one among many examples, which has an extensive formation of glaciers due to its high altitudes. The glaciers located in this region are an important source of freshwater for China, Pakistan, Nepal, and India. This region has been a subject of much controversy because it is less studied due to its inaccessibility, complex topography, rugged terrain and harsh environment. The 5th Assessment Report of Working Group- I of IPCC states that glaciers have continued to shrink worldwide.

Out of 15,000 glaciers in HKH region, a few have been studied with conflicting findings. Dirk Scherler, (2011) says that out of 42 studied glaciers in Karakoram region, 58% advancing/ stable and 42% retreating is in contrast to worldwide decline of mountain glaciers. A number of other scientists, including Hewitt (2011), Bishop (2008) and Copland (2011) report this region with stable/ slightly advancing glaciers. Still there are some other studies which denote melting of glaciers. Inman (2010) reports that according to a 2006 review by Cogley and others, the Himalayan glaciers are losing mass faster than European glaciers but slower than those in Alaska.

Since most of the Indus river streamflow originates mainly from the Karakoram glaciers (snow and glacier melt contribute up to 70- 80% to Indus River System flows), it is important to understand the temporal behaviour of these glaciers. Recently, a number of research studies have reported widespread evidence of glacier expansion in the Central Karakoram, in contrast to a worldwide decline of mountain glaciers, the so- called "Karakoram anomaly". The possible cause for the "Karakoram Anomaly" could be the debris cover, which generally characterizes the Karakoram glaciers and can exert significant influence on glacier terminus dynamics. Another factor could be the different weather regime of Karakoram and Hindu Kush- Himalayas: the former region is directly affected by westerly weather pattern (with a peak of precipitation in spring- winter) while the latter is more directly impacted by the South Asian monsoon system. A latest study based on state- of- the- art modeling methodologies concluded:

> "In combination with a positive change in precipitation, water availability during this century is not likely to decline. The river basins that depend on monsoon rains and glacier melt will continue to sustain the increasing water demands expected in these areas." (Immerzeel *et al.,* 2013).

The changes in Indus River System (IRS) flows are linked with the likely response of the Karakoram glaciers. Some modeling studies were conducted by the Global Change Impact Studies Centre (GCISC) wherein a hypothetical climate change scenario (CCS) implying 3 ^{0}C temperature rise over the average current temperature and 50% reduction in glacier area was used to assess any changes in the Indus River flows. The results revealed (Figure 25) that the peak flows in the Indus Rivers occurring in July and August each year will shift to May and June, disturbing the century's old pattern of agricultural cropping during summer. Also, there will be an overall 15% reduction in annual flows. So far there is no reliable evidence of any increase or decrease in the average annual river flows of the Indus River System.

Glacial Lake Outburst Floods (GLOFs)

As the glaciers are reported to be retreating worldwide and in particular are retreating on faster rate in the HKH region, GLOFs phenomena could increase with rapid melting of glaciers in the region. International Centre for Integrated Mountain Development (ICIMOD) previously reported that there are 2420 glacial lakes in Pakistan, which have now increased to 3,044 as studied by Pakistan Meteorological Department (PMD) recently. These potentially dangerous lakes can burst anytime and cause flash floods and are a continuous risk to the downstream livelihood. Climate change projections developed by GCISC indicate that the rate of change of temperature in northern parts of Pakistan is higher than that of the southern parts. Higher rate of increase of temperature and formation of glacial lakes in the vicinity of glaciers are the strong evidences of melting of glaciers at lower altitudes.

Floods & droughts

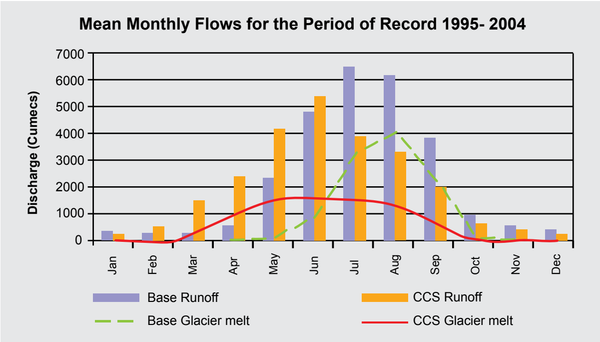
The most prominent aspect of climate change in Pakistan resulting from an increase in average global temperature is an increase in frequency and intensity of extreme climate events such as floods, draughts, cyclonic activities, extreme precipitation events, etc. as reported by IPCC in its latest assessments. The larger the temperature increase, the higher is the increases in frequency and intensity of such events.

The extreme events (floods, droughts, cyclonic storms, etc.) resulting from climate change have immense adverse impact on the human lives as well as the environment. For example, the super flood experienced by Pakistan in 2010 resulted in about 2000 deaths, over 20 million people affected several million hectares of agricultural land devastated, large- scale disruption of road and railways, communication network, etc., with the overall financial damages to the tune of USD 10 billion.

There has been, in general, an increasing trend in the occurrences of various extreme events in Pakistan over the past two decades, as one would have expected on the basis of an increase

Figure 25:

Changes in Indus river flows as affected by hypothetical climate change scenario of 3 ^{0}C temperature rise in average temperature of upper Indus basin region and 50% reduction in glacier area



Source: Arshad M. Khan Global Change Impact Studies Centre. Regional Conference on Climate Change: Challenges and Opportunities for South Asia Islamabad, 13- 14 January 2009

in average temperature of the country during that period. For example, following the hugely devastating flood of 2010, Pakistan experienced back to back floods every year during 2011-2015. There is thus a strong likelihood that with increased global warming in the coming decades, the incidences of such extreme events will increase further.

The frequency and intensity of extreme climate events leading to droughts are expected to increase with increased global warming. Pakistan is an arid country receiving low rainfall and higher solar radiation over most part of the country. About 59% of the total area receives less than 200mm of rainfall annually. Pakistan has experienced serious drought situation from 1998- 2002 facing adverse freshwater dearth. It was triggered by the history's strongest El- Nino event which not only disrupted the weather patterns of Pakistan but all over the globe. Balochistan, Sindh and southern Punjab were the worst hit area where thousands of animals died, thousands acre orchards dried, and a large proportion of population migrated to neighbouring regions for survival. Large-scale migration put a huge pressure on natural resources of less affected areas creating shortage of commodities. Lesson should be learnt from this event and a contingency plan to cope with such a situation is the call of the moment.

Sedimentation and loss of reservoir capacity

Situated in arid and semi- arid zone, Pakistan is suffering seriously with the soil erosion problems. This erosion, caused by glacier/ ice melt and decrease in natural vegetation due to deforestation and improper land usage, deposits heavy sediments in the dams and reservoirs downstream.

The Indus River and its tributaries transport considerable amount (≅ 200 M tonnes/ year) of sediment from their upper mountain catchments, causing silting in the major reservoirs located at Tarbela, Mangla and Chashma, which is expected to increase due to high intensity rains and rapid melting of glaciers under extreme climatic conditions.

Low water storage capacity

Pakistan's water storage capacity comprises three large reservoirs (Mangla, Chashma, and Tarbela). They were built in the years 1967, 1971 and 1974 with original capacities of 5.88 MAF, 0.87 MAF and 11.63 MAF respectively (total original capacity: 18.37 MAF). Owing to silting, the capacities of all the three reservoirs have been decreasing with the passage of time. The total capacity decreased to 13.68 MAF in 2003 and is projected to decrease to 12.34 MAF by 2010. The present reservoir capacity (live storage) corresponds to only 9% of the IRS average annual flow (142 MAF) and is low when compared with the corresponding figures for the world average (40%), India (33%), Nile river basin (347%) and Colorado river basin (497%) (Planning Commission, 2005). Furthermore, the water storage capacity per inhabitant in Pakistan is only 150 cubic meters which is very low as compared to 2,200 cubic meters in China and 5,000 cubic meters in the US and Australia (World Bank, 2006).

In view of the above, there is urgent need for considerable expansion in reservoir capacity (a) to take care of the increasing frequency and intensity of floods and droughts, (b) to take advantage of the greater water flows over the next two to three decades due to glacier melting as well as to address the expected decreases of flows in the subsequent years after the glaciers have largely melted, (c) to provide regulated minimum environmental flows to the sea to prevent excessive intrusion of sea water into Indus deltaic 19 region, (d) to take care of the loss in reservoir capacity due to silting, and (e) to meet future increases in water demand. [Even without specific consideration of the climate change related impacts, the Planning Commission (2007) envisages that without additional storage, the water shortfall will increase by 12% over the next decade alone].

Water Logging and salinity

Several areas of Pakistan particularly the Punjab and Sindh will suffer the most from water logging and salinity because of poor drainage system. Salts carried in surface water and mobilized through unregulated groundwater pumping accumulate in the root zone, adversely affecting crops and agriculture productivity. According to the Drainage Master Plan (DMP), 39% of gross commanded area in the country is water logged and is affected by salinity,12% of which has a water table depth up to 150 cm (5 ft) while other 27% of surface soil is saline (4% moderately saline, 7% severally and 6% sodic). The experts are of the opinion that due to salinity problem 25% agriculture productivity is reduced in the Punjab only. This salinity problem may be increased due to increased evaporation under higher projected temperature.

Groundwater depletion

According to IPCC Technical Paper on Climate Change and Water, "Groundwater levels of many aquifers around the world show a decreasing trend during the last few decades, but this is due to excessive groundwater pumping and not to climate- related decrease in groundwater recharge".

About 50- 60 MAF of groundwater is being exploited through over 600,000 private and about 16,000 public tube wells in Pakistan.

Sea level rise and degradation of coastal areas

According to IPCC 5th Assessment Report, the greatest increase in vulnerability is expected to lie on the coastal strips of South and South East Asia. In Pakistan, there is a 1050- km long coastline spread along the provinces of Sindh and Balochistan. In Sindh province, mangroves are found in the Indus Delta and have an area of about 600,000 ha. In Balochistan province, the mangroves' total area is estimated to be 7,340 ha. These mangroves provide food and shelter during larval stage of the life cycle for some 80% of the commercial species caught from water. Indus delta Mangroves are the largest arid climate mangroves in the world on an area of 345,000 ha.

Currently, the Indus Delta faces major threats due to inadequate fresh waterflows in deltaic region. The increased variability in the river flows due to extreme climatic events expected under climate change will further aggravate the situation. Another major threat is the sea level rise, which could significantly contribute to losses of coastal wetlands and mangroves by increasing salinity in the coastal areas. According to National Institute of Oceanography, Pakistan, the sea level at Pakistan's coastline shows an increasing trend of 1.1 mm/ year, i.e. within global average range of 1.7±0.5 mm/ year for the 20th Century (IPCC, 2007).

Shrinking wetlands

There is a broad and growing consensus that wetlands are critically important ecosystems that provide significant social, economic and environmental benefits globally. In Pakistan, 19 sites are declared as of international importance covering an area of almost 1,343,627 hectares (Ramsar Convention on Wetlands) and are under threat due to the projected changes in climate. Predictions of a warmer climate and changes in precipitation patterns would strongly affect wetland ecological functions through changes in hydrology, biogeochemistry, and biomass accumulation. According to the IPCC 5th Assessment Report, Species' ranges are likely to shrink by 2050. About one fifth to one third of the species may face extinction by that time with those risks increasing for the second half of the century.

Pakistan had produced a Wetlands Action Plan in 2000. The lack of a comprehensive Wetlands Management Strategy hindered policy formation, coordination and management of wetlands at a national scale. Additionally, options for financial sustainability had not been fully explored to enable the proliferation of long- term initiatives in biodiversity conservation.

Increasing water demand

Water demand will increase for all sectors due to population growth, and higher rate of evaporation projected under increased atmospheric temperatures. According to IPCC, higher temperature and increased variability of precipitation would lead to an increased irrigation water demand, even if the total precipitation during growing season remains the same. In Pakistan, where more than 95% freshwater is utilized for agriculture, the water demand for agriculture growth is already increasing and a considerable rise in this trend is expected under projected warming.

Ongoing programmes, actions undertaken or planned

Being cognizant of the fact that the climate change is there, and the country is not eluded from it, the following major steps have been taken by the Government of Pakistan to cope with the negative Impact of climate change on the country's water resources.

1. Establishment of the 'Global Change Impact Studies Centre

   To address various climate change issues, e.g. past and likely future climatic changes in various parts of Pakistan, to see impacts on various socio- economic sectors, and provide strategies to cope with negative impacts, a dedicated research Centre, namely Global Change Impact Studies Centre (GCISC) was established in 2002 which was granted the status of a regular national entity in March 2013 after parliament passed GCISC Act 2013.

2. Establishment of Task Force on Climate Change

   A 'Task Force on Climate Change' was established at national level by the Planning Commission of Pakistan in 2008. Which published its 'Final Report' in 2010. This report served as a seminal document for preparing the National Climate Change Policy (NCCP) and subsequent other related documents.

3. Establishment of Glacier Monitoring Research Center (GMRC) under WAPDA (for detailed initiatives regarding climate change, see Annexure- C)

3.3.2 Coastal Management

Observed and projected changes in climate show a consistent increase of mean annual air temperature and declining trend in annual total precipitation. Variability in temperature, frequency of extreme events, and sea surface temperature, which is ranked high in the study area, show abrupt changes in exposure indicators, therefore, should be categorized as moderate to highly sensitive and vulnerable. This situation renders negative impact on ecosystem functions, fish biodiversity and local livelihoods. Though the scores of all sensitivity indicators for the Keti- Bandar fall in the category of extremely sensitive and vulnerable, they may contribute to the community's sensitivity towards climate change. Notably, the inadequate and non- regulated release of freshwater flows from the Indus river impacting agriculture and fisheries production, reflects a very high impact on the economy of community, which is largely dependent on fisheries.

In terms of coping potential, the consumption patterns, income diversification, dependency ratio, schooling or education level, and infrastructure (access to basic facilities) are the indicators which reflect low adaptive capacity/ very high vulnerability among the community of Keti- Bandar. There are many reasons behind these circumstances, but low or nearly insignificant literacy rate and low diversified and intervallic sources of income are the most significant reasons behind low adaptive capacity.

Migrations in Keti- Bandar were recorded high, depicting high adaptive capacity of the community owing to the reasons that people were capable enough to migrate at the times of natural disasters to seek shelter and job opportunities while away from their villages.

The potential impacts that resulted from exposure and sensitivity indicators include devastation of mangroves, unavailability and low access to fuel wood, extinction of mangrove species due to increased salinity level, degradation of agricultural lands due to sea water intrusion, decrease in freshwater flows, decreased access to clean drinking water and absence of sanitation facilities, and increased frequency, intensity of climatic disasters and rising socio- economic costs associated with them.

3.3.3 Forest and Natural Ecosystem

Pakistan has made significant strides in improving the vegetative cover and increase the forest area. Besides annual afforestation campaigns, the two major programmes, viz Green Pakistan Programme and Billion Tree Tsunami are of significant importance under which a sizeable forest area is anticipated to increase.

Further, Pakistan is pursuing efforts for REDD+. One such effort is the approval of Forest Carbon Partnership Facility's REDD+ Readiness grant. Pakistan was amongst eight countries that won the grant after competing in the 16th meeting of PC. The grant agreement between FCPF and Government of Pakistan was signed on June 12, 2015, and since then, the Readiness Preparation Activities are being carried out by the Ministry of Climate Change. Under the FCPF grant, the REDD+ Readiness Preparation Activities are broadly categorized into four components. These include REDD+ Policy Analysis, REDD+ Technical Preparation, REDD+ Readiness Management, and Designing and Testing of REDD+ Payment for Environmental Services. These activities are envisaged to be completed by June, 2018. The uniqueness of this project output is that deliverables would make Pakistan compliant to the UNFCCC decisions in particular the Cancun Agreement on REDD+ and Article 5 of the Paris Agreement.

3.3.4 Public Health Sector

The climate change and extreme weather events are significant threats to the global health. Exposure to such climate hazards affects different people and communities to different degrees. Human health is profoundly affected by weather and climate. For example, diseases such as malaria, diarrhea, and the health impacts of malnutrition are highly sensitive to climate conditions, but they are also strongly affected by poverty, and the effectiveness of health and other social protection systems. Air pollution is now one of the largest global health risks, causing approximately seven million deaths every year. There is an important opportunity to promote policies that not only protect the climate at global level, but also have large and immediate health benefits at local level.

The largest health risks are observed, and will continue to occur, in populations that are most affected by climate- sensitive diseases, such as vector- borne and waterborne diseases, and in those that are deprived of economic development (Smith *et al.,* 2014). Both climatic and non- climatic factors have played a significant role in epidemics and the control of vector-borne diseases, but the net effects depend on socioeconomic development and the capacity of the health system to control vectors and provide timely diagnosis, management and effective treatment of affected individuals (Dhimal, 2017). Without considerable efforts made to improve climate resilience, it has been estimated that the global risk of hunger and malnutrition could increase by up to 20% by 2050 (World Food Programme, 2015).

3.3.5 Climate Change and Health of Pakistan

The potential health impacts of climate change in Pakistan include vector- borne, waterborne, airborne and foodborne diseases, nutrition-related diseases, injuries and mental illnesses. There is an emerging evidence that climate change plays a key role in the propagation of majority of the diseases indicating that it has altered the spatial distribution of some vector borne diseases like, malaria, dengue, chikungunya, etc. Climate change has also altered the seasonal distribution of some allergenic pollen species and increased heat wave related deaths and Non- Communicable Diseases along with injuries and mental health issues, constitute major part of the health impacts, causing far more disabilities and premature deaths.

Health system of Pakistan

There is a significant deployment of health care personnel in public sector over the past years. Currently the public health care system comprises of 1167 hospitals, 5695 dispensaries, 5464 basic health units, 675 rural health centers, 733 mother and child health centers and allied medical professionals i.e. doctors, nurses, midwives and pharmacists. As of year, 2016, there are 184,711 doctors, 16652 dentists and availability of 118,869 hospital beds in the country. The ratio of one doctor per 1038 persons, one hospital bed for 1613 persons and one dentist for 11,513 persons shows clear inadequacies (Ministry of Finance, 2016). The government hospitals provide most of the medical services free of cost. At certain places, medicines are also provided free of charges. The new vision for health outlined in the government's national health policy provides guidelines for the provision of better services in 2010. One of the promising initiative is the Lady Health Worker (LHW) community based programme, which provides some basic health care and family planning services to women at their doorsteps. That's why skilled birth attendance has improved from 18% in the late 1990s to 58% in 2015.

The life expectancy has increased from 59 years by 1990 to 67 years by 2015. The last maternal mortality ratio recorded was 276 per 100,000 live births (2006- 07), but it has improved significantly owing to wide outreach of national LHW programme, and better skilled birth attendance availability. Similarly, infant and under 5 mortality rates have improved (from 72/ 1000 to 66/ 1000 live births); but neonatal mortality rate remained stagnant; and so has the rising toll of stillbirths, i.e. 43/ 1000.

However, the improvements are not prominent due to several reasons., One of the major reasons is the rapid increase in population leading to urbanization. Other factors, arising from climate change are the abundance of vector- borne diseases which cause millions of deaths. The estimated projected population at risk to malaria annually is about 46 million towards 2070 under a high emissions scenario. But, if the global emissions decrease rapidly, the population at risk could be limited to about 12 million annually by 2070 (Rocklöv, J., Quam, M. *et al.,* 2015). Thus, the population growth can cause increases in the population at- risk in areas where the presence of vector- borne diseases is static in the future.

Among children, diarrhea and respiratory problems remain the major killers and their risk of incidence is expected to increase in Pakistan due to climate change. In the baseline year of 2008, an estimated 94,700 children under 15 had died due to diarrhea. Under high emissions scenario, such deaths, which are attributed to climate change, are projected to be about 11.7% of over 48,200 deaths due to diarrhea projected in 2030. Although deaths due to diarrhea are projected to decline to about 21,200 by 2050, the proportion of deaths attributable to climate change, will rise to approximately 17.0% (Lloyd, 2015). Other health impacts that result from climate change such as land and water scarcity, flooding, drought, and displacement cause extensive indirect health effects, impacts on food production causes breakdown in food systems, water provision, ecosystem disruption, infectious disease outbreak and vector distribution. Long-term effects of flooding may include post-traumatic stress and population displacement. In Pakistan, the prevalence of stunting in children under five was 45.0% in 2013, the prevalence of underweight children and wasting in children under five was 31.6% and 10.5% respectively in 2013 (WHO, Global Database on Child Growth and Malnutrition, 2015).

In Pakistan, mean annual temperature, CDD and warm spells (heatwave) are projected to increase resulting in a greater number of people at risk of heat- related medical conditions. The elderly, children, the chronically ill, the socially- isolated and at- risk occupational groups are particularly vulnerable to heat- related conditions. Under a high emissions scenario, heat- related deaths in the elderly (65+ years) are projected to increase to about 63 deaths per 100,000 by 2080 compared to the estimated baseline of under 10 deaths per 100,000 annually between 1961 and 1990 (Honda *et al.,* 2015).

The measures to ensure healthy environment for Pakistan in future are:

- Enhancement in the capacity of existing health infrastructures and construction of new ones,
- Increase in manpower to ensure health services during climate change adversity;
- Strengthening of capacity of health professionals, including doctors and nurses to deal with future climate change- related diseases;
- Continuous R&D and monitoring to understand the changes in the vectors, parasites and virus, and bacteria to changing climate,
- Massive awareness to control diseases related to floods, cyclones, heatwaves, cold spells, etc, and
- Increase in the use of hand pumps and latrines to reduce the threat of water contamination,

However, climate change can increase the burden of diseases, especially amongst the set of population that may have a lower capacity to combat its impact with particular reference to their access to medical facilities. Projections of the extent and direction of potential impact of climate variability and change on health are extremely difficult to make with confidence because of the many confounding and poorly understood factors associated with potential health outcomes. These factors include the sensitivity of human health to elements of weather and climate, differing vulnerability of various demographic and geographic segments of the population, the movement of disease vectors, and how effectively prospective problems can be dealt with.

Table 26:

Health Sector Statistics (Public Sector)

Facility Indicator	Number
Hospitals	106
Small Hospitals	120
General Practitioners (GPs)	>25000
Maternity Homes	300
Dispensaries	340

Table 27:

Selected Demographic Health Related Indicators

	2015
Total Population (million)	191.71
Urban Population (million)	75.19
Rural Population (million)	116.52
Total Fertility Rate (TFR)	3.2
Crude Birth Rate (per thousand)	26.1
Crude Death Rate (per thousand)	6.80
Population Growth Rate (%)	1.92
Life Expectancy (year)	
- Females	67.3
- Males	65.2

Source: Ministry of Planning, Development and Reforms

Vector- borne diseases

Several vector- borne diseases, including malaria, dengue and chikungunya are endemic in Pakistan. The factors influencing the growth of different species of mosquitoes that spread these vector- borne diseases like malaria, dengue and chikungunya in Pakistan include temperature, precipitation, humidity, elevation, and forest fringe areas. Any variability in climate largely determines the distribution and population dynamics of vectors (such as mosquitoes). Increase in temperature and change in rainfall pattern increases vector capacities, resulting in greater and wider transmission of these diseases. Owing to climate change induced differences in temperature and precipitation, the dynamics of malaria, dengue, chikungunya and other vector-borne diseases will change, the affected areas will increase in future and some new areas will be exposed to it. Areas that fall outside of stable endemic vector- borne disease transmission may be particularly vulnerable to increased transmission of the diseases due to climate warming. However, climate change can increase the burden of disease, especially amongst the set of population that may have a lower capacity to combat the impacts with particular reference to their access to medical facilities.

Dengue and Chikungunya is transmitted by the Aedes mosquito: *A. aegypti* and *A. albopictus.* While the mosquito normally acquires the virus when biting an infected person and thereafter transmits it to others, recent laboratory studies (Rohani *et al.,* 2008 50) show that the Aedes mosquito displays transovarial 51 transmission capacity of up to 5 generations, thereby sustaining the virus in the environment. The average life span of the Aedes mosquito is two weeks. It also exhibits multiple feeding behavior. An Aedes mosquito can bite several people during the short peak biting time in the morning between 6.00 to 8.00 am and late afternoon between 5:00 to 7:30 pm. Given the feeding times, it is difficult to control dengue with simple measures like bed netting, which has proved successful in malaria control.

Dengue

Dengue is currently a highly endemic disease in Pakistan. The warm and humid tropical climate is favorable for the Aedes mosquitoes to breed and survive. In such a situation, socio- economic and human drivers play an important role in dengue transmission.

In Pakistan, the first documented report of a dengue case appeared in 1985, but the first confirmed and reported dengue fever outbreak in Pakistan was occurred in 1994 among 16 hospitalized patients, 15 of which were DENV2 IgM- positive (Rasheed *et al.,* 2013). Since 1994 dengue incidence continues to increase unabated. In 1998, monoclonal antibody against DENV1 was revealed in some patients (Khan *et al.,* 2008). A sudden rise in cases and the annual epidemic trend first occurred in Karachi in November 2005. In 2006, dengue outbreak was reported in Karachi (Khan *et al.,* 2007). Since 2006, besides Karachi, there has been a change in dengue outbreak area as it hit the largest Punjab province. There were 113 confirmed cases in 2006, which increased to 232 in 2007 and a sudden surge of 1,407 cases was reported in 2008. In 2010 the major outbreak was reported all over the country. Since 2010, Pakistan has been experiencing an epidemic of dengue fever that has caused 16 580 confirmed cases and 257 deaths in Lahore and nearly 5000 cases and 60 deaths were reported from the rest of the country. The three provinces facing the epidemic are Khyber Pakhtunkhwa, Punjab and Sindh. After heavy rains in 2011, there was a huge outbreak of dengue fever in and around Lahore. An intensive survey of potential breeding sites of *A. aegypti* in Rawalpindi, Punjab Province, reported the presence of Ae. aegypti and concluded that increased urbanization, insufficient water supply and inefficient removal of urban trash resulted in increased number of non- bio- degradable containers around human dwellings, thereby creating ideal breeding habitats for *A. Aegypti* (Mukhtar *et al.,* 2018). “In 2017, a total of 12 people, including eight males and four females, died of dengue fever in Karachi out of which five were from dengue and seven others from multiple diseases, including dengue.

A total 250 dengue cases have already been reported throughout Sindh province in 2018, At least 36 suspected patients and 100 hotspots have been reported in the capital since the dengue surveillance campaign has started after March 15, 2018.

Malaria

Malaria being a major vector borne disease is the second most prevalent disease in Pakistan. Its transmission is seasonal, with epidemic outbreaks in Balochistan, Khyber Pakhtunkhwa and Sindh provinces. It is predominantly a problem in the Federally Administrated Tribal Area (FATA) and along Iran and Afghanistan border. However, in the Punjab, the most populous province, it is less common, and the disease incidence is much lower than in other areas of Pakistan. Globally there are almost 380 known species of Anopheles. In Pakistan, 24 species were reported. Among them, An. 'culicifacies' and An. 'stephensi' are two major malaria vectors (Reid, 1968). Two new species, namely, *An. 'fluviatilis'* and *An. 'annularis'* are suspected of transmitting malaria in Balochistan province. Malaria is usually known as the disease of poverty. Annually about 300 to 500 million people suffer from malaria with 1- 3 million deaths globally (Aditya *et al.,* 2013). A half million cases of malaria occur annually in Pakistan. About 50 thousand deaths occurred due to malaria annually; among these, infants, pregnant women and children are the most affected (Nizamani *et al.,* 2006).

According to a recent survey of the WHO, Pakistan is included among the top countries that have accounted 81% of the estimated deaths globally due to Malaria. Earlier, in 2015, more than 212 million and 429,000 deaths by Malaria were recorded across the world. In Pakistan, Malaria is the second largest disease with 4.5 million cases reported each year. As many as 39 districts of Balochistan and Sindh are the most at risk areas. Around 65% of the country's population is passing their lives in rural areas where no health facility is available, and Malaria is continuously killing them. Mostly the small children are being infected as 65% of children and 35% of adults are affected. One of the study conducted in Khanozai area of Pishin district, a rural area of Balochistan province highlights that male were more vulnerable to the malarial incidence probably due to more exposure to malarial vector. While as expected the incidence increases with the increase of temperature throughout the year (Khan, Kafaitullah, *et al.,* 2018).

Chikungunya

In Pakistan, Chikungunya virus was found circulating in rodents in the early 1983. A fewer patients with Chikungunya were also reported in Lahore during the 2011 dengue outbreak and more recently it has affected around 30,000 victims in Karachi.

Heatwaves

Pakistan is frequently affected by natural disasters in which heatwave is one of the major disasters, which is likely to become more frequent and severe in the coming years due to climate change impacts. Increase in the number of extreme weather events may cause more loss of lives and injuries unless adequate measures are taken. Loss of lives of dear and near ones and grave injuries may also lead to psychological distress, i.e. negative mood, stress- related physical symptoms, and psychological symptoms (O'Neill, 1999).

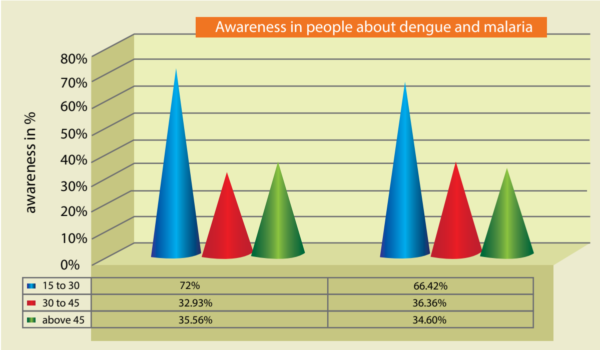
In June 2015, Karachi city was hit by a very severe heatwave that was among the 10 deadliest natural disasters in Pakistan since 1950 killing over 1,200 people and catching over 50,000 illnesses due to heatwave. Temperature in Karachi during June 2015 did not break the records as compared to other areas of Pakistan. The persistent pattern of no relief of minimum temperature during the night time results in heatwave (Eyzaguirre *et al.,* 2017). The rising trend of summer heat index and more frequent and intense heatwaves are observed to increase in all parts of the world, including Pakistan (Zahid & Rasul 2010, 2012). A two degree rise in temperature above the preindustrial levels will cause cities such as Karachi and Kolkata to experience conditions equivalent to 2015 heatwaves every year (Mattews *et al.,* 2017).

Pollen Allergy

Pollen grains are the male tiny particles which are released from trees, weeds, and grasses to fertilize the same plants, but many cannot

Figure 26:

Percentage of awareness of dengue and malaria difference in different age groups



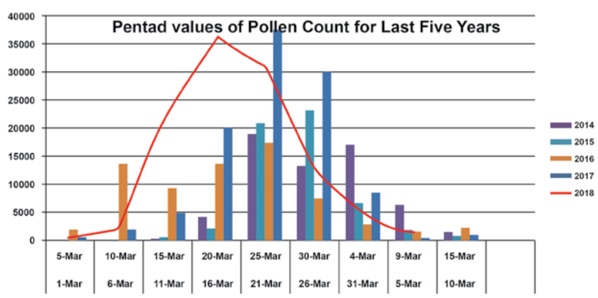
Source: Maria, *et al.,* 2015

reach their targets and remain suspended in atmosphere. Most species of pollen have some level of allergenicity but not all of them. The suspended pollen grains in the air reach the human respiratory track through inhalation, triggering a type of seasonal allergy called pollen allergy. Pollen is one of the most widespread of all the factors that can cause an allergy.

Islamabad is among the cities with the highest pollen counts in the world. The pollen concentration is more in Islamabad as compared to other cities of Pakistan, because of population of Paper Mulberry trees. They are mainly concentrated in Islamabad whereas almost negligible in other cities. Extremely high concentration of pollens is observed in spring (March & April) and relatively less high pollen concentration in monsoon season.

Figure 27:

Pentad values of pollen count for last years in Islamabad



Source: Pakistan Meteorological Department (pmd.gov.pk. pollen graph)

3.4 Adaptation Measures

Pakistan is among the most severely threatened countries in terms of climate- induced challenges where individual areas face unique stresses, which can be quite different depending on the geographical location and rate of urbanization of their respective administrative units. This requires a multifaceted approach to climate change at the national level, as well as active engagement with sub- national representatives.

For Pakistan, adaptation to the adverse impact of climate change is inevitable and likely to become critical in the near future. Owing to geo-physical conditions, climatic extremes and high degrees of exposure and vulnerability, Pakistan has become a disaster- prone country. Frequent exposure to extreme climate- induced events such as droughts, floods, landslides, cyclonic activities, recession of glaciers, GLOF and heatwaves have led the country to rank amongst top ten most climate- affected countries on the Global Climate Risk Index.

The vulnerabilities of various sectors to climate change have been highlighted and appropriate adaptation actions spelled out. These include actions to address issues in various sectors such as water, agriculture, forestry, coastal areas, biodiversity, health and other vulnerable ecosystems. Likewise, to address the impact of climate change on water resources and to help enhance water security, a detailed plan of action has been suggested in Framework for Implementation of Climate Change Policy. (see Annexure- B). Notwithstanding the fact that Pakistan's contribution to GHG emissions is very small, its role as a responsible member of the global community in combating climate change has been highlighted by giving due importance to mitigation efforts in sectors such as energy, transport, industries, urban planning, forestry, agriculture and livestock. Furthermore, appropriate actions relating to disaster preparedness, capacity building, institutional strengthening and awareness raising in relevant sectors have also been the part of this document.

This Framework for Implementation of NCCP has been developed as a catalyst for mainstreaming climate change concerns into decision- making that will create enabling conditions for integrated climate compatible development processes. It is, therefore, not a stand- alone document, but rather an integral and synergistic complement to future planning in the country. Further, this Framework for Implementation of NCCP has been designed as a 'living document'. This is because we are still uncertain about the timing and exact magnitude of many of the likely impacts of climate change. We will continue to deepen our understanding of the phenomenon, as we continue to implement our adaptation and mitigation programmes.

CHAPTER

4

Projections and Mitigation of GHG Emissions- Options and Challenges

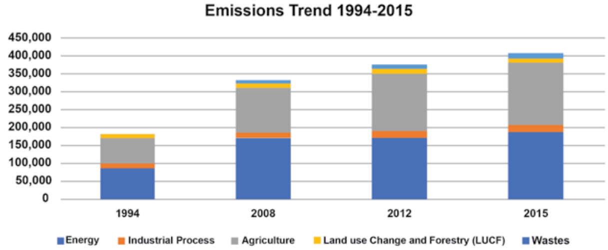
Projections and Mitigation of GHG Emissions- Options and Challenges

4.1 Major Emitters of GHG in Pakistan

Pakistan's 2015 GHG Inventory estimates indicate consistent growth of emissions in all sectors of economy. An analysis of the period between 1994- 2015 shows 123% increase in the overall emissions with energy and agriculture sectors accounting for about 90% of the total emissions as shown in the Figure 28. Similarly, the fairly consistent historical emission trends have been projected due to envisaged economic growth and conducive macro- economic environment – one of the distinguished reasons is China- Pakistan Economic Corridor (CPEC).

Figure 28:

National GHG emissions in 1994, 2008, 2012 and 2015, by sector Mt CO_2- eq.



Source: Ministry of Climate Change

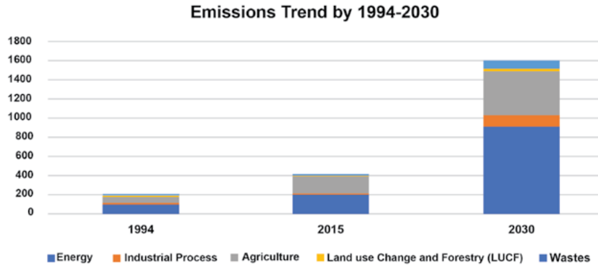
The total estimated emissions in terms of Mt CO_2- eq. for the year 2015 show a considerable increase in total GHG emissions when compared with inventories of 1994, 2008, and 2012.

4.2 Projection of GHG Emissions by 2030

Future projections for the period between 2015- 30 show a steady increase in emissions due to an ambitious plan of the government to spur economic activity through large- scale investments in energy, communication, and industrial infrastructure. The expected economic growth is historically unprecedented and unmatched. Accordingly, future emissions of the country will increase manifold. Consistent with the historical trends, both the energy and agriculture sectors are predicted to remain predominant in GHG emissions whereas significant increase is also expected in other sectors like industrial processes and waste.

Figure 29:

2030 Sector- wise Projections of Emissions (Mt CO_2-eq.)



Source: Ministry of Climate Change

4.3 Energy Sector

Energy sector is the single largest source of GHG emissions, contributing 51% of these emissions and is followed by the Agriculture sector (39%). The most important targets for mitigation efforts involving reduction of GHG emission are the Energy and Agriculture sectors. In the energy sector, integration of climate change and energy policy objectives is particularly important as today's investment will "lock in" the infrastructure, fuel and technologies to be used for decades to come. Similarly, building and transport infrastructure put in place today should meet the emission criteria of the future. Therefore, greater attention must be paid to the energy efficiency requirements in building codes and long- term transport planning.

Pakistan's energy sector has high reliance on natural gas (the fossil fuel with the lowest carbon intensity), and very low reliance on coal (the fossil fuel with the highest carbon intensity) in utter contrast to the patterns of primary energy consumption and electricity generation worldwide. It is largely for this reason that the CO_2 emissions per unit of energy consumption in Pakistan are among the lowest in the world. With this consumption pattern, Pakistan's natural gas reserves have depleted to such an extent that it will be difficult to maintain the present level of production for a long. Similarly, local oil resources are dismally low too. The only sizable fossil fuel resource available in Pakistan is coal with an estimated resource base of 185 billion tonnes. To meet an increasingly large fraction of its future energy needs, Pakistan has no alternative but to seek meeting an increasingly large fraction of its future energy needs through the use of its practically unutilized vast coal resources. As such, "clean" coal technologies are expected to be part of the energy mix for the medium- term future.

Fuel consumption in energy sector

The share of installed capacity of thermal power plants using oil, natural gas and coal to the total installed capacity in the country, during 2015- 16, was about 65.50% while the electricity produced by the thermal power plants, during 2014- 15, to the total electricity generated in the country during same period was about 64.01%. The statistics of different fuel used and their percentage share to the total fuel used for thermal electricity generation of the country from 2010- 11 to 2014- 15 are given in table 28.

Electricity sector overview

The total nominal power generation capacity of Pakistan as on 30th June, 2016 was 25,374 MW; of which 16,619MW (65.50%) was thermal, 7,116 MW (28.04%) was hydroelectric, 787 MW (3.10%) was nuclear and 852 MW (3.36%) was renewable energy (wind, solar and bagasse).

Pakistan has already taken a number of policy measures, which have contributed substantially in GHG emissions reduction. The major mitigation efforts have been done in the

Table 28:

Fuel Consumption for Thermal Power Generation (TOE)

Fiscal year	Unit	Gas	Furnace Oil	Diesel Oil	Coal	Total	Annual Growth rate
2010-11	TOE	6,493,766	7,827,500	105,160	43,169	14,469,595	-8.22
	% share	44.88	54.10	0.73	0.30	100	
2011-12	TOE	6,732,876	7,206,839	203,072	46,800	14,189,587	-1.94
	% share	47.45	50.79	1.43	0.33	100	
2012-13	TOE	7,084,177	7,342,755	218,584	28,204	14,673,720	3.41
	% share	48.28	50.04	1.49	0.19	100	
2013-14	TOE	6,602,422	8,486,744	304,994	71,902	15,466,062	5.40
	% share	42.69	54.87	1.97	0.46	100	
2014-15	TOE	6,847,894	8,234,479	565,953	67,638	15,715,964	1.62
	% share	43.57	52.40	3.60	0.43	100	

Source: Pakistan Energy Year Book 2015, HDIP/ State of Industry Report 2016

To find solutions to the present and future energy requirements, a creative and sustainable energy policy framework is necessary that may help in reducing the GHG emissions. This framework would facilitate the transition towards low carbon emissions for sustainable development. We may also need to realize the full potential of the country's renewable energy capacity, beside developing and enhancing clean sources and other efficiency measures towards a low carbon economy in the energy sector. As such the change in energy mix, the development of renewable energy resources and the increase in nuclear and hydroelectric share provides an opportunity to achieve the above- mentioned objectives of reduction in carbon emissions in the energy sector.

power generation sector through developing Alternate and Renewable Energy (ARE) based power projects. The government has introduced alternative fuel in the form of Compressed Natural Gas, Liquified Natural Gas (LNG) and more efficient fuel in the transport sector, i.e. RON92 which has also resulted in the reduction of CO_2 emissions. Energy Sector can be divided into supply side, demand side and power grid according to generation, transmission and distribution processes of the electricity grid. The CO_2 emissions of power sector are concentrated in supply side, where fossil fuels burn. Inefficient utilization in demand side and losses in power grid would increase energy consumption in supply side, which also indirectly contributes more CO_2 emissions. The 2013 Framework

Table 29:

Installed Capacity by Type (MW)

	As on 30th June	2011	2012	2013	2014	2015
HYDEL						
WAPDA Hydel		6,516	6,516	6,733	6,902	6,902
IPPs Hydel		129	214	214	214	214
Sub-Total		**6,645**	**6,730**	**6,947**	**7,116**	**7,116**
% Share (Hydel Installed Generation Capacity)		28.47	28.65	29.28	29.99	28.67
THERMAL						
GENCOs with PEPCO		4,785	4,785	4,785	4,590	5,762
KEL Own		1,821	2,381	2,359	1,951	1,874
IPPs	Connected with PEPCO	8,325	8,312	8,342	8,726	8,726
	Connected with KEL	252	252	252	252	252
RPPs	Connected with PEPCO	353	0	0	0	0
	Connected with KEL	50	0	0	0	0
CPPs/SPPs connected with KEL		324	239	203	200	200
Sub-Total		**15,910**	**15,969**	**15,941**	**15,719**	**16,814**
% Share (Thermal Installed Generation Capacity)		68.16	67.99	67.19	66.25	67.74
NUCLEAR						
CHASNUPP (I&II)		650	650	650	650	650
KANUPP		137	137	137	137	137
Sub-Total		**787**	**787**	**787**	**787**	**787**
% Share (Nuclear Installed Generation Capacity)		3.37	3.35	3.32	3.32	3.17
WIND						
Wind Power Plants connected with PEPCO		0	1	50	106	106
Sub-Total		**0**	**1**	**50**	**106**	**106**
% Share (Wind Installed Generation Capacity)		0.00	0.00	0.21	0.45	0.43
Total Installed Generation Capacity of the Country		**23,342**	**23,487**	**23,725**	**23,728**	**24,823**

Source: PSS/NTDC/KEL

for Implementation of Climate Change Policy (FICCP) includes 735 actions. About 22 priority actions deal with the energy security in the country, having following objectives;

(i) develop and enhance renewable energy sources and uses to achieve green growth in the energy sector. (ii) develop and obtain clean energy technologies and uses to achieve low carbon growth in the energy sector. (iii) reduce total energy demand through conservation and efficiency.

No	Categories	Priority Actions
1	Policy/ law making and implementation	7
2	Enabling Environment	3
3	Institutional Strengthening and Capacity Building	4
4	Awareness	2
5	Assessment/ Research	2
6	Infrastructure/ Technology Implementation	4

Electricity Generation:

Electricity generation of Pakistan from 2010- 11 to 2014- 15 is listed in Table 30. CO_2 mitigation measures adopted in supply side could be divided into three categories:

(a) improving conversion efficiency of fossil energy and lower energy intensity;

(b) developing non- fossil energy like renewable energy and nuclear energy and adjust energy mix;

(c) developing carbon capture and storage (CCS) technologies.

The most effective measure in CO_2 mitigation in demand side is to implement Demand Side Management (DSM), which improves utilization efficiency through incentive policies. Power grid is not only a bridge connecting supply side and demand side physically, but also an important medium of achieving mitigation benefits of both sides. Besides, it provides support for large- scale applications of non- fossil energy

Table 30:

Electricity Generation by Type (GWh)

As on 30th June		2010-11	2011-12	2012-13	2013-14	2014-15
HYDEL						
WAPDA Hydel		31,685	28,207	29,327	31,204	31,941
IPPs Hydel		305	436	706	1,035	1,038
Sub-Total		**31,990**	**28,643**	**30,033**	**32,239**	**32,979**
% Share (Hydel Electricity Generation)		31.80	28.85	30.44	30.50	30.24
THERMAL						
GENCOs with PEPCO		13,018	12,652	12,872	13,016	13,300
KEL Own		7,826	8,029	8,567	8,709	9,319
IPPs	Connected with PEPCO	41,209	42,222	40,062	43,701	44,638
	Connected with KEL	1,538	933	1,116	1,380	1,525
RPPs	Connected with PEPCO	546	758	0	0	0
	Connected with KEL	158	0	0	0	0
CPPs/SPPs connected with PEPCO		587	730	1,280	1,108	1,015
CPPs/SPPs connected with KEL		287	154	137	168	191
Sub-Total		**65,169**	**65,478**	**64,034**	**68,082**	**69,988**
% Share (Thermal Electricity Generation)		64.79	65.94	64.91	64.41	64.17
NUCLEAR						
CHASNUPP (I&II)		2,930	4,413	3,640	4,402	4,996
KANUPP		200	459	541	293	353
Sub-Total		**3,130**	**4,872**	**4,181**	**4,695**	**5,349**
% Share (Nuclear Electricity Generation)		3.11	4.91	4.24	4.44	4.90
IMPORT						
Import from Iran		269	296	375	419	443
Import from KEL		26	0	0	0	0
Sub-Total		**295**	**296**	**375**	**419**	**443**
% Share (Imported Electricity Generation)		0.29	0.30	0.38	0.40	0.41
WIND						
Wind Power Plants connected with PEPCO		0	6	32	263	300
Sub-Total		**0**	**6**	**32**	**263**	**300**
% Share (Wind Electricity Generation)		0.00	0.01	0.03	0.25	0.27
Total Electricity Generation of the Country		**100,584**	**99,295**	**98,655**	**105,698**	**109,059**

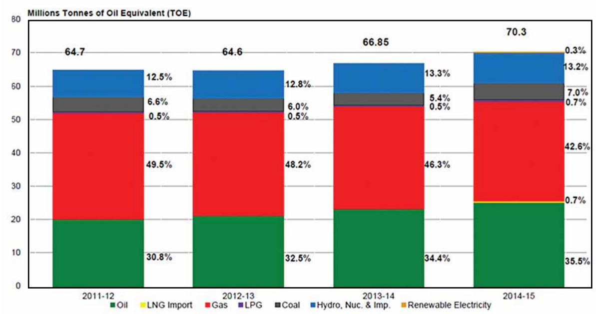
Source: PSS/NTDC/KEL

(including nuclear energy, hydroelectric energy and wind energy).

The Primary Energy Supplies graph of Pakistan as given below shows a mix of sources. Out of all the primary energy supply sources, natural gas is the only source that has not been imported till 2014 specifically.

Figure 30:

Primary Energy Supplies by Source



Source: Pakistan Energy Year Book 2015 published by Hydrocarbon Development Institute of Pakistan (HDIP), Ministry of Petroleum & Natural Resources, Government of Pakistan

From clean power generation perspective, Pakistan has enormous renewable energy generation potential and a number of on- grid and off- grid projects have been/ are being implemented. Policy for Development of Renewable Energy for Power Generation approved in 2006 specified the constitution of Joint Management Committee (JMC) for the sale and management of CERs earned through renewable energy projects. The committee comprises power purchaser, power producer and AEDB officials (Alternate Energy Development Board). Renewable Energy is best suited for CDM and can earn CERs. Based on the SRO 263(I)/ 2011 issued by the Federal Board of Revenue on 19 March, 2011, the import of PV equipment (panels, inverters, batteries, charge controllers, etc.) is exempted from all duties, so the increasing trend in imports of solar panel as shown in the graphs below is quite evident due to the exemptions. Penetration of panels was also seen in the off- grid areas. Net- metering regime shall also give necessary momentum to integration of panels in on- grid projects. Based on average 950- 1000 MW/ annum imports of Solar PV panels, it is expected that trend will further enhance once renewable energy integration becomes mandatory under energy efficiency and conservation building codes.

Alternative and Renewable Energy (ARE) has potential to be developed as projects as carbon offsetting initiatives under CDM. A broad spectrum of initiatives for the alternate energy development is underway and some of them have applied to CDM Executive Board as per the guidelines of UNFCCC to get CERs and earn carbon revenues. The list of CDM projects is given in Annexure- D.

In September 2015, National Power Regulatory Authority (NEPRA) issued net- metering regulations, which allows Distribution Companies (DISCOs) to purchase electricity produced by the consumers. The consumers or prosumers, who were interested to be the part of this mechanism would install solar panels or other assets to generate electricity and will be paid after deduction of electricity consumed from the grid. It is expected that in the future net- metering regime will gain more interest from the consumers to become prosumers.

From Demand Side management perspective, the National Energy Conservation Policy was approved by the Cabinet in 2006 and the step was taken to have the Energy Efficiency Act in place. To find solutions to the present energy needs and future energy requirements, an integrated sustainable energy policy framework is necessary that may help in reducing the GHG. This framework would facilitate the transition towards low carbon emissions for sustainable development. We may also need to realize the full potential of the country's renewable capacity, beside developing and enhancing clean sources and other efficiency measures towards a low carbon economy in the energy sector. As such the change in energy mix, the development of renewable energy resources and the increase of nuclear and hydroelectric share provides an opportunity to achieve the above- mentioned objectives of reduction in carbon emissions in the energy sector in Pakistan.

4.3.1 Policy Initiatives and Governance Structure

Pakistan's response to the challenges of climate change has already been incorporated in its strategic plan of Vision 2025, commitment to Sustainable Development Goals (SDGs), and objectives of the Convention on Climate Change. Adoption of the National Climate Change Policy and National Disaster Risk Reduction Policy 2012 provides a comprehensive framework for policy goals and actions towards mainstreaming the agenda of climate change. It specifically addresses the economically and socially vulnerable sectors of the economy. A follow- up to these policies was the launch of Framework for Implementation of the Climate Change Policy 2014- 2030, which outlines the vulnerabilities of various sectors to climate change and identifies appropriate adaptation and mitigation actions.

The Framework serves as a catalyst for mainstreaming climate change concerns into decision- making at national and sub- national levels and to create an enabling environment for an integrated climate- compatible development process. Moreover, it provided impetus to prepare the National Adaptation Plan (NAP), Nationally Appropriate Mitigation Actions (NAMAs), future National Communications to the UNFCCC as well as detailed sub- national adaptation action plans.

One of the recent key developments is the passage of Pakistan Climate Change Act under which Pakistan Climate Change Council was established. Institutionally, it will be headed by the Prime Minister of Pakistan with representation of the sub- national governments at the Chief Ministerial level. It also envisages establishment of a high- powered Pakistan Climate Change Authority and Pakistan Climate Change Fund. The Fund will mobilize resources from both domestic and international sources for providing finances to support mitigation and adaptation initiatives in the country.

Pakistan has considerably improved and strengthened its climate governance structure over time to achieve the objectives of different policy initiatives. Climate change and environmental protection issues have been extensively recognized in medium and long- term national plans, Economic Surveys of Pakistan, provincial budgets, and federal level Public Sector Development Programmes. Budgetary allocations have already been made at national and sub- national levels for the execution of the Framework for Implementation of the Climate Change Policy. Although, the climate change has become a provincial subject after 18th Amendment of the Constitution, some of the activities and responsibilities relating to climate change concerns are coordinated by the Ministry of Climate Change at the national level with corresponding support from the sub- national governments.

The Ministry of Climate Change not only works in close collaboration with the federal government departments, research institutions, universities and private sector but is also responsible for supervising and controlling several attached departments and implementation agencies. They are:

- Global Change Impact Studies Centre (GCISC)
- National Disaster Management Authority (NDMA)
- Pakistan Environmental Protection Agency (Pak- EPA)
- Zoological Survey Department of Pakistan (ZSD)

The ministry has specialized wings as well to deal with matters relating to environment and forestry. At the operational level, frequent interaction is maintained with the Pakistan Metrological Department (PMD), Pakistan Agricultural Research Council (PARC), Federal Flood Commission (FFC), Indus River System Authority (IRSA), Water and Power Development Authority (WAPDA), National Energy Conservation Center (ENERCON), Alternative Energy Development Board (AEDB), Civil Society Organizations (CSOs) and private sector.

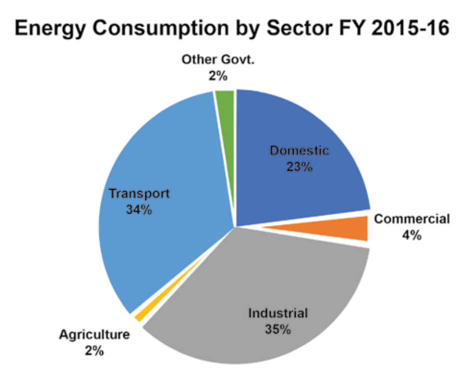
The National Climate Change Policy and its framework for implementation make key recommendations relating to mitigation measures in different sectors, including energy, agriculture and forestry. Both the documents also provide the policy framework on adaptation measures with particular focus on water, agriculture and livestock, coastal areas, Indus deltaic region, forests and other vulnerable ecosystems.

Climate Change Technology Needs Assessment (TNA) undertaken with the assistance of United Nations Environment Programme (UNEP) identifies a set of mitigation technologies in different sectors such as energy, agriculture, transport, etc. There is a huge potential for mitigation which can be harnessed but remains untapped due to financial and technical challenges.

The small hydel potential of about 3,000 MW for power generation in the shape of micro and small- scale hydro plants has so far been realized. Similarly, solar photovoltaic and wind technologies for power generation, water pumping, solar geysers and other renewable energy- uses can reduce the GHG emissions. Some steps have already been taken in this direction, and PKR 46057.7 million (Planning Commission, 2015) has been allocated for Public Sector Development Programme 2014- 15 to implement these projects by the Ministry of Water and Power.

Figure 31:

Final Energy Consumption by Sector 2015- 16



Source: Pakistan Energy Year Book

Figure 31 shows Pakistan Energy Sector consumption in different sectors. Both the domestic and transport sectors consume 54% of energy. A sizeable potential exists in domestic and transport sector for energy sector mitigation. To tap these potentials, energy-efficient buildings through implementation of buildings codes and achieving fuel efficiency in the transport sector can be technically and financially a viable option.

Similarly, agriculture sector offers promising potential for rationalizing the use of fertilizers and improving soil carbon management, promoting the use of biogas as a fuel and sustainable forest management for reducing emissions from deforestation and forest degradation. For carbon sequestration, wetlands are recognized as promising areas.

The ministry is actively reviewing policy considerations for further integration of market mechanisms in response to emerging threats in the context of Article 6 of the Paris Agreement. Institutionally and operationally, the key areas relate to (a) the establishment of organizational structure at the national and sub- national levels; (b) use of Clean Development Mechanism (CDM) and other market mechanisms to support climate change activities; (c) capacity building; and (d) financing of climate change regime using national and international resources.

Pakistan's Climate Public Expenditure and Institutional Review (CPEIR), undertaken by United Nations Development Programme (UNDP) in 2015 shows the total estimated federal climate- related expenditure. The federal government expenditures are concentrated in mitigation; it makes 63% of the total expenses; this is primarily because of its focus on energy and transport projects, particularly after 2013. Contrary to that, the provinces spending is concentrated on adaptation activities, with a range of 62%- 79% in the four provinces. The percentage share of adaptation has increased progressively in the last few years which can primarily be attributed to the 18th amendment that has devolved powers to the provinces.

Table 31:

Pakistan climate- related expenditure (CPEIR 2011/ 12 to 2015/ 16)

Unit	2011/ 12	2012/ 13	2013/ 14	2014/ 15	2015/ 16
Federal	6.5%	5.8%	6.2%	8.1%	6.5%
Khyber Pakhtunkhwa	7.2%	5.3%	7.1%	9.7%	8.9%
Balochistan	7.3%	10.4%	11.1%	11.3%	11.9%
Punjab	6.2%	7.1%	8.2%	9.3%	13.7%
Sindh	5.7%	4.2%	4.3%	6.9%	7.2%
FATA	13.1%	12.5%	11.6%	11.9%	10.2%
Gilgit- Baltistan	16%	19%	20%	28%	25.6%
Azad Jammu & Kashmir	9.2%	14.0%	12.5%	16.9%	14.3%
National	6.7%	6.1%	6.7%	8.5%	8.4%

Source: 2017 Climate Public Expenditure and Institutional Review (CPEIR), Policy Brief UNDP Pakistan.

In the federal budgets for the fiscal years 2015-16 and 2016- 17, additional initiatives were taken for climate- related activities, including interest-free loans for farmers to install solar tube wells, abolition of import duty on solar equipment, promotion of renewable technologies as well as an ambitious plan for afforestation.

The provincial governments, taking charge of the climate change concerns, also embarked upon several institutional and policy development initiatives. Some of the key climate change actions are as follows:

- Establishment of Directorates of Climate Change and Multilateral Environment Agreements
- Formulation of climate change policies and frameworks for their implementation
- Constitution of climate change policy implementation committees
- Construction of 1,000 MW Quaid- e- Azam solar park in the Punjab
- Improvement of urban public transport systems, especially Bus Rapid Transport at Lahore, Rawalpindi- Islamabad and Multan, and urban rail transport (Orange Line) at Lahore
- Green Pakistan Programme for tree plantation
- One- billion tree plantation programme in Khyber Pakhtunkhwa
- Conservation of national parks and protected areas
- Natural resource management
- Registration of Clean Development Mechanism (CDM) projects
- Green Charter for cities (already signed for Islamabad)

With the institutional infrastructure rapidly becoming operational at the provincial level, the national climate policy action plans are being re-defined with sub- national governments taking on dominant roles and responsibilities. It is expected that with the consolidation of legal and institutional infrastructure, the overall climate governance structure will strengthen and allow the Ministry of Climate Change to better assist the policy and operational activities of sub-national entities.

4.3.2 Climate Change Variability and Specific Measures

Pakistan's vulnerability to adverse impact of climate change is well- established and widely recognized. Despite its minor contribution to global GHG emissions, according to Global Climate Risk Index, it is among the top 10 most climate- affected countries of the world.

Extreme climate events between 1994 and 2013 incurred a USD 4 billion loss annually. The last five floods (2010- 2014) resulted in over USD 18 billion losses while affecting 38.12 million people, damaging 3.45 million houses, and destroying 10.63 million acres of crops. In 2015, over 1,200 people died due to the unprecedented heatwave in Karachi.

Pakistan is signatory to Kyoto protocol. The framework of the Clean Development Mechanism (CDM) is outlined in Article 12 of the Kyoto protocol. The CDM is among the three flexible Kyoto Protocol mechanisms, which facilitates implementation of GHG emission reductions in the developing countries. Analysis of CDM regime shows that Pakistan has not properly availed the benefits of CDM to earn the revenues of Certified Emissions Reduction (CERs). It was a new mechanism and Pakistan should have followed the steps of China and India as role models for attaining such benefits.

4.3.3 Options for Adaption Strategy

At a time when future emissions are set to grow rapidly, the country also offers a huge potential for mitigation in almost all sectors of the economy. Based on economic analysis, a reduction of up to 20% in the projected emission figures for 2030 would require an investment of approximately USD 40 billion, calculated at current prices. Similarly, a reduction of 15 % in GHG emissions amounts to USD 15.6 billion whereas a 10 % reduction is calculated as USD 5.5 billion. It must be underscored that under the Common But Differentiated Responsibilities (CBDR) principle of the Paris Agreement, the indicated mitigation potential can only be realized through international support in the form of financial grants, technical assistance, technology transfer and capacity building.

Pakistan being highly vulnerable to extreme climate events, is in a state of forced adaptation. There is a huge potential for strengthening and fortifying the flood infrastructure, including water reservoirs and water channels. This would involve enhancing resilience of local communities to the adverse impact of climate change and be able to bounce back after such frequent calamities. According to a national study, Pakistan's adaptation need is between USD 7 to 14 billion/ annum. Pakistan qualifies for being one of the promising carbon investment markets in the world. As it has low abatement cost coupled with an enabling regulatory regime. for prospective climate- resilient investments.

4.4 Pattern of Electricity Consumption and Recent Trends in Energy Efficiency

The overall electricity consumption in the country since 2000 was growing steadily. However, during the fiscal year 2015- 16 electricity consumption in the country excluding K- Electric area increased by 4.96%. The sector wise electricity consumption and their share in total electricity consumption of the country, for the years 2010- 11 to 2014- 15 are given in the table 32.

Table 33 presents the trend in energy intensity (which is taken as a measure of energy efficiency) in various activities in Pakistan between the fiscal 2004- 05 to fiscal 2015- 16. Energy intensity is computed as TOEs of energy used for producing Rs one million sectoral output (or, in case of the domestic sector, as TOEs of energy used per million rupees of private consumption). It is recognized that these computations provide only an approximation of energy intensity; it is also recognized that the formula and data used for the domestic (i.e. household) sector differ from that of other sectors. The data presented in this table is, therefore, only an illustration of recent trends in energy efficiency. It is designed to show, for example, that overall energy intensity declined[9] by about three- quarters of 1 % annually between 2005- 06 and 2015- 16.

[9] Another way of stating this is "0.67% less energy was used (per annum) to produce each unit of national output or GDP".

Table 32:

Sector wise electricity consumption share from 2011- 12 to 2014- 15

		2010- 11	2011- 12	2012- 13	2013- 14	2014- 15
Domestic	GWh	35,229	34,767	35,404	38,811	40,727
	%	4.75	-1.31	1.83	9.62	4.94
Commercial	GWh	5,725	5,690	5,941	6,300	6,442
	%	3.02	-0.60	4.40	6.04	2.27
Industrial	GWh	21,146	21,741	22,086	24,119	24,733
	%	6.90	2.81	1.59	9.20	2.55
Agricultural	GWh	8,972	8,544	7,699	8,289	8,032
	%	-7.38	-4.77	-9.88	7.66	-3.11
Public Lighting	GWh	435	481	498	496	503
	%	-5.26	10.58	3.58	-0.44	1.49
Bulk Supply + Others	GWh	3,699	3,592	4,270	4,461	4,465
	%	-16.25	-2.90	18.86	4.46	0.09
Traction	GWh	1,078	936	27	31	33
	%	3494.17	-13.18	-97.10	15.52	5.16
Total	**GWh**	**81,760**	**81,436**	**81,389**	**87,948**	**90,363**
Percentage change	**%**	**3.77**	**-0.40**	**-0.06**	**8.06**	**2.75**

Source: NTDC/K- EL

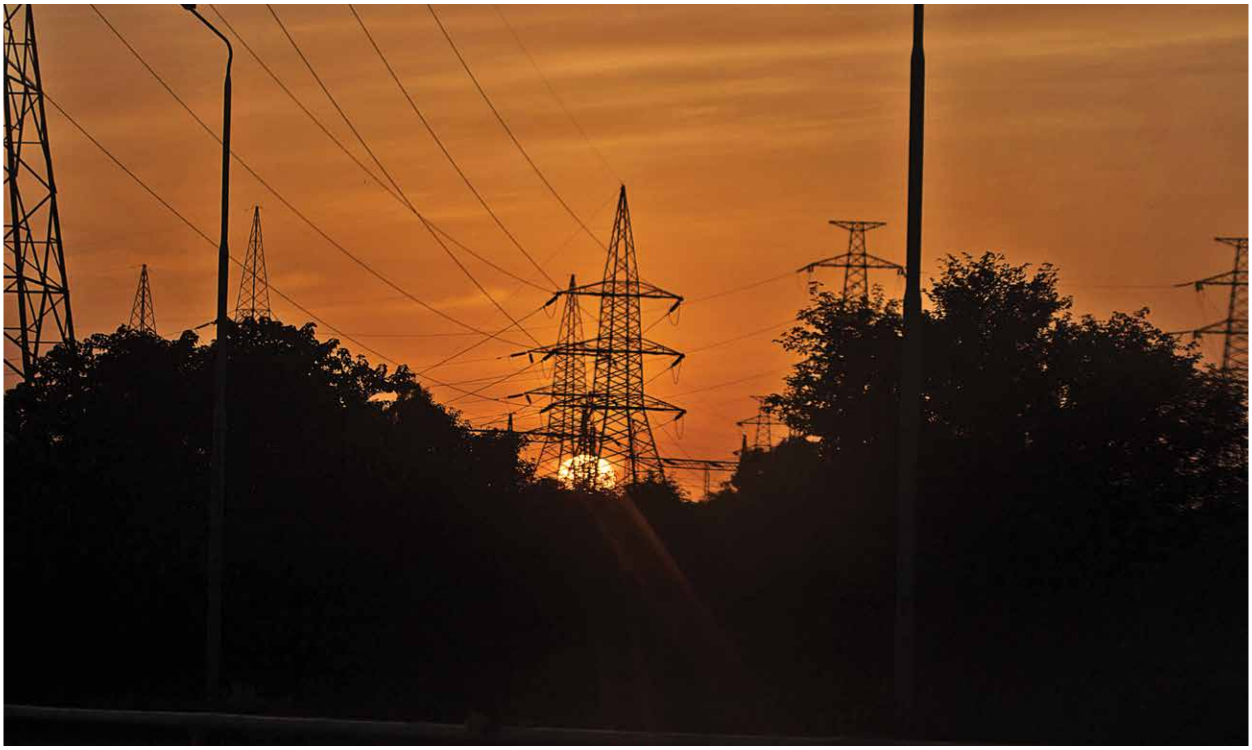


Table 33:

Pakistan's Energy Intensity (Historical)

Energy intensity (TOE/ million Rupees)											
Sector	**2005- 6**	**2006- 7**	**2007- 8**	**2008- 9**	**2009- 10**	**2010- 11**	**2011- 12**	**2012- 13**	**2013- 14**	**2014- 15**	**2015- 16**	**ACGR %**
Domestic	11.22	11.57	11.61	10.96	10.7	10.48	10.56	10.85	9.97	9.79	9.37	-1.62%
Commercial	0.54	0.56	0.56	0.58	0.6	0.58	0.6	0.59	0.57	0.56	0.58	0.67%
Industrial	9.07	9.07	8.9	8.29	8.43	7.73	7.58	7.13	6.59	6.75	6.85	-2.52%
Agriculture	0.41	0.42	0.43	0.41	0.44	0.39	0.35	0.31	0.34	0.31	0.32	-2.25%
Transport	9.89	9.48	10.69	10	9.96	10.03	10.02	9.74	9.54	9.54	10.24	0.31%
Others	1.79	1.7	1.68	1.7	1.54	1.49	1.21	1.12	1.18	1.2	1.35	-2.53%
Total	4.4	4.42	4.61	4.35	4.4	4.26	4.23	4.09	3.9	3.95	4.08	-0.67%
ACGR negative values indicate that the sector has become energy efficient over the years												
ACGR non- negative values indicate that the sector has become energy inefficient over the years												

Among sectors, the fastest reduction, (i.e. 2.5% per annum) in energy intensity was witnessed in Industry[10] followed by Agriculture (2.25%) and Domestic sector (1.6% per annum). The data also shows an increase in energy intensity in Commercial activities (by 0.7% per annum) and Transport sector (0.3% per annum). Conversely, these figures show that by 2015- 16 Pakistan's industries had got improved their energy use efficiency by about 25%, compared to 2005- 06. Corresponding improvements in agriculture and in domestic energy use were about 22% and 16% respectively. By contrast, energy use efficiency had declined by about 4% in Commercial activities and Transport sector.

Among the factors that contributed to improved energy use efficiency in various sectors, the government's decision to align energy prices with the cost of supply was a significant policy action. Up to 2008, the government did not pass to consumers the hike in the world market prices of oil (and gas), or the corresponding increase in electricity generation costs (and electricity prices) to consumers. In lieu of increasing prices, it provided subsidies to consumers directly from the budget. The world market oil prices reached USD 147.27/ barrel in mid- 2008. By not accepting this sharp price increase, the government (in fact) artificially reduced the value of energy for consumers. Therefore, consumers were not motivated to save energy or use it efficiently. When the burden of subsidies became unbearable for the federal budget, the government revised its policy and started aligning energy prices with the cost of supply. Initially, the prices for industrial and commercial users were raised more rapidly than for the domestic or agriculture sectors. The sustained improvement in energy use by industries is a direct result of this pricing policy. Given the higher cost of energy, consumers in general (and industries in particular) started investing in energy- efficient appliances and processes.

The first impact of this policy was on electricity use for lighting, i.e. by replacing incandescent bulbs with Compact Fluorescent Lamps (CFLs). From a market share of more than 90% of the lighting market up to about 2010, incandescent bulbs now account for less than 50%- and the share of CFLs has increased correspondingly. The next generation of energy saving lights, i.e. Light Emitting Diodes (LEDs) and Liquid Crystal Devices (LCDs), is also being used by consumers and the transition to LEDs would be much

[10] While energy intensity was also reduced by around 2.5% per annum in the Other Government sector, this activity accounts for a relatively small share of energy use/consumption– therefore the impact of this reduction was relatively minor.

quicker than CFLs. The government, through the DISCOs, also implemented a large- scale programme that supported the switch to more efficient forms of lighting. Specifically, about 30 million CFLs were procured under a project financed jointly by the Asian Development Bank (ADB) and Agence Francaise de Developpement (AFD), the French development agency. These CFLs were provided free of cost to consumers complying with certain criteria and who returned an equal number of incandescent bulbs to the DISCOs. About 850 MW of connected load was conserved. This project also improved the consumers' awareness about energy saving opportunities, and performance standards for energy efficient equipment and appliances.

Other factors which contributed to the improvement in energy use efficiency in industry are as follows:

- In some energy intensive sectors, a large share of capacity is relatively new, and production expanded significantly in recent years. In cement, for example, output expanded by nearly 50% after 2005- 06. Large increments in output (as new plants were installed) were recorded during 2007- 10 and between 2011- 12 and 2015- 16. Those plants incorporate the latest production technologies (and higher energy use efficiencies), therefore, contributed to improved energy efficiency in the sector as a whole.
- In textiles (the largest industry in Pakistan), the trend was quite adverse and output of yarn and cloth increased by only 2.7% p.a. and 1.2% p.a. respectively, since 2005- 06. This stagnation shows that the textile industry has not significantly upgraded its technology, and its role in improving energy use efficiency has been relatively minor.

Table 34:

Production Statistics from 2005- 6 to 2015- 16

Production in Selected industries- 000 tonnes				
	Urea	Ghee	Sugar	Cement
2005- 06	4,806.40	1,152	2,960	18,564
2006- 07	4,732.50	1 ,180	3,527	22,739
2007- 08	4,925.00	1 ,137	4,733	26,751
2008- 09	4,918.40	1 ,060	3,190	28,380
2009- 10	5,056.50	1 ,075	3,143	31,358
2010- 11	4,552.10	1 ,091	4,169	28,716
2011- 12	4,470.10	1 ,102	4,634	29,557
2012- 13	4,215.10	1 ,138	5,073	31,055
2013- 14	4,930.30	1 ,185	5,582	31,418
2014- 15	5,073.10	1,182	5,149	32,185
2015- 16	5,846.80	1,237	5,114	35,442
ACGR	1.80%	0.65%	5.10%	6.06%

Source: Pakistan Textile Mills Association

Improvements in energy use efficiency (1.6% per annum between 2005- 06 and 2015- 16) were also observed in the Domestic sector. While this is less than the gains achieved in industry, it is a significant outcome, particularly when one recognizes that electricity use (in absolute term, share of household consumption expenditure, etc.) in the domestic sector is expected to be rising, because:

- In recent years, the country has experienced large shortfalls in power supply, and there is a significant suppressed demand for electricity;
- A large segment of the population (covering both poor households as well as residents of far- flung areas) does not have access to electricity through the grid and DISCOs; and
- Pakistan's per capita consumption of electricity (467 kWh per annum) is still well below that of almost all countries in South East Asia.

Energy use efficiencies have deteriorated in commercial activities and transport sector. A larger quantum of energy is being used for producing the same level of sectoral output or income now than was required in 2005- 06. This trend mounts challenges for the government and sectoral institutions. In transport sector, despite a gradual upgrade of fuel and vehicle standards (to Euro II specifications), there was an increase (of about 0.3% p.a.) in fuel use per unit of sectoral output. This adverse development must be thoroughly evaluated, and targeted interventions to improve the fuel use efficiency need to be developed.

The same trend (with a much higher increase, i.e. 0.67% p.a., in energy use per unit of output) was observed in commercial activities. This increasing trend was partly the result of macro-economic developments in the early part of the last decade. At that time, consumer finance grew rapidly, and banks and financial institutions actively promoted lending to finance modern appliances, e.g. air conditioners. This improved the space cooling situation in buildings, but it also led to increased energy use in offices, shopping plazas, etc. While this could explain why energy use per unit of output has risen in commercial activities, the trend should be reversed and appropriate policy and other actions which help to achieve improved energy use efficiency in commercial activities need to be adopted.

4.5 Mitigation Analysis for GHG emission for Pakistan

4.5.1 Residential and Commercial Sectors

Over 29 million households in the Residential sector consume about 21.6% of the energy, however domestic sector consumes 48.3%[11] of the total electricity. It is pertinent to mention that only 25% of households in the country have access to piped natural gas whereas about 60% of the households (i.e. 130 million people) use traditional biomass (animal dung, firewood, etc.) for general heating and cooking purposes. Burning of biomass in conventional stoves and open spaces has a direct impact on deforestation and pollutes the household environment.

Domestic sector- electricity saving potential

Over 10 million new fans with 80 watts power each are sold annually in the Pakistani markets; their replacement with more efficient fans can save around 50 watts of power each. Moreover, 1.3 million new refrigerators are added to the market annually. Similar trends have been experienced in case of air- conditioners. Worldwide, the efficiency of these appliances has been improving and their costs have been declining.

Table 35:

Electricity savings potential for selected appliances

Appliance	Energy Savings Potential
Lighting	60%
Refrigerators	23%
Fans	50%
Air- conditioners	40%

Sources: RAFTAAR & Asian Development Bank

Electricity saving potential for selected appliances in the residential sector shows a potential of about 40% electricity consumption in the domestic sector. This translates into 3200 MW of power supply at the average system capacity factor of 60%[12]. This potential can be realized by replacing these appliances with more efficient technology.

Domestic sector- natural gas saving potential

A substantial amount of natural gas can be saved in the domestic sector as shown in the table 36. Energy efficiency potential for geysers is about 30%. In addition, the use of solar water heaters can bring down the consumption of natural gas in the residential sector.

Table 36:

Gas savings potential in residential sector

	Gas Savings Potential
Domestic Geysers	30%
Space Heaters	36%
Cooking Stoves	43%

Source: Asian Development Bank, 2009

[11] Energy Year Book 2015

The SNGPL network has two million gas geyser consumers with estimated saving of 15 BCF[12] annually or 41 MMCFD, which is about 9% of the total natural gas consumption in the Punjab. Space heating has 36% potential for improving energy efficiency, replacing existing low- quality space heaters with efficient heaters. Similarly, there is a 40% potential for improving energy efficiency. Promising options for improving energy efficiency in these sectors include:

- Use of efficient lighting appliances, fans, and water pumps
- Efficient air- conditioners, refrigerators and washing- machines
- Efficient cooking stoves and appliances, water heaters, and space heaters

The first two options relate to electricity use in these sectors whereas natural gas is the primary fuel for cooking, water, and space heating. Replacing incandescent bulbs with energy efficient lights and using more efficient fans and water pumps constitute low- cost options, therefore, apply to most households and commercial establishments. By comparison, air conditioners, refrigerators or washing- machines are expensive items used primarily by high- income groups. Replacing them with more efficient equipment, therefore requires focus on that subset of households or offices; however, (because of these appliances, energy consumption far exceeds compared to fans and lights) overall energy savings through such replacements can be much larger. Similarly, many gas appliances are produced in small- scale establishments and workshops, and (normally) do not achieve acceptable standards of thermal efficiency. Replacing existing appliances with more efficient ones is a significant option to save gas for households and offices.

Actions that the government and other stakeholders can take to promote these upgradations include:

- Establish energy performance standards regime for key appliances
- Introduce a testing, certification and approval system to ensure that the notified standards are adhered to;

  - Invest in re- tooling of production facilities to only manufacture/ sell appliances that meet the standards; and

  - Undertake skill upgradation programmes for small- scale/ cottage industry producers of stoves, heaters, water pumps, etc. starting with education and publicity campaigns to demonstrate the benefits of upgrading their manufacturing processes

Other options to save energy and reduce GHG emissions in these sectors include:

- Improved roof insulation and (other) building design
- Solar (and other renewable energy) for lighting, water heating, etc.

These options require investments and the scale of investment required for building/ roof insulations is substantial, so these are relevant or viable only for high- income households or establishments. Nevertheless, these options will be pursued- in many cases by consumers themselves without government involvement, as the cost of solar and other renewable energy equipment has declined sharply in recent years, and these sources of energy are in many cases cheaper than grid or utility supplied electricity or gas.

A common theme that will be pursued in future is to price energy at its true cost of supply, and limit subsidies on electricity or gas to only poor households. The government is aware that subsidizing energy creates a perception in consumers' minds that energy is a free good and using energy inefficiently (or wasting it) is not really an issue. This perception will be countered by adopting 'full cost recovery' pricing policies for electricity and gas.

4.5.2 Building Energy Efficiency Regime

Pakistan is one of the most rapidly urbanizing countries in Asia. By 2025, over 40 million people are expected to live in urban centers and towns additionally[13]. It represents massive and fast

[12] NTDC
[13] UNHABITAT, 2005. "Energy Efficient housing in Pakistan. A case of RC Roofs in Pakistan"

transition from rural to urban settlements.

Most of the areas in Pakistan undergo extremely hot weather condition with high temperature of above 40 ^{O}C in summers. The northern areas remain cold in winters with freezing temperatures particularly in the night. The traditional practices of sleeping outside in night- time in rural areas in south region are still good to save energy. However, urban life is not as conducive to this option as the people spend more time indoors even at daytime. In urban centers, they likely find themselves living in many different housing conditions, with smaller living space and less mobility for women and children, and more time spent inside buildings. The high density in urban areas results in poor levels of indoor daylight and ventilation condition.

Apart from housing, there is a new trend of high-rise buildings for living and commercial purposes in urban setting. In the wake of international trade agreement with China, construction of commercial buildings and new industrial estate will take place in coming years at very rapid rate. Hence, energy efficiency in building sector demands for concrete policy response due to ineffective energy policy as well as weak governance models.

To introduce the energy efficiency regime in Pakistan in building sector, multiple efforts are made at different level. The National Energy Efficiency and Conservation Authority previously known as Energy Conservation Centre (ENERCON) introduced some policy measures to ensure energy efficiency in building sector. The Journey started in 1990 when the Building Code of Pakistan existed but it did not address this energy efficiency issue in building. At that time, ENERCON came up with a Building Energy Code, as an addendum to the Building Code of Pakistan. The building code put forth the minimum performance standards for building windows openings, heating, ventilating and air-conditioning equipment and lighting. Though mostly based on the standards approved by American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE), every effort has been made to ensure its applicability in our buildings. In accordance with the Building Code of Pakistan, which divides Pakistan into five climatic zones, standards have been provided for each zone.

In the backdrop of disastrous earthquake in 2005, UNHABITAT made efforts to introduce the energy efficient housing. UNHABITAT focused to assess the traditional patterns of space and living, traditional construction materials and the changing pattern of construction with the innovation of technologies that were increasingly replacing in urban areas with conventional materials, including cement concrete block walls, firebricks and reinforced cement concrete roofs.

ENERCON is mandated for the energy efficiency and conservation in buildings. It has introduced several projects in coordination with provincial energy departments. Although, after the 18th constitutional amendment, provinces are independent to legislate the relevant laws as per the local needs and demands related to building energy efficiency regime. ENERCON is coordinating with the provincial line departments to ensure the implementation of energy efficiency measures. It is pertinent to note that ENERCON has taken initiatives to introduce Energy Audits Regime in Public Sector Buildings. A five year (2009- 2014) GEF funded project Barriers Removal to the Cost- Effective Development & Implementation of Energy Efficiency Standards and Labeling (BRESL) was also implemented by ENERCON which developed the basis for tested energy efficient products penetration in the market and promoted concept of regional harmonization of energy standards.

4.6 Industry

Industrial sector accounted for 20.3%[14] of the GDP and 43.5% of employment in 2015. It is the biggest energy consumer with 34.6% of total final energy consumption in 2015[15] and contributing over 18%[16] of overall GHG emissions in the country. The major industries in

[14] Economic Survey of Pakistan (2015)
[15] Energy Year Book (2015)
[16] International Institute for Sustainable Development, IISD

Pakistan include textile, fertilizer, sugar factories, cement, steel and large, petro- chemical plants. These industries contribute significantly to the total GHG emissions of the country due to the industrial processes in use, in addition to being responsible for more than a quarter of the emissions attributed to the energy sector.

ENERCON arranged training, education, outreach, and awareness programs for the general public and specific energy users. ENERCON also engaged private engineering consulting firms to conduct "energy audits" and provide energy conservation advisory support in the industrial, agricultural, transportation, and construction sectors[17].

In the industrial sector, ENERCON conducted the tune- up of 600 boilers and 72 furnaces in 387 companies with average efficiency improvement of 6.3%. Steam system diagnostic surveys were carried out in 84 units with 8% of realized efficiency improvement. For electrical system efficiency improvement 40 firms were audited and average efficiency improvement of 5% was realized.

Since 2005, GIZ's Renewable Energy and Energy Efficiency (RE&EE) project has been implemented in 42 units in the textile sector, 5 units in the foundry sector, 2 units in the steel re- rolling sector, 4 units in the edible oil sector, 1 unit in the dairy sector and in eight hospitals which resulted in overall energy savings of 9,340 ToE[18]. The initial phase of the project was completed in 2014. Phase II is expected to be completed in 2017[19].

During the project, in collaboration with APTMA and the Ministry of Industries, Production (MOIP) and special initiatives, various savings potentials have been quantified through energy audits. An energy management system has also been introduced in the textile sector leading to the successful roll- out of measures to improve energy supply. Textile companies are making energy savings of 10% to 20% when compared with their baseline energy consumption.

In August 2005, the "Energy Conservation Project for Punjab Tanneries" (ECPT), a three-year program, was launched for the leather sector to reduce energy wastage through the implementation of EE measures in tanneries. The project, which was funded by the Royal Netherlands Embassy (RNE) was implemented by the Cleaner Production Institute (CPI) in collaboration with Pakistan Tanners Association North Zone (PTA- NZ). Around 80 tanneries partnered with the project and received services in Energy Efficiency Audits. Action plans were also prepared for the implementation of EE initiatives. The energy conservation and efficienct initiatives were implemented in 55 tanneries. Tanneries invested around 22 million PKR for implementation of EE technologies and realized the savings of 34 million PKR over the project period of three years[20].

In December 2005, the Ministry of Industries attached department signed the agreement with GIZ to launch energy audits in the textile sector under Renewable Energy & Energy Efficiency (RE&EE) framework to enhance productivity and quality. In this regard, energy audits were conducted in six units under the supervision of German experts[21]. From 2009 to 2012, the attached departments conducted around 212 preliminary EE audits in 2 phases in the textile sector. In the same period, NPO conducted energy audits in 67 steel units[22].

In July 2007, a comprehensive three-year "Program for Industrial Sustainable Development" (PISD) was launched for the Sugar, Textile, Leather and Pulp & Paper sectors of Pakistan with the assitance of Royal Netherlands Embassy (RNE). The main object of the program was to enable the industrial sectors of Pakistan to comply with national and international environmental requirements and to adopt better EE practices. The project was

[17] Assessment of A.I.D. Environmental Programs Energy Conservation in Pakistan, USAID 1993
[18] http://energyefficiency.gov.np/uploads/14promotion_of__1449654042.pdf
[19] https://www.giz.de/projektdaten/index.action?request_locale=en_EN#?region=2&countries=PK
[20] http://www.cpi.org.pk/ECPTPFirstPagePDF/Success%20Stories.pdf
[21] http://www.npo.gov.pk/npo- services/energy- %5E- environment/
[22] http://www.npo.gov.pk/download.php?ufile=NPO%20Presentation- English.pdf

implemented by the Cleaner Production Institute (CPI) in collaboration with sector specific associations i.e. APTMA, PSMA, PTA. During the project, environmental and energy audits were performed in Karachi, Lahore and Faisalabad. Environmental Management Systems were also developed in the four industrial sectors. The services of the program were provided to 257 industrial units all over Pakistan. The program resulted in an investment of 566 million PKR and realized savings of 782 million PKR over the project period of three years. After successful implementation of Phase 1 of the project, Phase II (three- year program) was launched in 2010 to replicate and scale up the technical outputs of phase I in other industries as well. The services of the program were also extended to three Industrial Estates (Quaid- e- Azam, Sundar and Korangi). In Phase II, an environmental study was prepared on existing environmental policies and regulations. A Sustainability Framework for industrial estates was also developed under the program. Integrated environmental and energy action plans were prepared for 233 industrial units. A wastewater treatment plant design was provided to 17 industries and 6 industries received support for the implementation of the treatment plants[23].

In March 2009, a three- year project, "SCI- Pak Sustainable and Cleaner Production in the Manufacturing Industries of Pakistan", was launched under the SWITCH- Asia programme of the Europeon Unions. The main objective of the project was to improve the Energy and Resource Efficiency (E&RE) of the textile and tannery industries in Pakistan with potential replication in other industrial sectors[24].

In March 2009, the Energy Efficiency and Capacity Project (EECP), a three- year effort funded by USAID, was initiated. The aim of the project was to conduct training and capacity building in the energy sector of Pakistan through the development of industrial energy conservation plans and equipment upgrade for improvement of the power supply situation in Pakistan. One of the components of the project was the Industrial Motors Replacement Program. This program was implemented across all nine DISCOs of Pakistan and resulted in the replacement of 2,100 inefficient industrial motors.

A comprehensive seven- year project, the "National Transmission Lines and Grid Stations Strengthening Project", was initiated in March 2010. The main objective of the project is to improve the reliability and efficiency in the transmission and distribution (T&D) grid. Losses of 19.87%[25], observed in T&D system in Pakistan, are much higher than the neighboring countries, hence reducing the impact of all the efforts done for attaining the energy security. To reduce the T&D losses, the project aims at constructing new and upgrading existing prioritized 500kV and 220 kV transmission lines and grid stations in Punjab and Sindh provinces. The project is being executed by NTDC through a financial assistance of 23,300 million JPY from JICA [26].

USAID has undertaken extensive projects for EE improvement in the country. A five- year Power Distribution Program (PDP), funded by USAID, was started in September 2010[27]. PDP aimed to improve the performance of power distribution utilities (DISCOs) across Pakistan. The project has installed 71,000 smart meters in various DISCOs across the country. It has also involved Geographic Information System (GIS) mapping, load flow analysis and feeder rehabilitation of distribution systems. Rehabilitation of power meters and service cables was also undertaken.

In May 2011, JICA initiated a three- year project to support the upgrade of Technical Services Group of NTDC. The training centre of NTDC (Technical Services Group of NTDC) had been established in 1985 through Canadian assistance to provide training to the staff of NTDC and DISCOs. However, most of the training syllabus had become outdated and the testing equipment obsolete[28].

23 www.pisd.org
24 http://www.sci- pak.org/
25 Power System Statistics 2014 – 15 by NTDC
26 https://www.jica.go.jp/pakistan/english/activities/activity02_13.html
27 http://www.pdip.pk/
28 https://www.jica.go.jp/pakistan/english/activities/activity02_14.html

In February 2013, the Government of Punjab took an initiative by setting up a Center for Energy Research and Development (CERAD) at Kalashah Kaku (KSK) Campus University of Engineering & Technology (UET) in Lahore. It was a research- based project (for a duration of 2 years with a budget of 292 million PKR) which aimed at exploring and utilizing the RE resources in Punjab. The Centre is going to launch an EE&C Advisor Course. The EE&C Lab supported by GIZ is also part of the Centre. This Centre also has testing facilities for motors, solar PV along with a Heating, Ventilating and Air Conditioning (HVAC) laboratory[29]. In Ujaala II program, the Government of Punjab will be testing the solar panels in this facility[30].

In 2014, Ernest and Young carried out a study of Pakistan's industrial energy usage. It was based on audits of 230 manufacturers (conducted between 2006 and 2014) operating in the textile, sugar, paper and leather industries. The European Union (EU) is supporting the implementation of the high- pressure cogeneration projects for the sugar sector of Pakistan under the Switch Asia Program. This is a four- year project started in March 2014[31]. The specific objective of the project is to promote sustainable production of electricity through replication of high pressure cogeneration technologies in the sugar sector. It is estimated that 2,000 MW power could be generated in sugar mills through high pressure cogeneration technologies[32]. The project has prepared detailed feasibility study reports on High Pressure Cogeneration Power Plants for ten sugar mills out of which five sugar mills have acquired the generation license from NEPRA[33].

Business cases for 15 sugar mills have been prepared. The project has also provided assistance to the State Bank of Pakistan (SBP) with regard to revision of its existing Refinance Facility. The project has also built the capacities of local technology providers (six boiler manufacturers), and regulator (NEPRA) in terms of tariff determination, power generation, transmission and distribution.

Since April 2014, UNIDO has been implementing a four- year project in the industrial sector entitled "Sustainable Energy Initiative for industries in Pakistan". The project, funded by the Global Environment Facility (GEF), aimed at stimulating investments in EE projects in industry, which in turn will support industrial development. The project is targeted to address barriers through a sustainable approach for promotion of EE and RE in the Pakistan Industry and by offering a mix of technical assistance and investment activities. The project is focusing on the following three areas: (i) Developing the policy and regulatory framework on the use of RE/ EE in Industry for AEDB/ NEECA, (ii) Creating an investment platform for promoting investments in RE/ EE and scaling up the market, and (iii) Establishing an accreditation center for energy experts on EMS and RE applications in Industry[34]. The project has envisaged the reduction of 2 million tonnes of CO_2 during the project timeline.

In March 2015, the SMEDA and Ministry of Industries and Production of Pakistan started the implementation of a 22 month JICA funded "Energy Efficiency Management Project (EEMP) for Industrial Sector in Pakistan". The project is designed to provide direct benefits to the casting industry and auto parts manufacturing industry of Pakistan. So far, under the project, the technical guidance was provided to 13 casting and auto parts sector SMEs by Japanese energy experts[35]. Energy Management Opportunities for WASAs in Punjab was initiated in order to provide the maximum utilization of resources with reduced costs. Initially, energy cost of WASA was acquired by collecting historic energy bills for year 2014, and an operational survey- the Condition Survey was conducted to determine leakages and other ambiguities in the pipes. In

[29] http://cerad.uet.edu.pk/about- cerad/
[30] PC- I for "Ujaala- II, Provision of Solar Panels to Households Below the Poverty Line- Chief Minister's Ujaala Programme" (2015- 18)
[31] http://www.switch- asia.eu/projects/hp- cogen- pak/
[32] http://www.hpcogenpak.org/
[33] Shahtaj, Safina, Ansari, Bandhi, TAY
[34] https://www.thegef.org/project/sustainable- energy- initiative- industries
[35] http://www.smeda.org/index.php?option=com_rseventspro&layout=show&id=56:dissemination- seminar- of- smeda- jica- energy- efficiency- management- project&Itemid=453

order to build and maintain a database, tools were developed to collect data from Water and Sanitation Agencies.

In June 2015, U.S. - Pakistan Centers for Advance Studies (CAS) in Energy, Water and Agriculture were launched with a support of a 127 million USD from USAID[36]. The USAID funded program, "U.S.- Pakistan Centre for Advance Studies in Energy (USPCAS- E)", is being carried out to focus on applied research relevant to Pakistan's energy needs and help produce skilled graduates in the energy field. Project partners are the Arizona State University and two leading Pakistani universities: National University of Sciences and Technology (NUST) and the University of Engineering and Technology (UET) Peshawar. An 18 million USD funding has been allocated for the project[37]. The core mission of USPCAS- E is to efficiently address and implement the E3 criteria (Energy, Environment and Economy) for sustainable social development. The Centre is committed to create an ecosystem for addressing energy requirements by influencing policy makers, developing technologies, human resources and mobilizing communities for energy conservation[38].

In 2015- 16, ENERCON, in collaboration with WWF, conducted awareness raising sessions for schools with the participation of 5000 to 6000 students. Recently, NEECA, in collaboration with the Pakistan Engineering Council, conducted a special course on industrial energy audits in almost all main engineering universities in Pakistan. Various technical manuals, such as Energy Efficiency in Electrical Systems, Improving Energy Efficiency in Boilers and Tube wells, have also been upgraded. To reduce carbon dioxide emissions from the industrial processes used in Pakistan's major industries. The industrial sector has a huge investment potential. It is estimated that over USD 4 billion can be absorbed in energy efficiency improvements in the industrial sector, with a payback of around 5 years[39].

The majority of small and medium size industrial units use standby generators as a backup option in case of the power outages from the grid, while many units do not even rely on grid electricity and they have their power generation units for self- generation[40] which is more commonly known as captive generation capacity. According to an estimate, the import of backup generators exceeds USD 1 billion per annum[41]. Diesel and natural gas are two sources of fuel for local industry– while some units, especially textile mills, are beginning to use imported Liquefied Natural Gas (LNG) from Qatar. Cement & brick industries meet their fuel needs primarily through local or imported coal. Energy shortages and rising energy prices are driving industries to takes significant measures and reduce energy consumption on a voluntary basis. Some industrial units have already achieved savings of 15% of current electricity requirement. Such energy saving measures were achieved in the textile and sugar industry.

Table 37:

Energy and cost saving potential in the industrial sector in Pakistan

Industry	National Sector- Wide Energy Savings (%)
Textile Spinning	3.50%
Textile Processing	18.40%
Sugar	3.60%
Leather	6.90%
Pulp & Paper	6.30%

Source: IFC, 2014 (Also listed in footer 39)

Table 37 shows the estimated energy and cost saving potential in the industrial sector of Pakistan. The investments in textile industry can be attractive as it offers highest energy efficiency gains. Most energy efficiency gains can be achieved by implementing the most fundamental measures which are as follows:

36 https://uspcase.uetpeshawar.edu.pk/news- events/item/323- official- launching- of- u- s- pakistan- centers- for- advanced- studies
37 https://uspcase.asu.edu/
38 http://www.nust.edu.pk/INSTITUTIONS/Centers/CES/AboutUs/Pages/Welcome- to- CES.aspx
39 International Finance Cooperation, 2014
40 Market Study of Sustainable Energy Finance in Pakistan, IFC 2014
41 Energy Saving in Pakistan, RAFTAAR, DFID 2016

- Improvement in Process Operation, e.g. proper metering in the textile and sugar industry can reduce the energy consumption significantly;
- Replacement of low- pressure boilers with high- pressure boilers to increase the energy efficiency in the sugar industry;
- Installation of Variable Frequency Drive (VFD) on pumps and motors;
- Installation of Heat Recovery Systems (HRS) to exhaust flue gases in sugar and paper industry;
- Thermal insulation of steam lines and valves can reduce the energy losses in almost all the industrial units;
- Improvement of Maintenance Operation, i.e. reduction of air leakages; and Proper maintenance and operation of electrical motors.
- Besides, Electric Motor- Driven Systems (EMDS) in the industry consume almost half of the total electricity. The cost- effective potential to improve the energy efficiency of EMDS in the industrial sector is roughly about 20% to 30%[42].

Promising options for improving energy efficiency in various industry sub- sectors include:

- For the cement industry, convert from single-stage dry kilns to high- efficiency multi- stage kilns, many waste heat recovery and power generation projects have been installed in the cement sector.
- For bricks manufacturing, convert from existing bull- trench/ clamp kilns to zig- zag or other modern designs;
- In textiles and various other industries promoting thermal efficiency improvements, introducing energy audits and periodic inspections of manufacturing processes, energy management practices, etc.;
- Promoting the use of bagasse for electricity generation in the sugar industry; and
- Requiring industries to demonstrate regular maintenance of boilers and other machinery and replacing them with more efficient and high- performance equipment.

The above- mentioned options are directly applicable to large and medium- sized firms and plants, because such establishments have or can access resources (HR, managerial and financial) that enable them to upgrade their manufacturing processes and equipment. The government's role (complemented by private sector involvement in auditing and inspection) will mainly be to ensure that firms acknowledge the beneficial impact of energy savings– and the implied reductions in emissions and invest in adopting energy efficiency as a key objective.

For the small- scale and cottage industry segment, the government's engagement will be two- fold:

a) Provide skill- upgrading opportunities- through fiscal or other incentives for such firms to upgrade their labour and production skills; and

b) Motivate banks and other financial institutions to provide finances to firms that express an interest in energy- efficiency investments.

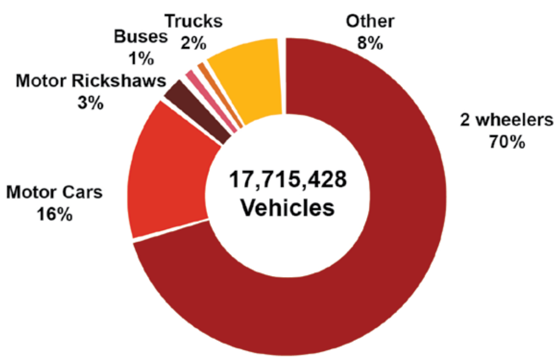
4.7 Transport sector

Transportation sector becomes critical for the economy of Pakistan contributing~ 10 % of the GDP and over 17 % of the Gross Capital Formation. The total road network is about 264,401 km, including national highways, motorways, expressway and strategic routes. The country also has two BRT corridors in Lahore and another in Islamabad- Rawalpindi. They are 27 and 23 km in length respectively. The Lahore BRT is busier and, in 2015, carried about 180,000 passengers per day. The Islamabad- Rawalpindi carried about 125,000 passengers per day. 17,715,428 motor vehicles are estimated to be registered by 2015 road vehicles, of which only 2.2% are buses, taxis and metro- cabs used majorly for mass transportation. Detailed breakup of the registered vehicles has been depicted in the figure 32.

[42] Trends in Global Energy Efficiency: An Analysis of Industry and Utilities, ABB (2011)

Figure 32:

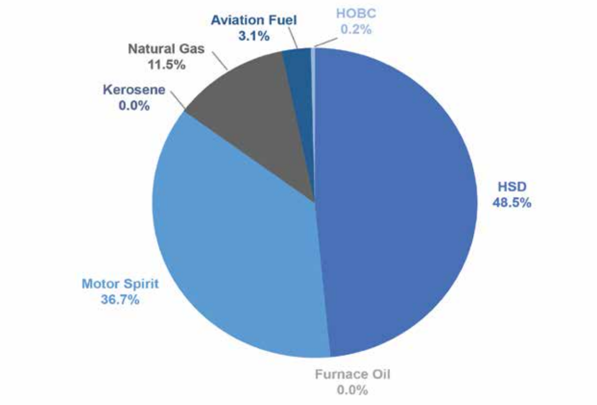
Breakup of total motor vehicles registered in Pakistan



Source: Pakistan Statistical Yearbook- 2015, Pakistan Bureau of Statistics

Figure 33:

Energy Consumption by Transport Sector



Source: Energy Year Book, 2015

Pakistan railways has a 7,791 km route length as of FY- 2015- 16, which has been constant over a decade. 52.19 million passengers travelled in FY- 2015- 16, showcasing a drop of 1.4% over the previous year. The total freight handled in FY- 2015- 16 grew more than three time in two years to 5 million tonnes, majorly driven by transportation of public goods. Civil Aviation also plays a crucial role carrying 19.64 million passengers in FY 2015- 16, 65% of which were for international travel. Further, 338,467 tonnes of cargo was being handled across 31 airports.

Transport sector accounted for 32% of total final energy consumption in 2016. With a contribution of over 13% to Pakistan's GDP, oil (liquid fuels) dominates in the transport energy consumption mix, while the share of natural gas is about 10%. the Pakistan Transport Plan Study (PTPS), a comprehensive transportation master plan for Pakistan for the period from 2005 to 2025, suggests the initiatives required to counter the environmental adverse effects of transport.

Much of this gasoline demand comes from increasing number of motor cars and motorcycles that have been growing at an excessive rate of 10%. According to a study conducted by Canadian researchers, the proper training and driver monitoring can achieve 10%[43] fuel efficiency. The 2013 Framework for Implementation of Climate Change Policy spells out 44 mitigation actions with the following objectives:

- To minimize GHG emissions from transport sector.
- To minimize the adverse effects of aviation's emission on the environment in the context of climate change.
- To upgrade, expand and modernize the railway network in the country.

[43] World Energy Council

Transport sector emission factors

Table 38:

Transport Sector IPCC Non- CO_2 emissions factors

Fuel	CH_4 kg/ TJ	N_2O kg/ TJ	NOx Kg/ TJ	CO kg/ TJ	NMVOC kg/ TJ
Initial Communication 1994					
Gasoline	20	0.6	600	8000	200
Jet Kerosene	0.5	2	300	100	0
Diesel Oil	5	0.6	800	1000	5
Furnace Oil	5	0.6	1200	1000	200
Coal	10	1.4	300	150	200
Natural Gas (CNG)	50	0.1	600	400	20
Revised 1996 IPCC Guidelines					
Gasoline	20	0.6	600	8000	1500
Jet Kerosene	0.5	2	300	100	50
Diesel Oil	5	0.6	800	1000	200
Furnace Oil	5	0.6	1200	1000	200
Coal	10	1.4	300	150	20
Natural Gas (CNG)	50	0.1	600	400	5

Source: 1996 IPCC Default Emission factor database

Table 39:

Transport Sector IPCC SO_2 emission factors

Fuel	Conversion factor TJ/ k tonnes	S content (%)	Retained in Ash (%)	Emission Factor kg/ TJ
Diesel Oil	43.0	0.3	0%	139
Furnace Oil	40.4	4	0%	1980
Gasoline	44.3	0.1	0%	45
Jet Kerosene	44.1	0.05	0%	22

Source: 1996 IPCC Default Emission factor database

Transport sector in Pakistan is characterised by low efficiency and poor performance. It is estimated to have accounted for about 40 Mt of CO_2- eq. of emissions in 2015, around 95% of which is attributed to road transport– from both passenger and freight vehicles. Options for improving efficiency and reducing emissions include:

- To upgrade performance standards for road vehicles[44], and fuel specifications;
- To improve vehicle owners' and operators' attitude towards vehicle maintenance, and (over time) enforce regular maintenance practices;
- To transfer from road to rail particularly for freight, and petroleum products from road to pipelines;
- To switch from fuel to electricity for railways, from diesel and petrol to CNG/ LNG/ Electricity for road vehicles; and
- To establish more, and efficient Rapid Bus Transport systems in urban areas

Upgrading vehicle performance standards and fuel specifications will require agreement on a target date by which local refineries can upgrade their production slate to comply with more stringent specifications. Achieving the full benefits from these actions will, however, remain a challenge if vehicle owners/ operators do not perform regular maintenance on vehicles. Therefore, actions to

a) motivate them to carry out routine maintenance; and

b) monitor vehicle performance once a culture of regular maintenance has been inculcated among vehicle owners/ operators will yield significant results.

This could be achieved by combining vehicle registrations with an annual maintenance certificate. Initially, such certification could cover routine items- such as replacing filters, engine and transmission oils, maintaining correct tire pressure, etc. Over time, the certificate could be enhanced to require annual vehicle inspections/ tests for fuel economy and emissions. These options require administrative actions by the government or involve only recurrent expenditures by consumers and are, therefore, low- cost and short- term actions to improve performance. The remaining options require substantial investments and can be implemented only once the required financial resources are mobilized, i.e. in a medium- to long- term horizon.

ENERCON through Energy Conservation Fund also established Tune Centers of Vehicles and

[44] In addition to vehicles, these standards could cover vehicle spares and replacement parts, tyres and other accessories.

imparted training to road side mechanics and electricians. The program captured lot of attention by general public. ENERCON under GEF funded Pakistan Sustainable Transport project focused on reduction in growth of the energy consumption and related GHG emissions from the transport sector in Pakistan, while simultaneously improving urban environmental conditions and improving Pakistan's trade competitiveness. The project had following objectives:

1. Creating an enabling investment environment for sustainable urban transport;
2. Creating an institutional and policy framework that is supportive of urban transit development;
3. Improving the fuel efficiency of trucking freight transport;
4. Increasing awareness and capacity in Pakistan on sustainable transport.

AEDB also developed the first fuel cell operated electric vehicle through a private contractor which was successfully demonstrated at various platforms.

4.8 Waste sector

Rapid urbanization, population explosion as well as change in lifestyle patterns in Pakistan has resulted in increased volume of waste disposal, which is the prime source of methane emissions. Domestic/ commercial solid waste management system and domestic/ industrial waste water handling practices influence GHG emissions from the waste sector. Emissions in waste sector is a function of consumption rate and population. According to GHG Emission Inventory for the year 2007- 08, the GHG emissions from the waste sector account for 1% of the total national GHG emissions[45].

The inventory has determined that some 4,733 thousand tonnes of CO_2- eq. as methane are discharged from waste management disposal facilities in Pakistan of which 2,832 thousand tonnes are generated from solid wastes and the remainder from the management of waste water[46]. In addition, 772 thousand tonnes of N_2O, CO_2- eq. is also discharged from these sources[47].

Pakistan generates about 30 million tonnes of solid waste a year, which has been increasing with a ratio of over 2% annually. Owing to lack of waste management infrastructure, serious environmental problems are being created. Most municipal waste is either burned, dumped or buried on vacant lots, threatening the health of the general population. According to estimates, 71,000 tonnes of solid waste is generated per day, mostly from major metropolitan areas. Karachi, Pakistan's largest city, generates more than 9,000 tonnes of municipal waste daily. All major cities face enormous challenges on how to manage urban waste. Regulatory barriers, lack of urban planning, inadequate waste management equipment, and low public awareness compound the problem[48].

Landfill sites, if any, are often designed poorly leading to incomplete decomposition, methane production, and contamination of ground and surface water. Fermentation of organic matter in informal waste dumps and industrial organic effluents also has the potential to generate significant quantities of methane, which makes up 45- 60% of the landfill gas mixture[49].

Waste has so far seen a gradual increase in the share of overall emissions in Pakistan. It is expected to grow significantly in the foreseeable future. The share of the waste sector in the current GHG inventory is 3%, which is quite low as compared to the size of the population. However, Pakistan is in the midst of rapid urbanization, which would result in a sharp increase in the overall amount of waste

[45] (PAEC-ASAD (2009): Athar G. R., Ahmad, Aijaz. and Mumtaz, A. Greenhouse Gas Emission Inventory of Pakistan for the year 2007-08 (This report has been commissioned by the Government of Pakistan and is in the final stages of approval and official publishing).
[46] Ibid.
[47] Ibid.
[48] Pakistan Waste Management (2017) Retrieved https://www.export.gov/article?id=Pakistan-Waste-Management
[49] Report of National Economic, Environment and Development Study (NEEDS) Climate Change carried out for Pakistan in 2010-11

generation and consequently an increased share of waste sector emissions. The increased GDP growth rate coupled with an urbanization growth rate of 3% are major considerations in calculation of waste sector emissions. Projected emissions for the waste sector for the year 2030 are 89 Mt CO_2- eq.

4.8.1 Current Policies and Mitigation Efforts

Mitigation measures in the waste sector include source reduction through waste prevention, recycling, composting, waste- to- energy incineration and CH_4 capture from landfills and wastewater. Policies for waste minimization and GHG reduction include taxes on solid waste disposal (bag fees), market incentives (e.g. offsets) for improved waste management and recovery of CH_4, and regulatory standards for waste disposal and wastewater management (e.g. mandatory capture of landfill gas). Specific mitigation options include: waste segregation, reduction at source, composting, anaerobic digestion for biogas, sanitary landfill sites with methane capture, healthcare waste management, proper statutory framework, public participation, private sector partnership, tax waiver for recycling enterprises, and financial management. Regulation is required to ban the entry of recyclable waste in landfill.

Landfill sites have not been selected by many of the municipalities. Wastes are simply collected, transported and dumped on to public land. Islamabad alone produces 387.6 tonnes of solid waste per day[50]. In many municipalities, hazardous wastes are mixed and dumped along with municipal waste. Similarly, industrial waste is burned, dumped or drained in a river or mixed with municipal waste.

4.8.2 Regulatory Aspects

There are different regulatory actions that have been enforced in order to manage solid waste of the country such as National Policy on Control and Safe Management of Radioactive Waste, National Climate Change Strategy & Action Plan 2011- 2015, Guidelines for Handling, Storage, Inspection and Accident Investigation of Hazardous Substances and Hazardous Wastes, Pakistan Environmental Protection Act (PEPA) 1997, Section 11 of the Pakistan Environmental Protection Act prohibits discharge of waste in an amount or concentration that violates the National Environmental Quality Standards (NEQS). Hazardous Substances Rules of 1999, Guidelines for Hospital Waste Management since 1998, Hospital Waste Management Rules (2005), Hazardous Substances Rules (2003), National Environment Quality Standards Rules, Islamabad Capital Territory by Capital Development Authority Islamabad and Section 132 of the Cantonment Act (1924) deals with Deposits and disposal of rubbish, etc.

Prime Minister's Committee on Climate Change also exists, which was formed to ensure the CDM requirements fulfilled under the Kyoto Protocol. This committee has a sub- divisional level technical committee on Waste Management. In 1994, Pakistan joined Basel Convention on the Control of Trans boundary Movements of Hazardous Waste and Their Disposal. The Convention aims to enable the member countries to initiate "Environmentally- Sound Management" (ESM) to protect human health and the environment by minimizing hazardous waste production. Section 12 of Pakistan Environmental Protection Act, 1997 directs that an Initial Environmental Examination (IEE), and wherever the project is likely to cause an adverse environmental effect, an Environmental Impact Assessment (EIA) should be filed with the Environmental Protection Agency (EPA) for review and approval before the initiation of construction at site. Currently, the World Bank is supporting the Urban Unit of Punjab responsible for reforming the solid waste management practices in the province.

4.8.3 Current Activities and Projects

According to the United Nations Environment Programme, there are different activities and plans taking place towards an efficient Waste Management System. These activities are as follows:

[50] Islamabad Waste Amount Survey Report October (2004)

- Solid Waste Management Guidelines (draft) prepared with the support of Japan International Cooperation Agency (JICA),
- Converting waste agricultural biomass into energy/ material source– project by UNEP, IETC Japan
- North Sindh Urban Services Corporation Limited (NSUSC)– Assisting the district government in design and treatment of water supply, sanitation and solid waste management
- Urban Sector Policy & Management Unit, P & D Department, Punjab conduct different seminars on awareness of waste water, sanitation, solid waste management, etc.
- Lahore Compost (Pvt.) Ltd deals with the organic waste with the cooperation of city district government Lahore. The company is registered as a CDM project with UNFCCC.
- Different NGOs are involved at small- scale for solid waste collection, and recycling.

Additionally, in November, 2013, a German company, agreed to invest for the installation of a 100- megawatt power plant, which generates energy from waste from Lahore. Progress is being made on the country's first scientific waste disposal site in Lakhodair. With this in mind, the Lahore Waste Management Company considered other possible technologies for their Waste- to- Energy project. The feasibility study results showed that the power plant had the potential to process 1035 tonnes of municipal waste daily and generate 550 megawatts daily.

- Landhi Cattle Waste Management Project
- Composting of Organic Content of Municipal Solid Waste in Lahore, Version 01
- Compost from Municipal Solid Waste in Peshawar
- Municipal Solid Waste (MSW) Project in Quetta
- Composting of Organic Content of Municipal Solid Waste at Padri Landfill Site Lahore Cantonment

4.8.4 Methodology and Choice of Emission Factors

The GHG contribution from the solid waste sector was calculated by using the IPCC tier I methodology. This is a mass balance approach that involves estimating the Degradable Organic Carbon (DOC) content of the solid waste (IPCC, 1996). Using this estimate, the amount of CH_4 that can be generated by the solid waste was calculated. The choice of emission factors was based on the revised IPCC 1996 guidelines default values for the particular context of solid waste management and wastewater handling practices in Pakistan. GHG emission depends on the waste volume that goes into the Solid Waste Disposal (SWD) sites, Degradable Organic Compounds (DOC) in the waste, waste management practices, and methane recovering facilities of SWD sites.

The estimation of GHG emissions takes into account the urban solid waste generation and emission from solid waste. In the rural communities, the emission has been assumed to be negligible as a big portion of the waste decomposes aerobically in the agricultural field and/ or is used for food stuff for animals. Moreover, there are no solid waste disposal sites in the rural communities. In addition to the population data, different studies have shown that solid waste generation in the urban areas varies from one municipality to another. Estimation of the GHG emission from the solid waste sector can be calculated from the average urban solid waste generation as kg/ capita/ day.

4.8.5 Major Factors Affecting Future Emissions

In Pakistan, major factors that will affect waste growth include: population size, economic development and structural changes besides change in lifestyle. Options to improve energy use in this sector include:

- Utilizing landfill gas;
- Composting;
- Wastewater treatment; and
- Electricity generation based on (sorted) urban solid waste

The first two options have not been tried in Pakistan. The required technology along with expertise to implement such programmes will, therefore, need to be acquired. Wastewater treatment is a mandatory requirement for all industrial units, under existing laws and rules. Therefore, in the future, the focus will be to develop monitoring and enforcement capabilities in the civic bodies and municipalities. The last option– which also applies to compost and landfill gas– has been piloted. A residential colony outside Lahore has installed about 20 MW of power generation capacity to serve the residential and commercial consumers of the colony, using municipal organic waste as fuel. The waste is acquired from nearby urban localities, where private owners have installed waste sorting plants. The power plant therefore uses waste which is free of metals, plastics, oils and lubricants, or other inorganic matter. This pilot scheme did not require government support either for the power plant or the waste sorting facility– and the capital cost of the power plant will be recovered through electricity sales to residents of the colony; it entailed a business-to– business agreement for the power plant operators to acquire the sorted waste– and the cost of the waste sorting plant will be recovered from the charges paid by the power plant; and the facilities are not only disposing of solid/ urban waste in a commercially sustainable manner, but are also providing electricity based on a renewable source to consumers. The success of this venture will be publicized to other localities and will serve as a model for them to replicate.

4.9 Forestry sector

Pakistan has lost about one million hectares of forest cover between 1990 and 2015. This is a significant loss of carbon stock, and the trend has to be arrested and reversed. Some promising mitigation options include:

- Community based forest management– particularly to conserve rare species and conifer forests;
- Agroforestry, particularly on irrigated farmlands;
- Commercial plantations;
- Afforestation of rangelands and degraded lands;
- Riverine plantations; and
- Provision of alternate fuels– to reduce dependency on fuelwood.

Assigning responsibility for managing (some) forest reserves to local communities will require compensating them for adopting sustainable harvesting practices– which implies limiting their harvesting of trees for firewood, training in sustainable management of forests, and introducing community- based monitoring schemes– to guard them against illegal and unchecked exploitation of the resources.

The practice of planting trees on irrigated farmlands is expanding, as farmers start to see the benefits of tree cover by way of protection from erosion and wind and as an economical source of fuelwood. This also indicates that wood- fuel markets appear to be functioning efficiently– the scarcity of wood- fuel is reflected in its price. Promoting even more plantation on irrigated farmlands will not entail any direct support or subsidy– it only requires that wood-fuel markets should be allowed to function, and the government should intervene only to ensure that monopoly and other exploitative behaviour is regulated and monitored. Commercial plantations will emerge if timber and wood-fuel markets function effectively, but some promotional measures will be required.

The provision of alternate fuels for cooking (and space heating, particularly in the northern areas) can serve as a major deterrent against unchecked and unsustainable exploitation of forests. Measures have been taken to enhance the supply of commercial fuels (notably LPG and kerosene) in remote areas. These included ending the monopoly of the publicly- owned utilities over LPG supply, allowing the private sector to import LPG, and aligning domestic LPG prices with an international benchmark price. These policy decisions resulted in large increases in LPG availability and supply over the past 10- 15 years. As a result, total LPG supply expanded from about 277,809 TOE in 2000- 01 to more than 756,414 TOE by 2014- 15. These policies will be continued in future, to ensure that there is no shortfall in the availability of this substitute for fire- wood.

4.10 Agriculture Sector

Agriculture is the backbone of Pakistan economy, which accounts for 19.5 % of the GDP, employing 42.3 % of the labor force and providing raw material for several value- added sectors. The rapid urban growth indicates that demand for high- value perishable products such as fruits, vegetables, dairy, and meat is rising.

The government focuses on increasing the yield for rural growers through major infrastructure investments, including reliable transport networks and other building blocks for modern supply chains. CPEC will go a long way in the enhancement of agribusiness benefits if value-added product innovation and supply chain is tapped.

Agriculture sector emits methane, nitrous oxide, and precursor gases- carbon monoxide and NMVOC s (non- methane volatile organic compound). The sector, in accordance with the IPCC guidelines and national circumstances, includes the following source categories:

A. Enteric fermentation;
   1. Cattle;
      a. Dairy cattle;
      b. Non- dairy cattle;
   2. Yak;
   3. Sheep;
   4. Goats;
   5. Camels;
   6. Horses;
   7. Donkeys;
   8. Pigs;
   9. Poultry.

B. Manure storage systems
   1. Cattle;
      a. Dairy cattle;
      b. Non- dairy cattle;
   2. Yak;
   3. Sheep;
   4. Goats;
   5. Camels;
   6. Horses;
   7. Donkeys;
   8. Pigs;
   9. Poultry.

C. Rice Cultivation;

D. Agricultural soils;
   1. Direct emissions from agricultural soils (including greenhouse farming and excluding grazing);
   2. Direct emissions associated with the use of animal products;
   3. Indirect emissions from agricultural soils, which may be associated with various nitrogen containing substances in agriculture;

E. Burning of agricultural residues.

F. Emissions from savannas burning and cultivated peat soils

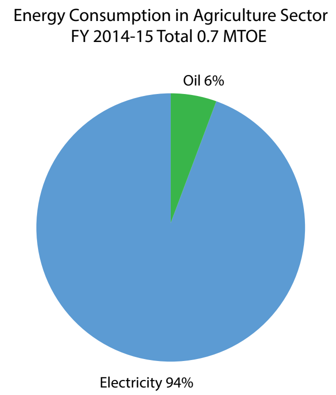
4.10.1 Energy Utilization in Agriculture Sector

Agriculture sector only accounts for 2% of total final energy consumption in Pakistan. Water pumps for irrigation and tractors for soil preparation are major energy consumers in this sector. Besides, the use of commercial energy is also steadily increasing with growing number of mechanized practices to improve agricultural productivity. The process of irrigation through diesel and electric powered pumps is extremely inefficient in Pakistan.

The overall performance of agriculture sector has been sluggish. In 2015, agriculture sector witnessed the negative growth of 0.19%, while the growth of important crops declined by 6.25%[51]. The negative growth in agriculture sector can partially be attributed to the lack of reliable energy supply at affordable prices. Electricity consumption has decreased by CAGR of 3.5% from 0.79 MTOE in 2010 to 0.65 MTOE in 2015, while oil consumption has decreased by CAGR of 8.5% over the same period.

Figure 34:

Final Energy Consumption Agriculture Sector by Source



Source: Pakistan Energy Yearbook 2015

Energy consumption in the agriculture sector has declined by 4% from 2010- 15. Over 90% of the energy consumed in the agriculture sector is in the form of electricity, while 10% is supplied by oil in the form of High- Speed Diesel for irrigation pumps and machinery. On the contrary, the ratio of electricity versus diesel pumps installed in the country is 20:80. Electric tube wells offer high-cost advantages as running cost is much lower than diesel pumps. However, electricity supply in rural areas for irrigation purposes is highly irregular which negatively affects the farmers and reduce yields.

Previously, an initiative to improve energy efficiency in agricultural sector was launched with the assistance of USAID in 2009. The tube-wells Efficiency Improvement Program (TWEIP) was introduced to reduce power demand of existing tube wells and replace them with more efficient pumping systems. The programme offered 50% subsidy to potential farmers, which helped reduce the power consumption of tube wells by 7 megawatts.

Mitigation options for agricultural sector

The 2013 Framework for Implementation of Climate Change Policy spells out 20 mitigation actions with the following objectives:

1. To build institutional and professional capacities for development and implementation of REDD.
2. To restore, conserve and enhance forest carbon sinks and minimize carbon loss from the existing forests.
3. To monitor and evaluate the progress of mitigation actions.

[51] Pakistan Energy Year Book 2015

Many programmes and associated research activities have been/ are being carried out covering the agriculture sector mitigation options specified below:

Table 40:

Mitigation Options for Agriculture Sector

Option	Justification for ranking/ Priority
Improve irrigation and water management	• High emission reduction potential • Prioritized in numerous strategy/ policy documents • High sustainable development benefits • Cost is reasonable
Manage water in rice cultivation to control release of methane from agriculture soils and introduce low water dependent verities	• High emission reduction potential • Included in numerous strategy/ policy documents • High sustainable development benefits • Cost is reasonable
Implement agroforestry practices through plantation of multipurpose and past growing tree species	• High emission reduction potential • Included in numerous strategy/ policy documents • High sustainable development benefits • Cost is reasonable
Promote use of green manure, better manure storage and management	• Medium emission reduction potential • Prioritized in 2013 framework of implementation • High sustainable development benefits • Cost is reasonable
Limit and reduce crop burning practices	• Current practices significant contributor to black carbon • Potential soil co- benefits • Potential for upscaling • Low cost
Other Attractive Options Unable to Quantify/ More Research Needed	
Feedstock mixes, dietary oils, and additives for livestock to reduce methane from enteric fermentation	• GHG mitigation potential • Grounded in GoP framework for implementation and task force on climate change • Potential to increase milk yield • Difficult to quantify GHG impact due to uncertainty on technologies and readiness • Would have an impact on GHGs as feedstock mixes are well established • Oil and additives from live stock are still in early development stage • Near term implementation difficult and expensive • Option for further research and development in longer term
More efficient and targeted use of chemical fertilizers	• Medium GHG reduction potential • Could be implemented short term • Grounded in national climate change policy • Co- benefit to reduce water contamination • Cost associate with planning and implementation
Introduce genetically modified crops that are more carbon responsive	• Medium low emission reduction potential • Included in 2013 framework for implementation • Medium sustainable development benefits • Stakeholder engagement indicates strong base of in country research to build on • Need for more research and development

Source: Pakistan's Low Carbon Scenario Analysis Report

4.11 Land- Use, Land- Use- Change and Forestry (LULUCF)

Historical emissions from the land- use- change and forestry sector remained 2 to 3 % of overall emissions. The projected increase in emissions is based on massive changes in land- use and enormous deforestation which the country is currently suffering and potential use of biomass in energy and industrial processes. Large- scale tree plantation programmes in Khyber Pakhtunkhwa and Green Pakistan Programme are likely to increase forest cover from the current 5 % to 6 %, using domestic resources during the period 2016-2020. An approximate amount of USD 936 million has been allocated for this purpose. An increase in the forest cover from 6 to 10 % by the year 2030 requires an estimated USD 3.74 billion. Projected emissions for the land- use- change and forestry sector for year 2030 are 29 Mt CO_2- eq.

Mitigation options for LULUCF sector:

Many programmes and associated research activities have been/ are being carried out covering the LULUCF sector mitigation options specified below and considered as high priority for application in Pakistan.

Table 41:

Mitigation options for LULUCF sector

Options	Justification for ranking/ Priority
Community base forest management	• Medium emission reduction potential • Prioritized in numerous strategy/ policy documents • High sustainable development benefits • Preservation and regeneration of existing forest is one of the cheapest GHGs abetment option
Preservation of forest land	• Medium emission reduction potential • Included in numerous strategy/ policy documents • High sustainable development benefits • Cost is reasonable
Implement agroforestry practices through plantation of multipurpose and fast- growing tree species.	• High emission reduction potential • Included in numerous strategy/ policy documents • High sustainable development benefits • Very low cost
Commercial plantations	• High emission reduction potential • Included in numerous strategy/ policy documents • High cost but would attract private sector funding
Reforestation of degraded land	• Medium emission reduction potential • Does not covert agricultural land • High sustainable development benefits • Cost is reasonable

Source: Pakistan's Low Carbon Scenario Analysis Report

4.12 Conclusion

Pakistan reiterates its commitment and obligations towards the United Nations Framework Convention on Climate Change and Paris Agreement, and the objective to limit the average global temperature increase to 1.5 to 2.0 ^{0}C. It will continue to play a meaningful role in global efforts towards achieving this goal. A number of mitigation and adaptation measures and actions are already being undertaken with domestic resources. Various initiatives/ measures which are to be or being under taken for mitigation in different sectors has been spelled out in the Framework for Implementation of Climate Change Policy 2014- 30 (see Annexure- E). These measures and actions can be intensified in coming years with expected availability of international climate finance, technology development and transfer, and capacity building.

CHAPTER

5

Integrating Climate Change Considerations into Social, Economic and Environmental Policies

Integrating Climate Change Considerations into Social, Economic and Environmental Policies

5.1 Key Sectors Sensitive to Climate Change

Pakistan, being an active member of international climate negotiation's forum, is part of global efforts to reduce GHG emissions in a way that fits the priorities of its citizens. In line with the other developing countries, it has agreed to craft its nationally appropriate mitigation actions with its national development objectives.

This chapter discusses key sectors of socio-economic importance, which are sensitive to climate change where Pakistan needs to prioritize its adaptation and mitigation efforts.

5.1.1 Agriculture

Agriculture is considered one of the key economic sectors of the country that contributes around 21% to the Gross Domestic Product (GDP). Moreover, it contributes 60% to the country's exports (Government of Pakistan, 2014- 15). The total cropland area of the country is around 23.4 million hectares, which makes around 29% of the total reported area (Asian Development Bank, 2017). Out of this total cropland area, irrigated areas make up around 18.63 Mha (about 24% of the total irrigated area) with around 77% in the Punjab, 14% in Sindh, 5% in Khyber Pakhtunkhwa, and 4% in Balochistan (Government of Pakistan, 2011a).

Crops production under irrigated areas and those under spate farming systems are highly sensitive to the available water amount and temperature variability. By 2040, the agricultural productivity will decrease by around 10% with 0.5 to 2° C increase of temperature (Government of Pakistan, 2011). Moreover, different climate model simulation studies, using the crop- growth simulation model, estimated a decrease in the yield of major crops, specifically the wheat and rice, and the length of growing season in four agro- climatic zones of Pakistan.

For the wheat crop, yield is significantly affected by various agronomic and socioeconomic factors, such as water availability, pesticides, labour supply, household characteristics, including number of women and past experiences, and exposure to extreme events and seasonal weather (Global Change Impact Studies Centre, 2009). Therefore, the country needs to adapt with the projected increasing temperature and need to shift their crops towards heat tolerant crops that could sustain the threats of such increasing temperature without sacrificing the yield. So, it is highly desirable to do a needful research with the help of international community in this direction.

5.1.2 Livestock

The livestock sector contributes around 56.3% to agriculture sector and 11.8% to the total GDP. It supports around eight million rural families, who are directly involved in raising livestock (Government of Pakistan, 2014- 15). The emissions produced by livestock sector create a significant part of the total emissions of the agricultural sector. For example, the contribution from enteric fermentation and manure management produces around 90% of the GHG emissions of the agricultural sector that makes approximately 40% of Pakistan's total GHG emissions (Mir and Ijaz, 2016). Vast rangelands and pastures in the country support the livestock sector, and it is estimated that 60% of land is used as a rangeland in northern Pakistan, Balochistan, arid and semiarid areas of Sindh, and Punjab. These rangelands support around 93 million livestock; in Balochistan province alone, approximately 87% of the total population derives their livelihood from livestock (Ahmad, 2012).

Contrary to agriculture sector, very little information is available as to how climate change affects the world's dairy and livestock system (Thornton, 2015). Even the Fifth Assessment Report (AR5) of IPCC contains very limited information on the projected impact of climate change on livestock systems, especially in Asia. However, a general understanding exists that it will be through degradation of grazing systems due to drought, floods, and a rise in temperature, and ultimately, loss of land productivity, increase in disease epidemics and decrease in fodder quality and quantity (WWF, 2005). Considering the size of the livestock sector and its importance in supporting rural livelihood, it is essential to analyze and better understand the impact of climate change on this sector. However, the research studies performed on livestock management in the face of climate change, especially in the tropical Africa region indicate that there are limitations and high costs are attached to the various adaptation options explored for the enhanced resilience of households and food security (WWF, 2005).

5.1.3 Forestry

Forests make an important natural resource explicitly in the context of rural livelihood. They provide timber, fuel wood, food, habitat for wildlife, and various important ecosystem services to mitigate the hazards of CO_2 and reduce cyclones by controlling strong winds and storms in coastal areas. In Pakistan, forests span an area of 4.19 million hectare, which makes around 4- 5% of the total land area (ADB, 2017). Coastal mangrove forests cover about 3% of the forest area of Pakistan.

The Indus River Delta alone supports around 97% of the total mangrove forests. It is home to over one million people, in which around 135,000 people depend on mangroves for their livelihood (Siddiqui, 1999). We can foresee that most of the anticipated impacts of climate change such as sea level rise, change in temperature and precipitation, and increasing frequency and magnitude of extreme events will severely affect the forest sector that will threaten the biodiversity status, and soil quality.

A limited amount of research work has been conducted on the consequences of climate change on forests in Pakistan. However, a study on the impact of climate change on forest ecosystems of northern Pakistan shows a decrease in forest cover for some plant types and migration of some forest species to a new forest biome, and an increase in net primary productivity of all biomes by using the BIOME3 model (Siddiqui 1999). The study assesses nine dominant plant types or biomes for the climate change impact. Out of nine selected biomes, three biomes (alpine tundra, grassland or arid woodlands, and deserts) showed a reduction in their area, and five biomes (cold conifer or mixed woodland, cold conifer or mixed forests, temperate conifer or mixed forests, warm conifer or mixed forests, and steppe or arid shrub lands) showed an increase in their areas. Net primary productivity exhibited an increase in all biomes and scenarios (Ministry of Planning, Development, and Reforms, 2010).

5.1.4 Water

Pakistan has the world's largest contiguous Indus Basin Irrigation System that largely depends on rainfall, glaciers and snowmelt, and groundwater abstraction. The primary sources of water availability are rainfall events during the monsoon season, and river inflows in the Indus

River System (IRS).

River flows have a high seasonal and annual variability where the magnitude of highest flows is almost double of the lowest flows. Analyses of river flows from 1947- 2003 show a decreasing trend. There was a particularly rapid decline during 1998- 2003, attributed to the persistent drought from 1998- 2004 (Chaudhry, 2017).

The impact of declining glacier mass on river discharge as a result of climate change will be more substantial in the Indus basin because of the high proportion of discharges from melted water. This may cause substantial variations in future water supply in the IRS. Western Himalayan glaciers are projected to retreat, presumably in the next 50 years initially causing increase of Indus river flows. Then, the glacier reservoirs will remain empty, resulting in the decrease of flows by as much as 30% to 40% over the next 50 years. Based on surveys between 1997 and 2002, it is reported that some of the large Karakoram glaciers, which are around 40- 70 km in length and exhibit 5- 15 m of thickening over substantial ablation zone areas. These conflicting findings make the impact of climate change on Karakoram glaciers and Indus river flows uncertain (Chaudhry, 2017).

In 2010, the then Task Force on Climate Change identified some climate change- related threats to water security, which are listed below:

- Increased variability of river flows due to an increase in the variability of monsoon and winter rains, and loss of natural reservoirs in the form of glaciers
- Increased demand of irrigation water because of higher evaporation rates at elevated temperatures in the wake of reducing per capita availability of water resources and increasing overall water demand
- Increase in sediment flow due to increased incidences of high intensity rains, resulting in more rapid loss of reservoir capacity
- Increased incidences of high altitude snow avalanches and GLOFs generated by surging tributary glaciers blocking main non-glaciated valleys
- Increased degradation of surface water quality due to increase in extreme climate events such as floods and droughts
- Lack of current knowledge and monitoring effort on climate change impact in the HKH region, and lack of understanding and modeling capability about the patterns of glacier melt and rainfall feeding the IRS and their corresponding impact on IRS flows.

The key findings regarding water availability and its challenge under climate related threats are listed below:

- Increased variability of river flows due to increase in the variability of monsoon and winter rains
- Uncertainty about future river flow and glaciers melting
- Increased demand of irrigation water because of higher evaporation rates at elevated temperatures in the wake of reducing per capita availability of water resources and increasing overall water demand
- Reduction in water storages capacities due to increased sediments (0.2 MAF/ year)
- Conventional irrigation system with high water losses and low crop water productivity (wheat at 24% and rice at 55% less than the world averages)
- Influence of groundwater recharge due to high level of abstraction and changes in precipitation and evapotranspiration
- Lack of trans- boundary river inflows and glaciers monitoring infrastructure

5.1.5 Energy

Energy is one of the major GHG emissions contributing sector of the economy. It is expected that rising population, economic growth and changing patterns of consumption will ultimately increase Pakistan's GHG emissions. Pakistan energy needs are largely managed by oil and gas where supply and demand follows a precarious path. Whereas Pakistan is the largest consumer of gas in the region despite having the sixth largest reservoir of coal in the world. It is estimated that even with moderate consumption, the country's gas reserves will be depleted by 2025 (Chaudhry 2017).

Most probable impact of climate change on the energy sector is the reduction of changeable water resources for reliable hydro - electric supply, which is a key provider of the country's power sector, leading to reduction in the reliability of the whole power generation system. Variations in water supply will be further aggravated by increased sedimentation of major reservoirs (Ministry of Climate Change, 2012). The climate change- induced natural hazards may also damage oil and gas infrastructure due to heavy precipitation leading to flooding. Major gas fields are located in the vicinity of the Indus river. The infrastructure damage of these resources may stop supply for a long- time putting a large burden on the national economy. Higher temperatures under climate change will increase evapotranspiration rates resulting in increased electricity needs for pumping water for agriculture irrigation. Increased water temperature used for cooling nuclear and thermal power plants affects power plants' efficiency. Supply gaps may arise between maximum demand and the installed capacity in some months during peak hours, as cooling requirements might increase. The increase in share of space cooling will make the peak more pronounced and the reliability of Pakistan's power system will further deteriorate. The operation and maintenance cost of the transmission and distribution system will also increase due to the higher rate of failures in extreme events.

The key findings on projected climate change implications for energy sector are listed below:

- Reduction in water availability for hydropower generation, (the most likely impact of global warming is the recession of Himalayan glaciers that is the largest source of freshwater supply in the country, and this would very likely affect the country's power generation systems).
- Extreme climate events damaging oil, gas, and power infrastructure, (the other major likely impact on the energy sector is damage to oil and gas infrastructure due to heavy precipitation leading to flooding).
- Hotter temperatures increase energy demand, (due to increase in air conditioning and refrigeration requirements particularly in summer, energy demand is expected to increase. Further, climate change induces higher temperatures, and evaporation will increase electricity needs for pumping water for irrigated agriculture).
- Warmer air and water temperatures may affect efficiency of solar, nuclear and thermal power plants, (increase in water temperatures used for cooling of nuclear and thermal power plants will affect the power plants' efficiency).

5.1.6 Coastal Areas

It is expected that sea level impact on coastal areas and its resources may be as large as already evident in the degradation of mangrove forests, inundation of low- lying areas, declining drinking water quality, and decrease in fish and shrimp productivity (Global Facility for Disaster Reduction and Recovery, 2011). Pakistan has a 1,046 km- long coastline that stretches along the border of the Arabian Sea towards South of the country falling within the administrative boundaries of Sindh and Balochistan provinces. The Sindh coastal zone's vulnerability is considered higher than that of the Balochistan coastal areas because of its tidal flat topography and higher population concentration with marked industrial activities along coastal areas, such as Karachi. A Sea Level Rise (SLR) by 2m is expected to submerge 7,500 km^2 in the Indus Delta. SLR may also impact the low- lying Balochistan coastal areas, such as Pasni, since the mean sea level in the coastal town of Pasni is about 1.4 m. However, the Balochistan coast is tectonically active and is uplifted at the rate of 1- 2 mm/ year due to subduction of the Indian Ocean plate (Khan, 2000). The south side of the mouth of Ghoro Creek shows the highest erosion frequency of 176 m/ year with a retreating rate of 425 m from 2006 to 2009 (WWF- Pakistan, 2012). Furthermore, the delta region is both sinking and shrinking due to lack of sedimentation and subsidence. There is an 80% reduction in the river sediment compared to the early 20th century due to extensive damming of the Indus river (Khan, 2000).

The current rate of sediment aggradations of 1 mm/ year no longer exceeds relative projected SLR and this sediment retention is considered one of the primary causes of the effective SLR in nearly 70% of the world deltas, including the Indus Delta (WWF, 2012).

Owing to threats, the Indus is ranked third among the global deltas in the greater risk scale (Chaudhry, 2017). The delta sinking or subsidence process is natural and generally ranges from less than 1 mm/ year to more than 10 mm/ year. This rate is exceeded due to groundwater and petroleum extraction due to humans' activities. The subsidence rate for Indus Delta is not established yet, but deltas in Asia have the highest rate of 2.1- mm/ year subsidence (Tariq 2010). A significant study has inferred the baseline effective sea level rise condition from 2000 to 2050 to estimate potential vulnerability to sea level incursion into deltas (Ericson, 2006). It shows that 0.79% of the Indus Delta population is at risk with 2.73% of the delta area potentially lost by 2050.

Following are the major findings on the projected impact of climate change on coastal areas of Pakistan:

- Increased level of coastal erosion due to sea level rise; (the current level is as high as 176 m per year in some places in the Indus creek system).
- The delta is shrinking due to sediment loss, which is mainly due to extensive damming of the Indus river. The current rate of sediment aggradation of 1 millimeter per year (mm/ year) no longer exceeds relative projected sea level rise and this sediment retention is considered one of the primary causes of the effective sea level rise.
- The delta is sinking due to subsidence. The subsidence rate for Indus is not established yet but the other deltas in Asia have the highest rate in the world at 2.1- mm/ year subsidence.
- By 2050, after seawater incursion into the delta, 0.79% of the Indus Delta population will be at risk while 2.73% of the delta area will potentially be lost.

5.1.7 Transport

Transportation system, which relies on the infrastructure most importantly the vehicles, is supposed to be the lifeline for a nation's growth. Alongside the infrastructure, climate change also affects transport- related features of an area, as these services are also located in the same geographical location. With dense population and high requirements for travel, the conditions in urban areas of Pakistan are more stressing as compared to suburbs or rural areas. This is because of the old infrastructure of airports, ports, railways and highways. Overpopulation, as well as economic and environmental pressures contributes significantly to this stress. Heavy floods or snowfall, caused due to climate- related events impose adverse effects on the transportation system (Wilbanks, 2014). Similarly, in mountainous areas, weather- induced landslides can disrupt transportation systems for extended periods. Sea level rise in addition to storm surge during extreme weather events can also increase the frequency and magnitude of floods in coastal areas. These events of flooding, saltwater intrusion, and corrosion due to storm surges and wave action can lead to serious damage to coastal transportation infrastructure. Higher average temperatures and extreme temperature events may also damage or weaken the structural integrity of transport networks, including bridges and road surfaces.

In economic terms, there are two types of impacts of extreme weather events on the transportation system. The first is the damage inflicted upon infrastructure, such as flood damage to road, rail, and bridges and the second is the economic cost of interruptions to the consumer economy in the operation of the transportation systems, which prevent employees from going to work; goods from being delivered to factories, warehouses, and stores and shoppers from getting to stores.

5.1.8 Urban Infrastructure Services

The climate change impact on urban infrastructure is due to changes in parameters related to weather or climate, either in magnitude or duration. These include changes in temperature (either minimum or maximum), precipitation resulting in heavy floods, frequency and intensity of storms, and sea level rise. In Pakistan, past experiences show that the infrastructure located in areas (which are exposed to such events or near climate- sensitive features such as rivers, coastal areas, storm tracks, or arid areas) is at high risk from extreme weather events. Generally, the urban infrastructure services are interdependent and failure of services in one infrastructure in most of the cases results in disruptions to other connected services. Climate change may increase the frequency of such disruptions in the coming decades. For instance, on 23 July, 2001, a cloudburst resulted in 620 mm of rainfall recorded in 12 hours in Islamabad. Heavy floods in Nullah Lai, a rain- fed tributary that flows through Rawalpindi city, inundated the nearby houses, bridges, and roads. This urban catastrophe resulted in a death toll of 61 people, destruction of 800 houses, and damage to 1,069 houses (Chaudhry, 2017).

5.1.9 Health

Climate change has the potential to affect both environmental and social determinants of health that include safe drinking water, clean air, food security, and secure shelter. This may be disturbed due to extreme heat events, natural disasters, and variable rainfall patterns. Both the frequency and magnitude of heatwave events are projected to increase.

Variations in rainfall and temperature were correlated with the spread of different infectious diseases and food security (Chaudhry, 2017). During the 2010 floods, a preliminary study conducted by United Nations Development Programme (UNDP) found that the proportion of population below the minimum level of dietary energy consumption increased by 3%, thereby adding an additional five million to the population of undernourished people (United Nations, 2010). Similarly, extreme events were correlated with the mental health of the affected population, i.e. extreme events generally cause, distress, depression, aggression, etc. With the rise of temperature, the risk of vector- borne and water- borne diseases also increases. Higher numbers of dengue and malaria cases are due to changes in temperature and heavy precipitation, probably resulting in the increased number of breeding sites for mosquitoes.

5.2 Climate Change Linkages to Key Sectors

Climate change is a cross- cutting issue and necessitates strong linkages with other key sectors of economy that are specifically sensitive and vulnerable to the impact of climate change. The extent to which climate change is integrated in policy instruments across key sectors provides an indication of the extent of climate change mainstreaming. In this subsection, various key sector policies, specifically the National Climate Change Policy are examined.

5.2.1 National Climate Change Policy, 2012

The National Climate Change Policy is the main document, which highlights the policy framework for climate change in Pakistan. In early 2011, the Ministry of Environment, in collaboration with UNDP Islamabad, initiated the process to develop the country's first climate change policy. It took about 1.5 years of extensive consultation to formulate the policy. It was approved by the Federal Cabinet in September, 2012, and then launched by the newly- formed Ministry of Climate Change in February, 2013.

5.2.2 Climate Change Objectives: Adaptation and Mitigation

A number of policies and actions have so far been taken to frame the overall objectives toward climate change adaptation and mitigation. The NCCP of 2012 is the guiding policy document on climate change, acknowledging the growing risk of future extreme natural hazards due to climate change and providing a detailed picture of vulnerabilities faced by individual sectors, eco-regions and socioeconomic classes (Chaudhry, 2017). The major climate threats identified in the policy document are briefly summarized below:

- Considerable increase in the frequency and intensity of extreme weather events, coupled with erratic monsoon rains causing frequent and intense floods and droughts.

- Projected recession of the glaciers in HKH region due to global warming and carbon soot deposits from transboundary pollution sources, threatening water inflows into the IRS
- Increased siltation of major dams caused by more frequent and intense floods
- Rising temperatures resulting in enhanced heat and water- stressed conditions, particularly in arid and semiarid regions, leading to reduced agricultural productivity
- Further decrease in the already scanty forest cover from too rapid change in climatic conditions to allow natural migration of adversely affected plant species
- Increased intrusion of saline water in the Indus Delta, adversely affecting coastal agriculture, mangroves, and the breeding grounds of fish
- Threat to coastal areas due to projected sea level rise and increased cyclonic activity due to higher sea surface temperatures
- Increased stress between upper and lower riparian regions in relation to sharing of water resources
- Increased health risks and climate change-induced migration

The National Climate Change Policy sets out the clear goal of achieving climate resilient development through mainstreaming climate change in the economically and socially vulnerable sectors of the country. The NCCP document identifies the vulnerability to climate change risk with a focus on different sectors and recommends policy measures on mitigation, adaptation, technology, capacity building, and forest- related actions. Furthermore, it has also prioritized adaptation and mitigation efforts due to its low level of per capita GHG emissions.

To achieve the goal of sustained economic development, the NCCP has laid out a set of objectives as stated below:

- To pursue sustained economic growth by appropriately addressing the challenges of climate change
- To integrate climate change policy with other interrelated national policies
- To focus on pro- poor gender- sensitive adaptation while promoting mitigation to the extent possible in a cost- effective manner

5.2.3 Climate Change and National Development Plan (NDP)

This section focuses on the development of a national strategy that may be viable to reflect the present and future threats of the changing climate by inclusion in the National Development Plan (NDP) of Pakistan. We have tried to devise strategies in this document to focus on the climate change issues of the country. This document consists of two sub sections, which discuss the challenges and threats of climate change and development of a strategic plan to include climate change as a major actor of the NDP.

5.2.4 National Climate Change Strategy (NCCS)

Pakistan is amongst the highly vulnerable countries to the impact of climate change. Issues like poverty alleviation, institutional weaknesses, and sustainable development should be addressed on priority basis. The economic growth alone is unlikely to be sustainable or equitable enough to counter threats from this change. An ever- increasing concentration of the GHGs in the atmosphere due to the use of fossil fuels and other human activities has become a major international concern. It is a phenomenon, which is likely to impact almost every sector of Pakistan’s economy. Today, it stands not only as a major environmental problem but also as a multi- dimensional developmental issue. It poses a direct threat to the water, food and energy security of Pakistan.

Implementation of National Climate Change Strategy is urgently needed to:

- Ensure sustainable economic development in different sectors of economy to appropriately address mitigation and adaptation challenges posed by climate change, in particular, the threats to Pakistan’s water, energy and food security

- Make full use of new developments in science and technology for effectively addressing climate change issues
- Contribute to the international efforts to check climate change by controlling Pakistan's own GHG emissions to the maximum extent feasible, and
- Build the capacity of the institutions concerned, and establish effective national and international linkages to adequately address the issues.

5.3 Major Climate Change Related Issues of Pakistan

The most serious challenges for Pakistan are threats to its water, food and energy securities, due to:

- possible drastic shifts in weather patterns, both on temporal and spatial scales, in particular increased variability of monsoon
- likelihood of increased frequency and severity of extreme events such as floods, droughts and cyclones
- increase in sediment flow due to increased incidences of high intensity rains resulting in more rapid loss of reservoir capacity due to siltation
- rapid recession of the HKH glaciers, causing reduction in the capacity of natural reservoirs and affecting the magnitude and pattern of water inflows into the IRS
- increased incidences of high altitude snow avalanches and GLOFs generated by surging tributary glaciers blocking main un-glaciated valleys
- increased degradation of surface water quality due to increase in extreme climate events
- severe water- stressed and heat- stressed conditions in arid and semi- arid regions, leading to reduced agriculture productivity due to increased heat- and water- stress as well as more frequent and intense floods and droughts and power generation
- abundance of insects, pests and pathogens in warmer and more humid environment, particularly after heavy rains and floods
- reduced productivity and fertility of livestock due to heat- stress
- degradation of the rangeland and further deterioration of the already degraded cultivated land areas such as those suffering from water erosion, wind erosion, water-logging, salinity, etc.
- adverse impact on power generation capacity due to irregular river flows and more frequent and intense floods and droughts
- increased health risks (heat strokes, pneumonia, malaria and other vector- borne diseases)
- increase in deforestation, land erosion and soil degradation
- risks to fragile marine, mountainous, and coastal area ecosystems
- loss of biodiversity
- increased upstream intrusion of saline water in the Indus delta, adversely affecting coastal agriculture, mangroves and breeding grounds of fish
- threat to coastal areas, including the city of Karachi due to sea level rise and increased cyclonic activity due to higher sea surface temperatures
- limited technical expertise in the country for the climate change research, and
- low adaptive capacity to adverse climate change impacts due to lack of technical know- how and low financial resources

5.4 Disaster Preparedness

Climate change projections are scenario based, and hence have some degree of uncertainty. Nonetheless, there are strong indications that in South Asia, particularly in Pakistan, climate change is intensifying the floods, droughts, draughts, etc. Pakistan is already experiencing climate change impacts which are too visible to ignore. Most disasters or hazards that lead to destruction cannot be prevented; their impact however, can be minimized by adaptation and preparedness measures. To address disaster management in the context of climate change in a holistic manner, the government, in collaboration with other relevant entities, needs to make strategic measures.

5.5 Socio- economic Measures

5.5.1 Poverty

Climate change poses a serious risk to poverty reduction efforts and threatens to undo decades of development efforts. While it is a global phenomenon, its negative impact is more severely felt by the marginalized socio- economic population. They are more vulnerable because of their high dependence on natural resources, their limited technical capacity and insufficient financial resources. One of the objectives and goals of economic development planning in Pakistan is poverty alleviation. With the onset of climate change, the plight of the poor is becoming even more miserable. Therefore, it is imperative to incorporate the possible impact of climate change on communities living in deprivation and poverty, into future developmental plans. The Millennium Development Goals (MDGs) have specified a way forward by combining efforts towards poverty alleviation along with management of climate change impact and environmental degradation effects. A renewed effort is needed to involve local communities in population control programmes and in managing natural resources as a part of training and education towards economic well- being. To address the problems of the poor communities living in urban areas and those living in the rural areas practicing agriculture, in the context of climate change, the government needs to make strategic measures.

5.5.2 Gender

Climate change affects the underprivileged regions, communities and people disproportionately as they are more vulnerable and have the least resources to adapt. In Pakistan, women are likely to be strongly affected by climate change as the majority of rural women are engaged in agriculture sector, which is highly climate sensitive. Climate change is expected to increase the work of agriculture production and other subsistence activities such as fuel wood and water collection, putting extra pressure on women. Further, women are found to be more vulnerable during extreme climate events and disasters. Pakistan fully recognizes that women are powerful agents of change. It is, therefore, vital to ensure participation of women and female gender experts in all policies, initiatives and decisions relating to climate change. To address the gender aspects of vulnerability from climate change, the government in collaboration with other relevant entities needs to make strategic measures.

5.5.3 Institutional capacity

Pakistan is least prepared to meet the 21st century's biggest challenge of climate change as far as human resources and institutional capacities are concerned. Insufficiently trained human resource is a big constraint due to a brain drain, limited investment in climate change education, and lack of demand and opportunity for skilled individuals in Pakistan. The country does not have enough climate change scientists, modelers, technologists and experts, who can handle international negotiations, which are critical for every country. Similarly, there is a lack of credible institutions to deal with the climate change science, modeling, management, adaptation, mitigation, and policy issues. Since capacity building and institutional strengthening is a priority area for the government, a number of area specific policy measures are mentioned in the relevant sections and will generally not be repeated here.

There are several organisations, which can make useful contribution towards addressing climate change. It has been planned to:

(i) enhance capacity of all such organisations,

(ii) introduce climate change related scientific disciplines in the leading universities so as to ensure a regular supply of trained manpower, and

(iii) establish a National Data Bank for climatological, hydrological, agro- meteorological and other climate change related data to cater to the needs of all relevant institutions.

Also, core groups will be developed for climate change adaptation at the national, provincial and local levels.

Adequate national resources will be allocated to combat serious consequences of climate change and conduct R&D on issues such as changes in precipitation patterns, cyclones, droughts, floods (including flash floods), glacial melt and GLOFs. The development of partnerships will be encouraged by bringing together multiple sources of funding. This includes availing opportunities and processes for accessing donors support and other resources for climate change projects and interventions that increase resilience to face the adverse impact of climate change in the country.

However, the government needs to take strategic steps to address the deficiencies in climate change related requirements, human resources and institutions.

5.5.4 International and Regional Cooperation

Developing countries face the dual challenge of addressing the negative impact of climate change and pursuing socioeconomic development. Hence, it is essential that they work together to face these challenges. Pakistan is committed to engaging vigorously with the international community to find solutions and help the world towards a new era of global cooperation on climate change. South Asia is particularly prone to climate change related disasters making the need for a regional response to meet the challenge urgently. In order to achieve this international and regional cooperation, strategic measures are needed.

5.6 Development of NCCS for Inclusion in NDP

The groundwork of a sound national strategy for climate change would require crucial assessment of what is already in place and what existing mechanisms and processes the strategy can be built on. The strategy should also reflect upon time dependency of different components or phases, including the urgency with which the strategy is needed, the efficiency of the decision-making processes on the part of the government and the complexity of the underlying issues of climate change.

5.6.1 Strategy Options for Climate Change to Reflect in NDP

Regarding good strategy options, we propose the following phases in the process of reflecting climate change as a major issue to be adapted in the National Development Plan (NDP).

Phase I: Launching the strategy building process

The key outcomes of this critical phase should be a decision and a plan to develop an NCCS. This mainly depends upon the government procedures, for example, through a decision of parliament, or the minister with responsibility for climate change. Some of the processes that can be useful in getting the decisions agreed may include advocacy, sensitization, and dialogue with politicians, policy- makers, and decision-makers. for example, through conducting policy dialogue workshops, national policy discussions for preparation or monitoring of the NCCS, etc. Along with the leadership decisions, the strategy needs technical management and leadership to coordinate the design of the strategy, working closely with staff and other stakeholders of the NCCS. Members of the design team should come from various parts of the strategy, including structures of government, policy makers, politicians, scientists, and other stakeholders. Once the decision is made, the agencies leading the preparation of the strategy need to prepare a road map to set out the requirements as what needs to be done by whom, when and how it will be financed.

NCCS design road map

Design process is critical, and success of all other phases depends upon this phase being properly executed. Very important decisions need to be taken in the design, i.e. regarding the relevancy of the strategy to the NDP objectives, arrangements that need to be made for the proposed strategy for efficient delivery, timelines, the main actors, and the implementation and practicability of the strategy. Mechanisms also need to be ensured about the political support, endorsement and reporting. Assessments need to be made, i.e. as a country do we have the capacity and skills to undertake the task or do we need assistance. If so, what form should it take, and what funding and/ or technical assistance would be required and how will it be sourced. The strategy design process will be mapped out, setting out the major stages and processes, including how and when political and financial commitment to implementing the strategy will be secured. Engaging potential donors at this stage will be important for the NSDS to serve as a coherence framework for multilateral and bilateral assistance.

Building a constituency, identifying stakeholders, and managing consultation

Experiences from countries that have produced strategic climate change development plans, and from the processes to design and manage climate change strategies, have highlighted the importance of inclusive consultation and communication. At the initial stage, therefore, it will be necessary to identify stakeholders and put in place processes to get them involved. This can be initiated through a stakeholder analysis, which would identify the relationship of stakeholders within the NCCS and analyze their involvement and relative influence. In this way, key actors may be identified and be brought into the process. Different stakeholders will have different interests and need varying types and degrees of involvement. Some might need to be the part of core or extended design team. Others will need to be consulted at the stages of processes appropriate for their involvement. Some will be the part of political or technical management and approval processes for the strategy design and outputs.

Non- government organizations, civil society and business community need to be involved. Umbrella organizations might be suitable intermediaries, for instance civil society federations and trade unions. Individual academics, who are knowledgeable, interested and have time can also add considerable value as data analysts and users. There are likely to be key issues and stages in the design process when broader consultations and discussions will be needed, for instance, to launch the process and consult on the vision and draft reports. It will be possible and helpful to link these broader consultations to other processes, for instance on up- dating or monitoring the strategy or other policy frameworks.

A strategy launch workshop would engage key stakeholders and tell them what is expected of them. It might introduce relevant management principles and how these, if appropriately applied, can lead to significant improvements in national climate change considerations. Outline proposals for designing the NCCS and prepare for implementation may include outlining processes and timelines, introducing participants to relevant international experience, guidelines, standards, frameworks and concepts.

Developing a communications plan

The strategy design team will need to keep stakeholders informed throughout, communicating key messages, keeping the momentum going and building wider support for the strategy, for instance amongst parliamentarians and the general public. It is often important for both to consult and communicate and to be seen to consult and communicate in order to build commitment and ownership of the process beyond those directly involved in the design process. This may slow progress down but yield long- term benefits. A communication plan will be helpful and need to be supported by staff time as well as a budget. Different modes of communication and messages are likely to be needed for different audiences. A regular briefing note or newsletter could be addressed to all identified stakeholders, reporting progress and inviting comments and contributions. A separate briefing arrangement might be needed for parliamentarians, preparing the ground for instance for new legislation as well as regular reports to those responsible for both the technical and political management of the strategy process (e.g., steering committees). Informing and building support more generally could be tackled through media, including press releases and briefing, radio and TV interviews, and posters.

Phase II: Assessment of current status of national climate change actions

Need for assessment

Very few countries want to start strategic planning from scratch and the purpose of a strategic plan will normally be to improve an existing national climate assessment system. In most cases, countries will for instance already be participating in national climate actions. The purpose of the existing action plans will be to build on and extend the existing approaches to cover all data sectors and users, including prioritizing climate output parameters.

As the first step in developing a strategy, it is desirable to carry out an in- depth assessment of the current status of the system, including from the user perspective and taking account of existing improvement programmes. The assessment should be realistic, objective, and critical. It should use best practices and be benchmarked against international standards and frameworks as appropriate. The assessment should lead to an understanding of the adequacy of the outputs and the organization and management of the NCCS as a whole. Specifically, it should lead to an understanding of the users' current and perceived future requirements for climate information, their assessment of the adequacy of existing knowledge and the gaps in planned data, their priorities and their ability to make effective use of climate change information. The strategy should also be based on the climate change statistics currently available, their sources and how quickly they are made available to users (publication and dissemination policies).

Assessing user satisfaction and needs

There are many types of users from politicians, government agencies, public and private sector companies, civil society organizations, academia, media, general public, donors and international agencies. They need distinct climate information for various purposes and vary in their capacity and sophistication of their use of information. Some needs may have been suppressed by the lack of available resources, and potential demand should be considered as well as current demand. User needs cannot be properly met unless these have been properly identified, synthesized, understood and prioritized. It is important to emphasize that users invariably have a long list of need for resources, and every effort should be made to guide users to identify their priorities. Also, user needs, and priorities are always changing and tracking these changes requires that consultation and dialogue with users should be an ongoing activity. This can be done through various approaches to assessment of user needs. As with assessment generally, it is likely that the design team will be able to build on existing processes, but a benchmark assessment of user needs is recommended for the NCCS.

One approach for user involvement is to identify those who are interested in particular data sets or groups of data and arrange contacts with these users. The mailing list used for dissemination of statistics and those frequently in contact with the NCCS may be a good start in identifying the main data users. Selected institutions from each of the main user groups should be included in the consultations and discussions held with them, either individually or in small groups, whilst others might be invited to contribute to writing. The process should ensure that policy and decision- makers as well as technical staff in user institutions are consulted. A second approach to user involvement that has met with success in a number of countries is country workshops. These workshops bring together data compilers, data users, and donor agencies. The workshops deal with specific statistical topics of interest to participants and in addition encourage dialogue among groups of compilers and users. The workshops have proven useful in sensitizing participants to the importance of climate change, providing progress reports on data improvements, and discussing new issues.

Phase III: Developing the vision and identifying strategic options

These activities are built on the assessment, including agreeing on a mission and vision statement, agreeing on desired results, setting priorities and strategies, employing scenarios to deliver the vision and results.

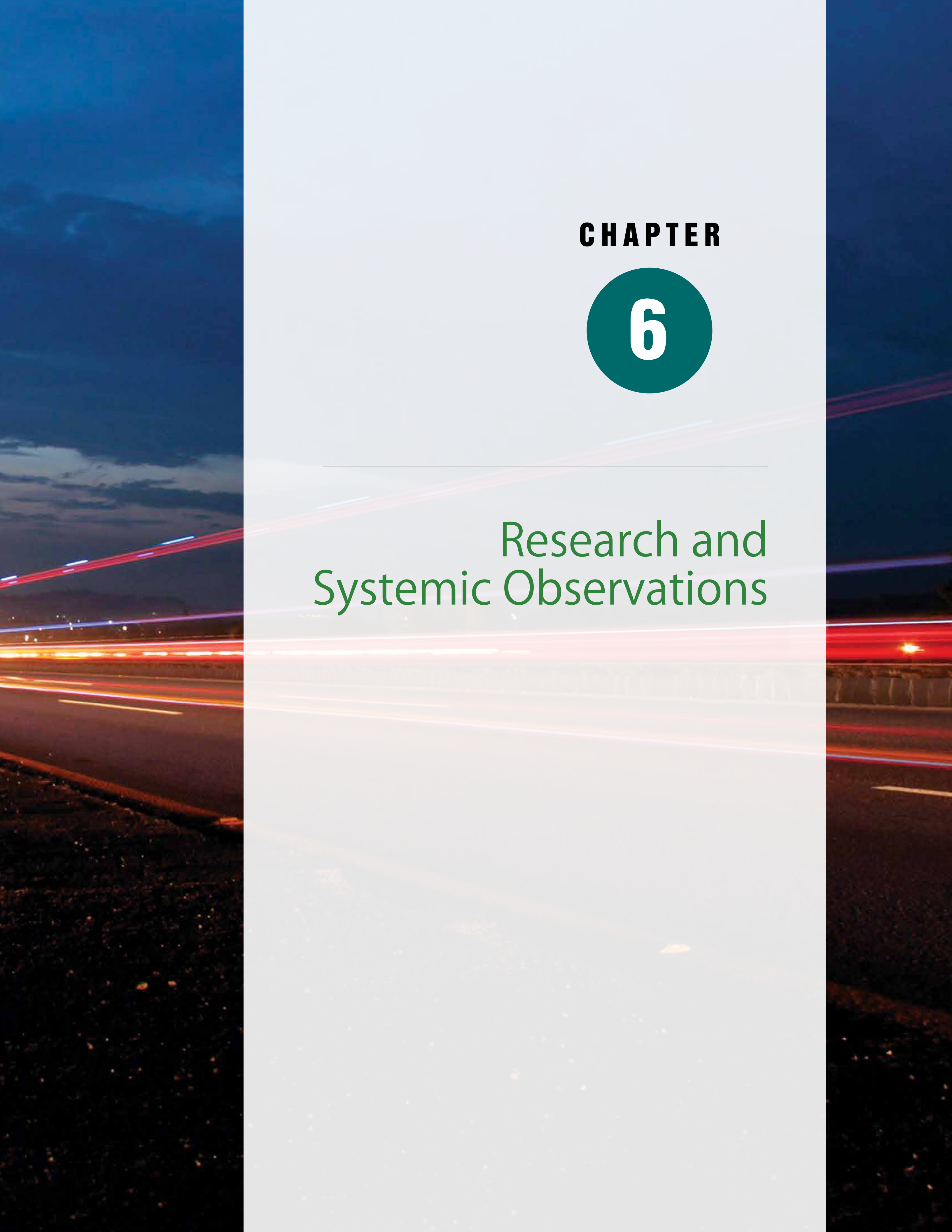
Phase IV: Preparing the implementation plan

It is important to point out that "right strategies" are not all that are needed to make an NCCS effective. The strategies have to be properly and effectively implemented through a costed and time- bound action plan, including a financial plan incorporating proposal for external assistance.

Phase V: Implementation, monitoring and evaluation

The most important consideration is to see strategic management, as a continuous process and the preparation of initial document represents only the beginning. To be effective statistical systems must remain flexible and respond to new demands for data and a changing environment. Any medium- term plan, therefore, will inevitably require modification in the light of experience. The strategic management process, therefore, needs to build in mechanisms to monitor and evaluate progress, to review the strategy and to make modifications when required.


SLOW
NHA AT WORK



CHAPTER

6

Research and Systemic Observations

Research and Systemic Observations

6.1 Climate- related Research Institutions

In Pakistan, the promotion of research and development in almost all the fields especially climate change remained the priority agenda of successive governments. Apart from some of the independent think tanks and non- governmental organizations, a number of ministries/ departments are engaged in climate- related research activities. They are:

- Global Change Impact Studies Centre
- Pakistan Meteorological Department (PMD)
- Pakistan Council for Research in Water Resources
- Space and Upper Atmosphere Research Commission
- Pakistan Agricultural Research Council
- Ministry of Climate Change
- Ministry of Science and Technology
- Ministry of Food Security and Research
- Ministry of Water Resources
- Ministry of Energy,
- Ministry of Defence
- Ministry of National Health Services, Regulation and Coordination

6.2 Assessment of Measurement Equipment for Meteorological Observation

PMD provides meteorological services throughout the country for numerous public activities and projects which require climatic information. Apart from meteorology, the department extends services in the fields of hydrology, earthquake seismology, and geomagnetism. The main objectives of PMD are to provide information on weather, climate and geophysical phenomenon with the aim of traffic safety in air, on land and sea, mitigation of disasters, agriculture development based on climatic potential of the country, climate change, impact assessment, future projections of climate and adaptation options in different sectors.

Meteorological observations for rainfall, temperature, snowfall, extreme events (such as floods, droughts, heatwaves, tsunami), and GLOFs in northern Pakistan are being carried out mainly by the PMD, H&R WAPDA & GMRC. A total of 97 observatories (Meteorological, Pilot balloon and Aeromet) are in place at the moment throughout the country, (see Table 42 and Figure 36), while there are still 40 districts where there are no met observatories as shown in Figure 37.

Continuing along the path of modernization, four Weather Surveillance Radars have been installed at Karachi, D.I Khan, Islamabad, and Rahim Yar Khan. Quantitative Precipitation Measuring radars have been installed at Lahore, Sialkot, and Mangla. A radar at Mardan is being installed for early warning of Nullah Kalpani (a stream) flash floods. These radars have the capability to monitor the weather systems and their characteristics up to a radius of 300 kms. Advancement of Remote Sensing and Satellite technology has provided a lot of ease to the meteorologists in order to observe and study different weather patterns in detail. Pakistan has two satellite ground receiving stations in Karachi and Islamabad.

For hydro- meteorological services and flood forecasting, Flood Forecasting Division (FFD), Lahore is a specialized unit of PMD for this purpose. The FFD responsibilities are:

(i) Flood forecasting

(ii) River stream flow forecasting

(iii) Water availability forecast for dams and

(iv) Water management assistance at dams specially during monsoon.

Figure 39 shows the detailed Flood Forecasting System of PMD. FFD is responsible to improve the capacity of meteorological and hydrological services to timely deliver more accurate products and services required in flood forecasting and warning in collaboration with disaster managers, active in flood emergency preparedness and response. It collects floods data and information from Water and Power Development Authority (WAPDA), Irrigation Departments, Pakistan Commissioner for Indus Waters and the regional Met data shared through GTS (Global Telecommunication System) and integrates weather, climate and hydrological forecasting information to make available in a relevant format for use by civil organizations responsible for disaster preparedness and mitigation. National Disaster Management Authority (NDMA) serves as the implementing, coordinating and monitoring body for disaster risk management at the national level. FFD along with NDMA provides information to general public, news media, flood warning centers and rescue & relief agencies.

Table 42:
Existing Weather Radars in Pakistan

No.	Year of installation	Station Name	Type of Radar	Made by	Age (years)
1.	1991	Islamabad	C- Band	Japan	26
2.	1991	Karachi	C- Band	Japan	26
3.	1996	D. I. Khan	C- Band	Japan	21
4.	1996	R. Y. Khan	C- Band	Japan	21
5.	1997	Lahore	Doppler & S- Band	USA	20
6.	1978	Sialkot	C- Band	USA	39
7.	2004	Mangla	Doppler & S- Band	USA	13

6.3 Weather Forecast by PMD

PMD issues following main types of weather forecasts:

- Short Range Weather Forecasts (24 hours)
- Medium Range Weather Forecasts (5- 7 days)
- Long Range Weather Forecasts (1- 3 months)
- Water availability forecast for dams

Table 43:

Details of PMD Observatories in Pakistan

Islamabad	Punjab	KP	Sindh	Balochistan	GB	Kashmir
1	31	15	18	18	9	5

Figure 35:

Meteorological observatories map of Pakistan

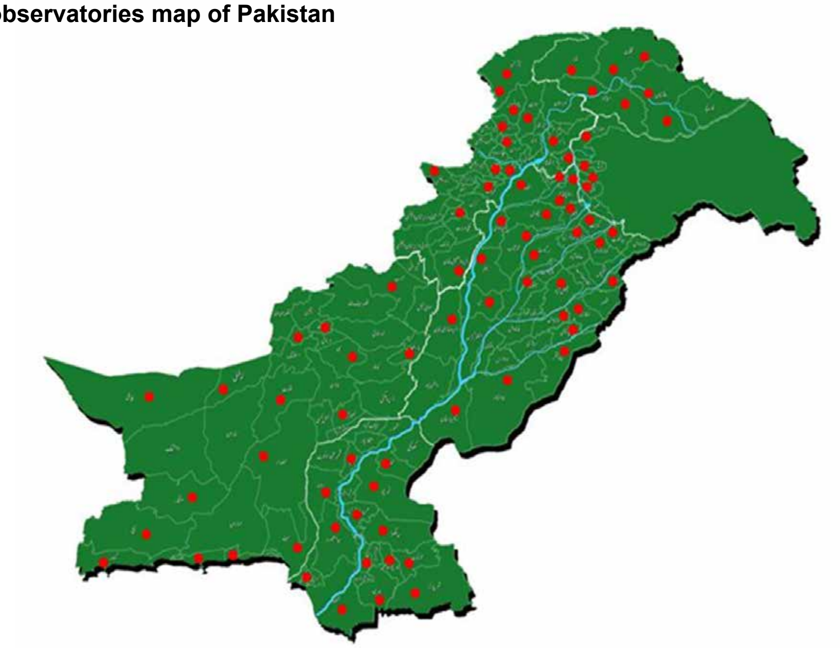


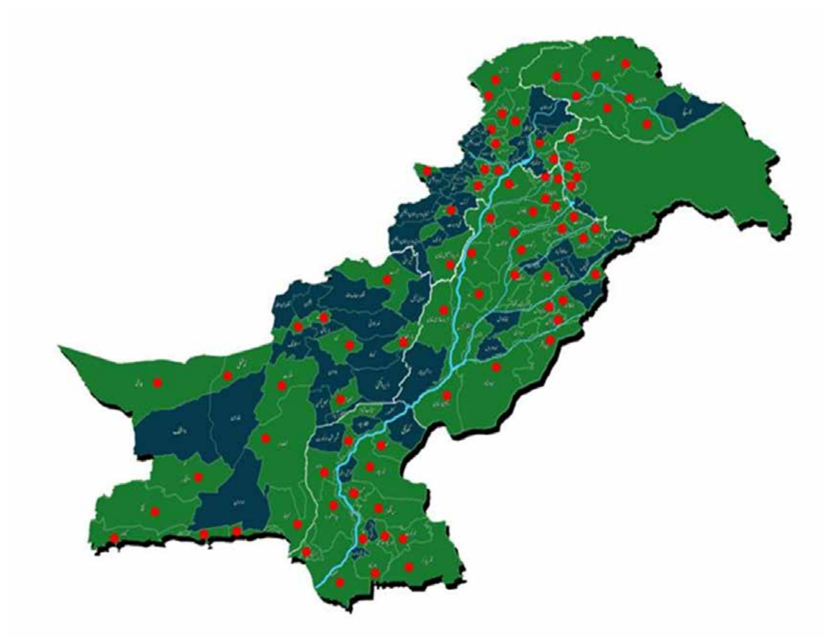
Table 44:

Details of PMD Observatories in Pakistan

Punjab	Sindh	KP	Balochistan	Fata	AJK	G-B
9	7	8	14	0	0	2

Figure 36:

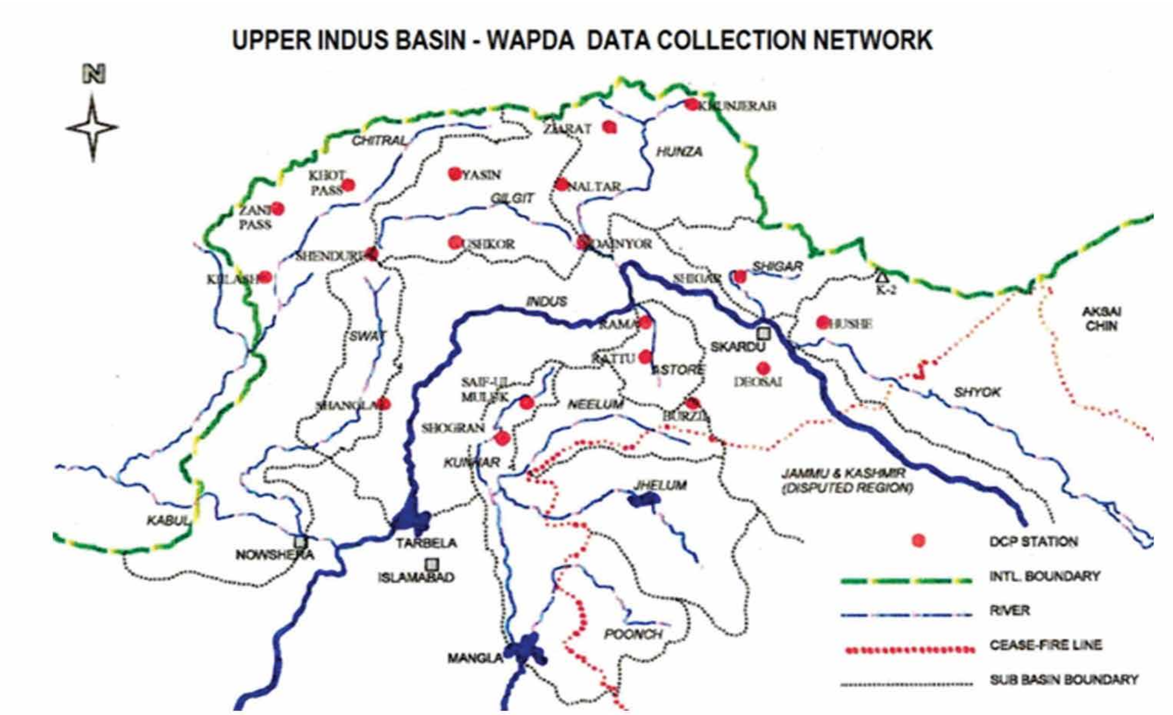
Districts which don't have meteorological observatories in Pakistan



To supplement the leading role of PMD, WAPDA is another prominent state organization which has a hydro- meteorological gauging network. It has exclusive 20 meteorological stations; Data Collection Platforms (DCPs) in the northern region as shown in Figure 38. These DCPs were installed as part of one of the WAPDA's project named as Snow and Ice Hydrology Project (SIHP). Under this project, WAPDA carried a lot of work in the Upper Indus Basin (UIB) regarding snow and ice dynamics of Pakistan.

Figure 37:

WAPDA's DCP stations' network in the mountainous north of Pakistan (Source; WAPDA)



Apart from PMD and WAPDA, Space and Upper Atmosphere Research Commission (SUPARCO) is the third main organization which deals with meteorological and atmospheric observations. It has Satellite Ground Station (SGS) facility in Islamabad. The station provides satellite data support and services to various public sector departments, including PMD and WAPDA. Atmospheric data receiving and processing centre at Karachi acquires and processes data from various satellites, including MODIS (Aqua/ Terra), NOAA series (AVHRR) MTSAT and FENGYUN satellites. ADRPC was established in 2008 for receiving data from Geostationary as well as Polar orbiting meteorological/ environmental satellites. The data is used in climate change studies, snow cover mapping, drought monitoring, monitoring of oceanographic parameters, including marine environment, sea surface temperature and phytoplankton and monitoring of disasters.

Pakistan Space Weather Centre (PSWC) set up by SUPARCO consists of country- wide ground-based instruments for acquiring round- the- clock space weather data. Its archives, processes and disseminates information, Pakistan has also launched its own PAKSAT- 1R Communication Satellite which has disaster recovery application along with its other many applications. PakTES 1A, Pakistan National Student Satellite Programme (PNSSP) and Pakistan Space.

Under Space Applications Program, SUPARCO has undertaken a number of projects targeting towards the socio- economic development of the country. They are: agriculture, disaster relief & mitigation, natural and anthropogenic disasters (such as floods, cyclones, dust storms, oil spills earthquakes, depletion of glaciers, fog, etc.), land management, mineral resources prospect, and glaciology. Excessive glacial melt can also result in increased hazards like floods, landslides, or avalanches, forestry and coastal ecosystem.

6.4 Dealing with Climate Induced Disasters

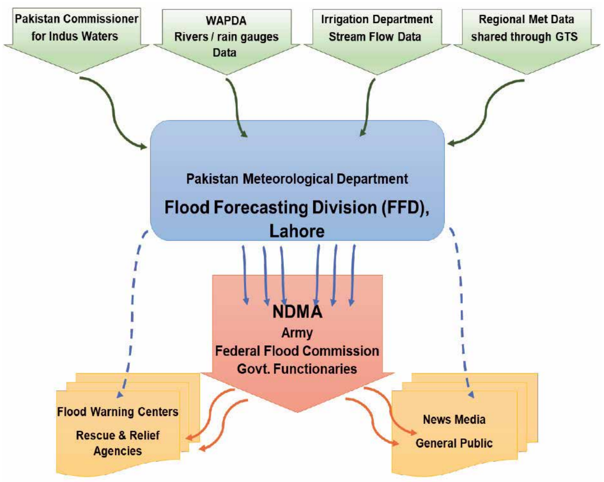
In 2005, when the country was hit by a massive earthquake that caused huge losses to the economy, NDMA was established to take measures for the prevention of disasters, mitigation, preparedness, and capacity building to deal with disaster situations as necessary. Later, after the 18th Constitutional Amendment, Provincial Disaster Management Authorities and the Provincial Disaster Management Commissions were set up at provincial level in line with the devolution plan to empower the provincial and local managements. Previously, the Provincial Relief Commissionerate had been responsible for the relief, compensation and rehabilitation of people affected by natural disasters. After its establishment, the functions have been handed over to the PDMA.

In 2011, National Disaster Management Ordinance (NDMO) was made an Act and the District Disaster Management Units (DDMUs) were created to facilitate PDMAs work. Under the National Action Plan, 2009 and 2010, Pakistan carried out Disaster Risk Management (DRM) especially in terms of capacity building initiatives in the field. In the future, they wish to incorporate disaster risk reduction into all development goals. They also aim to continue to strengthen the capacities of the DRM institutions. Although Pakistan shows commitment at the institutional level, the achievements are neither comprehensive nor substantial. The focus lies mainly on emergency response rather than DRM. There is still a lack of awareness among institutions to take disaster risk reduction as a basic part of development. There is still a lack of capacities as the field is relatively new and there is a lack of financial means. At a provincial level, the institution still needs to work on awareness, capacities and budgetary provision. There is a need for more meaningful participation from the civil society and the humanitarian community to ensure ownership of the national DRM policies by all segments of the society.

Figure 39 shows the existing flood forecasting, early warning and management mechanism of the country that depicts the role of a number of national agencies with a central role of PMD.

Figure 38:

Existing flood forecasting system of Pakistan



Source: National GHG Inventory

PMD has established operational and specialized centers that develop operational products for the benefit of disaster managers, planners and communities. The following are the operational and specialized early warning centers:

- National Weather Forecasting Centre (NWFC), Islamabad
- National Drought Monitoring Centre (NDMC), Islamabad
- National Seismic Monitoring & Tsunami Early Warning Centre (NTWC), Karachi
- Marine Meteorology & Tropical Cyclone Early Warning Centre (TCWC), Karachi
- Flood Forecasting Division (FFD), Lahore
- Flood Forecasting & Warning Centre for Nullah Leh Basin, Islamabad
- GLOFs Early Warning Center for GB and Chitral

6.5 Main Challenges & Issues related to Meteorological Observations and Disaster Management

According to Pakistan Meteorological Department, following are the challenges and issues Pakistan is facing at the moment related to meteorological observations and to deal with disasters.

- Lack of hydro- meteorological data and gauging technology: Table 45 presents a comparison of Pakistan with other countries that clearly supports this argument
- Early warning systems for urban flash flooding
- Tsunami warning system & Seismic monitoring network
- Human Resources and capacity building to adopt new and advanced technologies

Table 45:

Comparison of meteorological observatories of Pakistan with other countries

Country	Met. Stations	Radars	AWS	Wind Profilers
Pakistan	97	7	25	0
Japan	1300	29	1200	16
China	2423	323	45926	58
Bangladesh	35	5	100	2
India	650	33	675	6

6.6 Recommendations

As discussed above, there are still 40 districts in Pakistan where there is no meteorological observation station in place. In particular, the mountainous headwater catchments of the Indus river (also called the upper Indus basin-UIB) has an extremely sparse network with no stations above 4700 meters above sea level having long- term records. The number and spread of flow measuring/river gauging stations also need to be increased, especially to monitor major streams in the high elevation zone to supplement the scarcity of climate records.

Similarly, there is an utmost need to improve and increase the satellite and radar data acquisition by participating in the regional and global data and information exchange efforts so that early warning systems can perform efficiently especially in disaster prone areas.

Table 46 provides a numeric list of required instrumentations and facilities to upgrade the existing meteorological observation system and improve early warming and management of climate induced disasters.

Table 46:

Pakistan's need for upgraded meteorological equipment

No.	Equipment Required	Qty
1	Weather Radars	18
2	Establishment of New Observatories Strengthening/ Up- gradation (Automation- WMO)	40 97
3	Automatic Weather Stations (AWS)	400
4	FFD- Establishment of Regional Flood Forecasting Centres	05
5	Establishment of GLOF Stations	15
6	Establishment of Flash Flood Warning Centers	15
7	Seismology (Tsunami- 10, Earthquake- 10)	20
8	Aviation: Wind Profilers	8
9	Awareness/Technology (FM- Radio Channel)	-
10	Capacity buildin- Advanced Technology	-

(Source: PMD)

CHAPTER

7

Development and Transfer of Environmentally Sound Technologies

Development and Transfer of Environmentally Sound Technologies

7.1 Environmentally Sound Technologies (ESTs)

Article 4.1 (c) of UNFCCC binds its members to promote Environmentally Sound Technologies (ESTs), practices and processes that reduce GHG emissions. Pakistan's high vulnerability to adverse impact of climate change, specifically extreme climatic events, imply that the country is in critical need of innovative adaptation of ESTs to protect its natural ecosystems along with people and properties. Innovative adaptation of these technologies plays an essential role in mitigating climate change, dispensing with its causes and at the same time adapt to its outcomes. Therefore, their wide dissemination is essential. With the realization of this fact by the public and private sectors, ESTs are being given high priority in sustainable development policy dialogue and implementation frameworks of Pakistan. Projects such as Technology Needs Assessment (TNA) have been launched to identify the needs of ESTs for mitigation of, and adaptation to climate change.

ESTs are not just individual technologies but can also be defined as total systems that include knowhow, goods, services, and equipment, as well as organizational and managerial procedures. They:

- apply to the transitioning of all technologies in becoming more environmentally sound
- capture the full life cycle flow of the material, energy and water in the production and consumption system
- cover the full spectrum from basic technologies that are adjunct to the production and consumption system, to fully integrated technologies where the environmental technology is the production or consumption technology itself
- include closed system technologies (where the goal is zero waste and/ or significant reductions in resource use), as well as environmental technologies that may result in emission
- consider technology development within both the ecological and social context

Ecological principles, cleaner production and appropriate technologies are involved in the adoption and use of ESTs. It also involves the use of environmental technologies for the prevention and control of pollution, monitoring and assessment, remediation and restoration of the natural environment.

Prevention involves technologies that avoid the production of environmentally hazardous substances or alteration of human activities in ways that minimize damage to the environment.

It encompasses product substitution or the redesign of an entire production process, rather than simply using new pieces of equipment. Monitoring and assessment technologies are used to establish and monitor the condition of environment, including releases of pollutants and other natural or anthropogenic materials of a harmful nature. Control technologies render hazardous substances harmless before they enter the environment. Remediation and restoration technologies embody methods designed to improve ecosystems that have declined due to naturally induced or anthropogenic effects.

7.2 Identification of Sectors

The sectoral shares of GHG emissions has been shown in Table 47.

Table 47:

GHG emissions by sector

Sectors	Mt CO_2	Percentage Share
Energy (Power)	126.694	34.3
Transport	42.572	11.6
Industries	14.301	3.9
Agriculture	165.295	44.8
Forestry and land use change	9.671	2.6
Waste	10.470	2.8

Source: Ministry of Climate Change (2016)

The sectors mentioned in Table 47 as well as Table 18 are the main contributors to climate change in terms of GHG emissions. Water sector is being adversely affected by climate change and is impacting the future water availability. So, the consumption demand for water is increasing day by day due to increase in the country's population.

Based on the analysis of the above information and the details given on GHG emissions of Pakistan by USAID (2016), different sectors are being prioritized in the following order for Technology Need Assessment of ESTs.

- Power
- Transport
- Agriculture
- Water
- Forestry
- Waste Management

7.3 Needs Assessment

Technology Needs Assessment (TNA), which is the first step in understanding the need for technology transfer, provides an opportunity to identify the needs for new technology, equipment, knowledge and skills for mitigating the effects of climate change. This section discusses the TNA in order to achieve the goal of climate resilient development. The objectives of needs assessment for ESTs are to:

- identify key social, economic and environmental development priorities of Pakistan mentioned in various policy and development plans, such as Vision 2025 (Ministry of Planning, Development & Reform 2014) strategy papers on poverty reduction (Ministry of Finance 2009), policy papers such as climate change policy (Ministry of Climate Change 2012), etc.
- identify and prioritize suitable technologies that contribute to climate change adaptation in the relevant sectors.
- devise an enabling framework for the development and diffusion of prioritized technologies in relevant sectors by analyzing technology barriers.

All- out efforts are being done to enact, legalize, set standards, develop and implement policies for a secure and lively environment. The strategies, policies and plans of the government acknowledge that ESTs play an essential role for the mitigation of environmental hazards. The ESTs are sector specific, hence needs assessment of each sector is performed separately as described in the following sections.

7.3.1 Power

Pakistan has been facing energy shortfall for the last two decades. This situation forced the domestic as well as industrial users to rely more upon generators running on furnace oil, increasing GHG missions in return (Ministry of Climate Change, 2016). The government has come up with certain directives to overcome this problem, which are briefly discussed here.

Future directives for power sector

According to Vision 2025 by the Ministry of Planning Development and Reforms (2014), Integrated Energy Plan 2009- 2022 by the Ministry of Finance (2009), Policy for Development of Renewable Energy for Power Generation by Alternative Energy Development Board (2006) and Pakistan's Energy Vision 2035 by the Sustainable Development Policy Institute, following goals need to be achieved for environment- friendly power generation.

- Power generation through renewable energy resources (a minimum of 9,700 MW by 2030
- Promotion of alternative energy technologies and product
- Efficient power generation
- Construction of big dams for power production
- Construction of energy efficient buildings

Needs assessment of ESTs in power sector

Pakistan's Energy Vision 2035 (Abbasi *et al.,* 2014), TNA Mitigation Report (Ministry of Climate Change, 2016) and Policy for Development of Renewable Energy for Power Generation (AEDB 2006) were reviewed for identifying the following technologies, needed to be deployed for achieving the future objectives (Section 4.1.1) in power sector:

- Increased energy efficiency for boilers and furnace by using them optimally
- Energy efficient buildings and introducing energy management systems
- Renewable energy technologies and products (wind energy, solar energy, micro hydro power, biogas, etc.)
- Use of clean shale gas
- Increasing awareness about energy management in domestic and industrial consumers
- Laws and regulations for implementing international standards of energy management
- Introducing the culture of energy audits in industries

7.3.2 Transport

Transport, a paramount sector of Pakistan's economy, contributes to 10% to the GDP, 6% to employment and consumes more than half of the total oil (Ministry of Climate Change 2016). As a result, the GHG emissions for this sector contribute significantly to the total emissions of the country. Within transport sector, road transport plays a major role. Owing to lack of public transport, the number of vehicles plying on the roads has increased thereby increasing the consumption of hydrocarbon based fuels, which results in increased GHG emissions, especially CO_2.

The Metro bus or Bus Rapid Transport (BRT) service is operational in Lahore, Islamabad and Rawalpindi. Similarly, the BRT corridor in Multan is being operated as Multan metro bus system. The Punjab Mass transit Authority is in the process of starting operation of integrated public transport system (feeder routes) in Rawalpindi and Multan. The provincial government of KPK is also developing BRT in Peshawar. However, according to the Engineering and Development Board (EDB), effective inspection and regular maintenance of the buses will be required to reduce the overall emissions.

For a sustainable transport sector, the federal government has launched the National Automotive Development Policy 2016 with the objective to establish a modern, competitive and viable automobile and auto parts industry capable of meeting national and regional demands by 2021. Future directives for the deployment and transfer of ESTs in transport sector are mentioned in the following section.

Future Directives for Transport Sector

In the light of National Transport Policy (2006), National Climate Change Policy (2012), National Energy Conservation Policy (2007), National Automotive Development Policy (2016), Pakistan

Vision (2025) and National Energy Conservation Act 2016, the future directives to make transport sector environmentally- sound and sustainable are as follows:

- Provision of fuel efficient public transport
- Up gradation of railway tracks and road networks
- Promotion of hybrid vehicles
- Construction of walking tracks for short distances

Needs Assessment of ESTs in Transport Sector

According to TNA reports (MoCC 2016, 2017), following are the major future directives for the deployment of ESTs in transport sector:

- Mass transit system
- Up- gradation and proper management of road and railway networks.
- Reduced taxes on import of hybrid vehicles and production of hybrid vehicles locally
- Introduction of engine emission standards
- Awareness campaigns as to why people should walk, use public transport and bicycles for shorter distances

7.3.3 Agriculture

The agriculture sector itself is the most sensitive to climate change effects (Tanveer *et al.,* 2009). Agriculture and food security in Pakistan are particularly threatened due to increased heat and water stress on crops and livestock. Besides, a higher frequency of floods and droughts causes changes in climate. The effects include changes in crop patterns, land- use- systems, crop productivity potential and availability of water (Tanveer *et al.,* 2009).

In 2009, Pakistan Agriculture Research Council (PARC) introduced drought- resistant wheat variety (Tanveer *et al.,* 2009). Another project (titled: Introduction and Adaptation of high value crops and fruits in climatic conditions of the Punjab) has also been initiated by Agriculture Department Punjab with the objective to promote diversified, climate resilient and sustainable agricultural production systems in the changing environmental scenario. There are some other ongoing projects for the development of basmati rice hybrid resistant to flood and salinity in the Punjab, heat resilient maize hybrids, rainwater management in cotton fields to minimize the impact of climate change, and promotion of high value agriculture through the provision of climate smart technology package. Khyber Pakhtunkhwa (KPK) government introduced a climate change policy with the aim to work on innovative methodologies for adaptation of agriculture sector to climate change. The future directives for the mitigation and adaptation of climate change in agriculture sector are mentioned below:

Future directive for agriculture sector

The National Conservation Strategy (1993), National Environmental Policy (2005), National Climate Change Policy (2012) and Khyber Pakhtunkhwa Agriculture Policy were reviewed to identify the following future directives for adaptation of ESTs in agricultural sector:

- Promotion of climate change resilient crops production
- Breeding of climate change resistant livestock
- Improved and efficient irrigation system
- Appropriate application of fertilizers and soil carbon management

Needs assessment of ESTs in agriculture sector

Based on the TNA reports (MoCC, 2016, 2017), new schemes of the Punjab Agriculture Department, and Khyber Pakhtunkhwa, the ESTs needed in this sector are:

- High efficiency irrigation systems for irrigated and rain- fed areas
- Drought and salt tolerant crop varieties
- Climate monitoring and forecasting early warning system
- Improved livestock breeding
- Off field crop residue management

7.3.4 Water

Water is the basic necessity for human survival.

Pakistan is becoming a water scarce country (ENERCON, 2007) because of water resources mismanagement and population expansion. However, it meets the demands of various sectors, especially agriculture, industrial and domestic (Alternate Energy Development Board [AEDB], 2006). Flooding due to melting glaciers, and droughts due to climate change (Ministry of Climate Change [MoCC], 2016) are the two major threats the country is faced with.

PARC has initiated some new projects such as bioremediation of sewerage water for safe food production in peri urban areas, solar energy for desalination of saline water and exploitation of horticulture potential of rain-fed and dry regions, including Potohar, Thal, and Khyber Pakhtunkhwa. Pakistan Council of Research in Water Resources has also completed public sector development projects in rainwater harvesting, combating drought and desertification in Thar and Cholistan deserts. Water and Power Development Authority is also carrying out some research studies regarding groundwater management.

Future directives for water sector

According to Vision (2025), Vision (2030), Vision (2035) and Energy Conservation Act, following goals and directives have been identified for the promotion of ESTs in the water sector.

- Effective management of water resources
- Increase in water storage capacity
- Provision of clean drinking water to every individual of Pakistan
- Prevention of hazardous super floods

Need Assessment of ESTs in Water Sector

According to TNA reports, the most suitable technologies and procedures for ESTs deployment in the water sector are listed below:

- Groundwater recharge (managed aquifer recharge)
- Urban storm water management
- Flood Early Warning System
- Furrow irrigation
- Construction of big dams and reservoirs such as Bhasha Dam

7.3.5 Forestry

Plants and trees that keep the environment fresh, clean, and pollution- free provide resistance against natural calamities like floods. In rural areas of Pakistan, wood is used as fuel for cooking and heating purposes, incurring damage to the forests. Besides, using trees for commercial purposes (i.e. for furniture making) and unplanned urban and industrial expansion are also the reasons for deforestation.

A project for afforestation has recently been completed along highways in the Punjab by the provincial Forest, Wildlife & Fisheries Department. A billion- tree plantation project has already been launched in KPK by Forestry, Environment & Wildlife Department. Another 5.5 million trees will be planted in the Punjab over the period of five years from 2016- 2021. A project has been initiated for the enhancement in range lands production and planting of fodder trees for farmer community by the Forest, Wildlife, & Fisheries Department. However, concrete efforts are required for the efficient deployment of ESTs in this sector. In this regard, the future directives regarding mitigation and adaptation of climate change in the forestry sector are given in the following section.

Future directives for forestry

According to Vision 2030 (2007), KPK Climate Change Policy (Environmental Protection Agency Khyber Pakhtunkhwa), Vision 2025 (2014) and Vision 2035, the following goals are identified as future directives for the forestry sector:

- Reducing the use of forest land for agricultural and industrial purposes
- Afforestation and reforestation programmes with plantation suited to the effects of climate change
- Sustainable Forests Management (SFM) in accordance with national and international best practices
- Increasing awareness among masses about the importance of trees and forests

Needs assessment of ESTs in forestry

According to the TNA reports, the most suitable technologies and procedures needed to be adopted in this sector are:

- Social/ Farm forestry as carbon sink
- Reducing emissions from deforestation and forest degradation
- Sustainable forest management
- Rehabilitation of mangroves
- Fire management in forests
- Use of solar thermal energy and biofuels for cooking and heating purposes instead of wood
- Awareness campaigns in educational institutes and communities about the importance of tree plantation and forests

7.3.6 Waste Management

Waste management especially solid waste management is a challenging task in Pakistan especially in big cities. According to Environment Protection Department, Punjab, solid waste generation ranges between 0.283 to 0.612 kg/ capita/ day and the waste generation growth rate is 2.4% per year. Solid domestic waste is typically dumped on low lying land that could be used for more productive purposes; secondly, potentially valuable recyclable materials are lost.

In Pakistan, inadequate waste management, and its improper collection and disposal are the critical issues, however, some progress in this regard has been observed in recent years. A policy on solid waste management was prepared in 2005 by Pakistan Environment Protection Agency, but strict measures are required for its implementation. Similarly, National Policy on Management of Radioactive Waste has also been formulated by Pakistan Nuclear Regulatory Authority in 2014. All the radioactive waste produced by Pakistan Atomic Energy Commission is saved and secured by the organization and stored at Pakistan Institute of Nuclear Science and Technology, and Karachi Nuclear Power Plant.

Future directives in waste management

According to the Solid Waste Management Policy (2005), National Environment Policy (2005) and National Conservation Strategy (1993), major directives in this sector are:

- Promotion of waste minimization
- Improvement in technical systems of solid waste management, including garbage discharge, collection, storage and transportation of hazardous material
- Upgradation of garbage processing and treatment methods
- Recycling and improved final disposal

Needs assessment of ESTs in waste management

Following technologies can be useful for the development and transfer of ESTs in this sector.

- Wastewater treatment and reuse
- Biogas preparation from cattle dung
- Fuel production from kitchen waste
- Usage of black bags for residual waste and ban on the usage of plastic bags
- Public awareness campaign to promote the usage of plastic bins in public areas, avoid littering the waste and recycling of paper, glass, and food waste

7.4 Barriers and Recommendations

After discussing the needs assessment of ESTs in different sectors along with future directives, it is necessary to identify the barriers in deployment and diffusion of ESTs in different sectors and make recommendations as to how transfer and diffusion of these technologies can be made in Pakistan.

Identification of barriers and recommendations presented in this section are based on surveys. Pakistan Council of Renewable Energy Technologies also conducted a detailed survey and collected primary data to identify the barriers and recommended for an efficient transfer and diffusion of ESTs in different sectors.

Barriers to technology transfer vary according to specific context from sector to sector. However, some of the barriers are common to all sectors. The common and sector specific barriers along with recommendations to overcome them are summarized in Table 48. A review of different official documents concluded that the barriers for an efficient deployment and transfer of ESTs in all the sectors are classified as follows:

- Economic
- Social
- Technical
- Governmental (policies, implementation and management)

Table 48:

Barriers and recommendations for an efficient deployment and diffusion of ESTs in different sectors

Category	Sectors	Barriers	Recommendations
Economic	All	• High Capital Costs • Risk of investment • Scale of investment by developed countries is less • Lesser financial incentives	• Financial assistance in the form of subsidy, low taxes, and soft loans • Need to exploit alternative revenue generation sources • Level of investment by developed countries needs to be scaled up • Soft loans and low tax rates
Social	All	• Lack of awareness • Technology push vs market pull • Lack of transfer experience	• Wide dissemination of knowledge and information to raise awareness level • Provision of test and demonstration facilities to end users • Proper training programmes
Technical	All	• Lack of skilled manpower • Limited institutional capacity • Insufficient locally manufactured technologies	• Capacity building of institutes • Increased technical trainings
Miscellaneous	Renewable Energy Sector	• Lack of technological skills • Government policies, strategy and regulations without incentives for the promotion of renewable energy • Less coordination between • Govt. departments and NGOs	• Need to increase certified technicians trained by accredited institutions • Encouraging private sector to introduce leasing and installation of renewable energy technologies. • Improvement of coordination between stakeholders
Miscellaneous	Transport Sector	• Absence of national transport policy • Employment Loss for people working in existing transport system • Lack of long- term plans and strategies	• Development of National Transport Policy supporting BRT • Create alternative jobs • Adoption of energy efficient measures • Local manufacturing of efficient buses to reduce cost • Domestic manufacturing and installation of the computerized tune up equipment and machineries to reduce cost

Category	Sectors	Barriers	Recommendations
Miscellaneous	Agriculture Sector	• Limited communication among technology developer, supplier, and users • Limited R&D capacity • Limited human skills and training in designing and installation of systems • Small underdeveloped market • Weak supply chain and distribution mechanism	• Need to improve coordination and collaboration among national, regional and international organizations and R&D agencies for data and products sharing • Training of farmers and other users, including agriculture extension staff • Need to increase number of testing facilities and skilled staff • Need to increase allocation of financial resources for the modernization, expansion, and up- gradation of climate monitoring, forecasting, and early warning systems
Miscellaneous	Water Sector	• Limited financial allocation for local governments • Lack of sound comprehensive cross sectoral policies for resource protection, development and management • Limited institutional capacities especially at local level in integrating climate change risks in development planning • Limited human skills and maintenance especially at local level	• Ensure the availability of sufficient local development funding • Approval of water policy with special focus on water conservation and sustainable groundwater management • Define administrative boundary of groundwater aquifers and authorize a single ground water management body in each province • Recognize the role and authority of water user organization and/or other indigenous administrative set up in formal decision- making processes. • Resolve ownership right to water and land and property rights through improved policy coordination • Invest in technical capacity building of R&D and local government institutions • Ensure local training and availability of construction and maintenance staff • Need to launch awareness campaigns for the conservation of water
Miscellaneous	Forestry	• No economic incentive mechanism in place for SFM • Policy and regulatory measures not supportive to SFM • Low capacity of staff for development of SFM plans • Limited participation of community in decision making • Alternate strategies in case of disasters and forest fires not defined • Lack of R&D in identifying and cultivating local species of the forest Return from forestry require a long period of time • Unavailability of land resources for forestry and Illegal wood- cutting	• Creation of economic incentives • Promotion of SFM • Strong Legal regulatory body • Increasing awareness about innovative and precision agriculture methods
Miscellaneous	Waste Management	• Lack of enforcement of waste management standards by relevant government agencies • Lack of long term plans and strategies for waste management • Lack of energy efficient machinery	• Inclusion of long term plans in government policies for waste management • Inclusion of waste management standards • Creation of economic incentives i.e. carbon credit

Category	Sectors	Barriers	Recommendations
Miscellaneous	Industrial Sector	• No check on GHG emissions by regulatory authorities • Lesser implementation of energy conservation measures	• Optimal utilization of machinery • Implementation of energy conservation measures

7.5 Financial Resources for Development and Transfer of ESTs

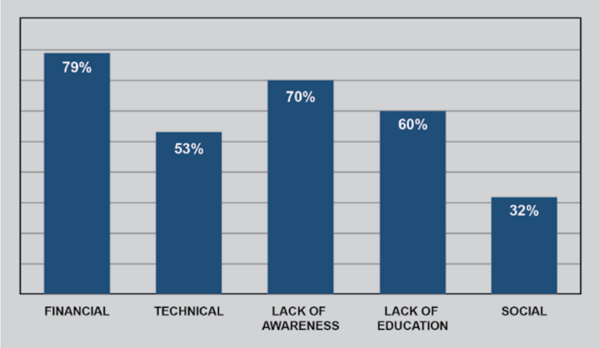
The biggest barrier recognized through literature review in the development and transfer of ESTs is financial. However, there are various global and national financial resources that can be tapped for the deployment and transfer of ESTs in different sectors. Some of these resources have been utilized by various departments in the country. Lack of awareness regarding these resources/ funds is a major cause of inefficient tapping of these financial sources. To overcome this barrier, a list of international and national financial resources has been developed (Annexure- F).

7.6 Survey by PCRET

This section presents analyses of the current status of development and transfer of ESTs in different sectors. PCRET developed a structured questionnaire for engaging all the stakeholders.

Figure 39:

Major barriers in development, transfer and diffusion of ESTs in Pakistan



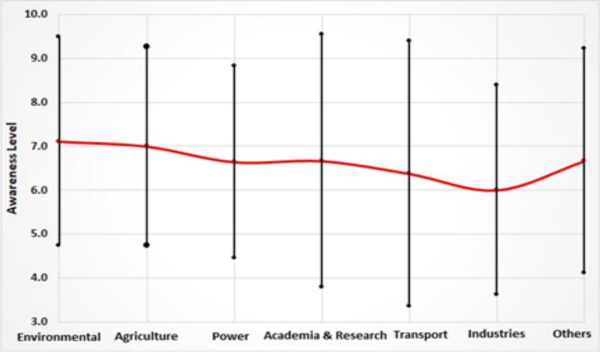
The questionnaire used for the survey is given in Annexure- G. This survey is sample based and data was collected from different sectors. PCRET also developed a database to store this information electronically. Structure of this database is presented in Annexure- H. The analyses in this section are based on the data collected from stakeholders during this survey.

According to this survey, the major barriers in the promotion, development, transfer and implementation of ESTs are financial, technical, lack of awareness and lack of relevant education, as shown in Figure 41. Finances and lack of awareness are identified as major barriers in the transfer and development of ESTs in all sectors. These funding sources can be used to overcome the financial barrier to some extent. The government must take steps for the provision of financial incentives to different sectors for the promotion of ESTs and increasing awareness and education about ESTs. Furthermore, banks shall also be encouraged to provide short- term and long- term loans for this purpose.

The other major barrier in the development, transfer and diffusion of ESTs in Pakistan is lack of awareness about these technologies. Reduction in GHG emissions cannot be achieved without engaging grassroot community in projects related to ESTs. The analyses of data obtained from the survey responses shows that awareness level about ESTs in different sectors is significantly low. The awareness level was measured on a scale of 0 to 10; 0 being the lowest and 10 being the highest. The average awareness level along with standard deviation (bars) is presented in Figure 42. It was observed that the highest awareness level is about the environment, as the organizations in this sector directly work on climate issues. The awareness level in the industrial and transport sector is critically low despite the fact that these sectors are the major contributors of GHG emissions. The awareness level in other areas is also quite discouraging. Analyses of the survey shows that lack of commitment by policy makers and top management is also a major barrier in development, transfer and diffusion of ESTs. This shows that significant efforts are required for increasing the awareness level about ESTs.

Figure 40:

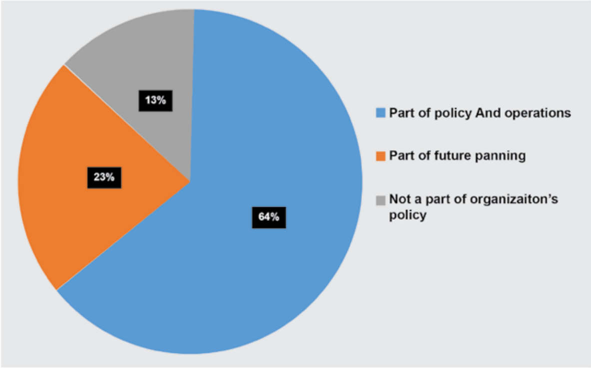
Awareness level about development, transfer and diffusion of ESTs in different sectors in Pakistan along with standard deviation.



Despite all these barriers and hurdles, there are some encouraging signs as well. It can be seen in Figure 43 that 64% of the surveyed organizations have ESTs as part of their current policy and operations while 23% are planning to include ESTs in their future planning. Organizations in different sectors have identified the relevant ESTs in that sector, which have been recorded in the database. Similarly, there is a realization that implementation of ESTs is not only beneficial for climate issues but also for the organizations' profitability and efficient operations and maintenance as well.

Figure 41:

Status of ESTs in planning, policy and operations in different sectors in Pakistan



7.7 Conclusion

Reduction in GHG emissions can be achieved through efficient development and transfer of ESTs in different sectors. Survey analysis and literature review of the barriers in the development and transfer of ESTs in different sectors show that finances, relevant technical education and commitments at all levels are required for the deployment of these technologies. Review of various policies, planning, strategies and research documents for future directives show that efficient policies and strict regulations are also required for the implementation of these policies in each sector. Furthermore, engagement of different donor agencies and effective enabling environment is a must to make it a success story.

GHG emissions cannot be controlled without cooperation from the grassroot community no matter how much advanced technology is deployed. An effective campaign along with a strong will is required to increase the awareness level about ESTs throughout the country. Technical education relevant to ESTs will not only build the capacity of human resources for the labor market, but also increase the awareness. Therefore, a proper action plan is required for increasing the awareness of ESTs at individual as well as organizational level.

CHAPTER

8

Constraints, Gaps, and Related Financial, Technical & Capacity Needs

Constraints, Gaps, and Related Financial, Technical & Capacity Needs

This chapter discusses the constraints, gaps, related financial, technical, and capacity needs, as well as proposed activities to implement activities, measures, and programmes envisaged under the UNFCCC.

8.1 Constraints & Gaps

8.1.1. Greenhouse Gas Inventory

The main constraints are related to lack of quality, information, and expertise in the respective sectors. Owing to the unavailability of relevant data, assumptions were made and data were obtained from secondary sources.

Some of the challenges encountered in preparing the GHG Inventory are as follows:

- Lack of local emission factors (hence the more general IPCC default factors were used).
- Available data are not segregated according to IPCC Guidelines categories.
- Gaps in knowledge and skill in understanding the relationship between processes, especially industrial processes, and emissions released.
- Lack of centralized activity data collection and compilation in all key sectors.
- Lack of historical data for relevant sectors such as forestry, agriculture, and waste.
- Financial constraints for inventory preparation.

Actions/ plans to Improve GHG Inventories

- Efforts to establish GHG Inventory management systems.
- Plan to develop inventories on regular basis
- Measures being taken to develop Tier- II and Tier- III coefficients.
- Steps underway to prepare remote sensing data- based GHG inventories.

8.1.2 Vulnerability Assessment and Adaptation

Climate modeling

There is a lack of access to these models and the immense cost in terms of financial and high-performance computing to run model simulations.

Impact modeling

Water Sector- There is a limited long- term historical data for hydrology and water resources. Also, the number and frequency of hydrological and river flow data stations are still low.

Agriculture Sector- There is a lack of data, and access to crop simulation and integrated models is quite limited.

Health Sector- There is a lack of data, expertise and models. Eventually very less work has been done in health sector in relation to climate change.

Forestry & Land- Use- There is a lack of data, expertise and models; hence there are a few studies on the impact as well as mitigation potential of this sector.

Oceans- There is a lack of data, expertise and non- availability of models on increased cyclonic activity and impacts of climate change on ocean and coastal line.

Extreme Events- Very few diagnostic studies on extreme events has been done. There is a need to build capacity.

8.1.3 Technology Needs for Adaptation and Mitigation

With the inception of latest technologies to respond to climate change through adaptation and mitigation in various socio- economic sectors, there is a need to equip the developing countries with these tools and technologies for which the following are needed:

- Financial support
- Involving developing/industrialized countries
- Knowledge sharing
- Capacity building of Non- Annex- I Countries

Table 49:

National Adaptation Priorities

Long- term Vision	To build a climate resilient society and economy by ensuring that climate change is mainstreamed in the economically and socially vulnerable sectors of economy.

Medium to long- term actions (up to 2030)	To support achievement of long- term adaptation vision of a climate- resilient society, Pakistan will pursue efforts up to 2030 that address the vulnerability of water, agriculture and infrastructure to climate change by taking the following actions:
	• Improving the irrigation system through actions such as lining of canals and irrigation channels
	• Enhancing water resource management through:
	  • Integrated watershed management
	  • Water conservation
	  • Development and optimization of water resource allocation, implementation of strict water management regulations and utilization of unconventional water resources such as recycling of used water and harvesting rain water and flood water
	• Strengthening risk management system for the agriculture sector
	• Implementing a comprehensive Climate Smart Agriculture programme
	• Building climate- resilient infrastructure with focus on improved and safe operation of water- related infrastructure and better management of transport operations and energy transmission, supported by innovations in urban planning for synergistic implementation of mitigation and adaptation actions
	Improving the emergency response mechanism for managing extreme climate events and strengthening the development of disaster reduction and relief management systems based on risk assessments, aligned with the goals of Sendai Framework on Disaster Risk Reduction: 2015- 2030

Near- term actions (2020- 2025)	• Led by the Ministry of Climate Change, Pakistan shall develop a National Adaptation Plan (NAP) that will create a framework for guiding the mainstreaming of medium- and long- term climate change concerns into national sectoral policies, strategies and programmes. The framework will help provide a basis for a more coordinated approach within and among different levels of government for climate- resilient development. • Sub- national adaptation planning capacity will be strengthened, leading to the formation of adaptation strategies and plans aligned with NAP that will facilitate local level adaptation and mainstream adaptation into sector- level policies at the sub- national level. • Disaster risk management capacity will be further enhanced through the implementation of actions under 'National Disaster Management Plan' that includes strengthening of institutional and legal system for disaster management, preparation of disaster management plans, awareness raising and establishment of a national emergency response mechanism.
Support	• Development of a multitude of professionals in the field of climate change through strengthened educational opportunities for individuals in the disciplines of geo- sciences, social sciences, management sciences, governance, policy formation and implementation • Providing financial support based on detailed cost assessments and balancing domestic contributions with needed support from the international community

8.1.4 Capacity Needs for Mitigation

Sector	Action	Potential interventions
Energy	Awareness raising through the promotion of Energy Standards and Labeling (ESL) for manufacturers and importers, and promotion for consumers	• Technical & Technological Expertise on Capacities to manage power system with high share of Renewable Energy Technologies. • Forecasting Tools • Training/advisory support in awareness raising for ESL from agencies and countries that have implemented such programmes • Training through technical courses organized in Pakistan and abroad • Training/advisory support for financial institutions on designing and implementing fiscal instruments • Development of national systems for regulating the renewables and improving institutional/technical linkages with key players in the private sector
	Technical expertise in developing, installing and maintaining solar and wind power sources	• Training through technical courses organized in Pakistan and abroad
	Public sector capacity for promoting, regulating and monitoring energy efficiency	• Development of capacity to monitor and verify progress on the enforcement of ESL
Transport	Awareness raising and provision of incentives for efficient vehicle operations	• Development of awareness materials and organization of demonstration events in cities to show how to maintain vehicles' efficiently • Training of vehicle service providers through short courses on how to disseminate information to vehicle owners and users • Preparation of training materials for financial institutions on loan packages to finance efficiency improvements in the vehicle fleet • Visits of representatives from financial institutions to countries where such loaning schemes have been successful
	Up- gradation and modernization of rail services	• Training of government officials at the national, sub- national and city levels on monitoring and evaluating mitigation programmes and on methods of management for modern rail systems • Training of technical staff to operate modern rail systems
	Up- gradation and development of efficient public transport systems	• Training of government officials at the national, sub- national and city levels on monitoring and evaluating mitigation programmes and on methods of management for public transport systems in urban areas • Training of technical staff to operate modern urban transport systems
	Public sector capacity to monitor and evaluate programmes of mitigation and effectively manage the modernized rail and energy efficient public transport systems	• Visits of transport specialists to Pakistan • Training of public sector officials on regulating and monitoring modern transport systems • Study visits of Pakistan staff to countries with modern rail and bus rapid transport in cities
Agriculture	Climate Smart Agriculture (CSA)	• Training programmes on climate change and CSA for national, sub- national and local authorities by national and international experts • Training programs on climate change and CSA financing needs for banks and micro- finance institutions • Farmers' field schools focusing on specific CSA activities (e.g. soil conservation) • Exposure visits of farmer groups to different regions to learn about specific CSA activities • Curriculum development/enhancement within universities and technical institutes providing training to extension workers on climate change and CSA practices
	Strengthening Risk Management system	• Training of extension workers in risk management and risk transfer mechanism • Developing an institutional set- up for providing agriculture insurance • Farmers' field schools to build awareness about agriculture insurance options • Study tours of government officials/members of the financial sector in other relevant countries • Pre- feasibility study to assess viability and capacity gaps pertaining to the development of national weather index insurance system

8.2 Information of financial resources and technical support from national sources, bilateral & multilateral institutions, and GEF

Adaptation concerns are profound than mitigation concerns as far as the country's vulnerability to climate change is concerned, which means that climate change adaptation costs are likely to be relatively high in Pakistan compared to the rest of South Asia where impacts on vulnerable sectors are already predicted to be enormous. Some assessments suggest that Pakistan already faces significant economic losses due to climate change (Ahmed & Suphachalasai, 2004).

In Pakistan, Climate Change has been recognized as a core component of the economic growth model, which is required for growth, poverty reduction and well-being of the population. This is embedded in national economic policies such as the Framework for Economic Growth (FEG) 2011, Vision 2025 and the Medium- Term Development Plan (2010- 2015). In response to these challenges, the Government of Pakistan developed and adopted the National Climate Change Policy in 2012, which aims to ensure that climate change is mainstreamed in the economically and socially vulnerable sectors of the economy, and to steer Pakistan towards climate- resilient development. In 2012, the Ministry of Climate Change expressed an interest in undertaking a CPEIR to assess the level at which the government has so far been able to respond to the challenges of CC, and to identify opportunities for further strengthening its response.

The national budget comprising federal government, four provinces and three regions increased from PKR 4959 billion in 2012- 15 to PKR 6771 billion in 2014- 15 at an annual average growth rate of 10.9%. In the corresponding period, GDP at market prices increased from PKR 20,046 billion to PKR 27,493 billion at an annual average growth rate of 11.1%. If the annual average inflation rate of 8.1% during the period is accounted for, the real growth in budgetary expenditures and GDP represent a very modest increase. The table below gives a summary of CC related expenditure (both current and development) aggregated as well broken down by federal and sub- national governments during the four- year period. The four- year average climate change related expenditure at national level is worked out to be around 7% of the country's total aggregated budget and this share during 2014- 15 at national level is 8.5%.

Table 50:

Country's Climate Related Expenditure

Country's Climate Related Expenditure Details (%)					
	2011- 12	**2012- 13**	**2013- 14**	**2014- 15**	**2015- 16**
Federal	6.5	5.8	6.2	8.1	6.5
Khyber Pakhtunkhwa	7.2	5.3	7.1	9.7	8.9
Balochistan	7.3	10.4	11.1	11.3	11.9
Punjab	6.2	7.1	8.2	9.3	13.7
Sindh	5.7	4.2	4.3	6.9	7.2
FATA	13.1	12.5	11.6	11.9	10.2
Gilgit- Baltistan	16	19	20	28	25.6
Azad Jammu & Kashmir	9.2	14	12.5	16.9	14.3
National	**6.7**	**6.1**	**6.7**	**8.5**	**8.4**

Source: Pakistan's Climate Public Expenditure and Institutional Review (CPEIR), UNDP, Pakistan (October, 2017)

8.2.1 International Support

In the past, Pakistan received international climate financing from the Asian Development Bank (ADB), the Global Environment Facility (GEF), the Adaptation Fund, and Japan's Fast Start Finance Initiative. From 2011- 2015, ADB's climate finance to Pakistan has reached USD 389.8 million, covering both investments and technical assistance. A large portion of this figure (USD 375.9 million or 96.4%) was for mitigation and only USD 13.9 (3.6%) million was for adaptation. The country has also received around USD 12.5 million, most of which has been disbursed, through the GEF for mitigation activities (Asian Development Bank, 2017).

The financing from the Adaptation Fund and the Fast Start Finance Initiative were mainly for adaptation activities. With the adaptation financing from the Adaptation Fund, Japan's Fast Start Finance Initiative, and ADB, the current adaptation support funneled into Pakistan is currently small when compared to the adaptation needs of the country estimated between USD 7 billion to USD 14 billion annually.

8.2.2 GEF Projects in Pakistan

Global Environment Facility (GEF) is one of the mechanisms of the UNFCCC to promote projects aimed at providing global environmental benefits. The scale of providing funds to various projects is small, but the list of project concepts in the country is quite long. Around 50 projects have so far been able to secure GEF funding. Ministry of Climate Change is the designated agency for GEF on Pakistan. A few of the GEF projects are listed below:

No.	Project Name	Focal Area	Executing Agency	Type	Status
1	Protected Areas Management Project	Biodiversity	The World Bank	Full size Project	Completed
2	Fuel Efficiency in the Road Transport Sector	Climate Change	UNDP	Full size Project	Completed
3	First National Report to the CBD and establishment of a CHM	Biodiversity	UNEP	Enabling Activity	Completed
4	Enabling Activities for the Preparation of Initial National Communications Related to the UNFCCC	Climate Change	UNEP	Enabling Activity	Completed
5	Mountain Areas Conservancy Project (MACP)	Biodiversity	UNDP	Full size Project	Completed
6	Protection and Management of Pakistan Wetlands	Biodiversity	UNDP	Full size project	Completed
7	Sustainable Development of Utility- Scale Wind Power Production (Phase 1)	Climate Change	UNDP	Full size project	Completed
8	Mainstreaming Biodiversity Conservation into Production Systems in the Juniper Forest Ecosystem	Biodiversity	UNDP	Medium size project	Completed
9	Conservation of habitats and species of global significance in Arid and Semi- arid Ecosystems in Balochistan	Biodiversity	UNDP	Medium size Project	Completed
10	POPs Enabling Activity: Preparation of the POPS National Implementation Plan under the Stockholm Convention	Persistent Organic Pollutants (POPs)	UNDP	Enabling Activity	Approved
11	National Capacity Needs Self- Assessment for Global Environmental Management in Pakistan		UNDP	Enabling Activity	Approved
12	Expedited Financing for Interim Measures for Capacity Building in Priority Areas (Phase II)	Climate Change	UNEP	Enabling Activity	Approved
13	Sustainable Land Management for Combating Desertification (Phase I)		UNDP	Full size Project	Completed
14	Promotion of Energy Efficient Cooking, Heating and Housing Technologies (PEECH)	Climate Change	UNDP	Medium size Project	Completed

No.	Project Name	Focal Area	Executing Agency	Type	Status
15	Productive Uses of Renewable Energy in Chitral District, Pakistan (PURE- Chitral)	Climate Change	UNDP	Medium size Project	Completed
16	Pakistan Sustainable Transport Project	Climate Change	UNDP	Full size Project	Completed
17	Development of National Clearing House Mechanism, Capacity Assessment of ABS, Preservation of Traditional Knowledge and In- situ and Ex- Situ Conservation in Pakistan	Biodiversity	UNEP	Enabling Activity	Completed
18	Mountains and Markets: Biodiversity and Business in Northern Pakistan	Biodiversity	UNDP	Full size project	Approved
19	Promoting Sustainable Energy Production and Use from Biomass in Pakistan	Climate Change	UNIDO	Full size Project	Approved
20	Rural Livelihoods Climate Change Adaptation Support Programme	Climate Change	IFAD	Full size Project	Cancelled
21	Fifth Operational Phase of the GEF Small Grants Programme in Pakistan	Biodiversity and Climate Change	UNDP	Full size project	Completed
22	Comprehensive Reduction and Elimination of Persistent Organic Pollutants in Pakistan	POPs	UNDP	Full size Project	Approved
	Sustainable Energy Initiative for Industries	Climate Change	UNIDO	Full size project	Approved
23	Sustainable Land Management Programme to Combat Desertification	Land Degradation	UNDP	Full size project	Approved
24	NAP Alignment and Strengthening National Reporting Processes	Land degradation	UNDP	Enabling Activity	Approved
25	Generating Global Environmental Benefits from Improved Decision- Making Systems and Local Planning in Pakistan		UNDP	Medium size project	Approved
26	GEF UNIDO Cleantech Programme for SMEs	Climate Change	UNIDO	Medium Size Project	Approved
27	GEF UNIDO Cleantech Programme for SMEs	Biodiversity	UNEP	Enabling Activity	Approved
28	Sustainable Forest Management to Secure Multiple Benefits in High Conservation Value Forests	Biodiversity/ Climate Change	UNDP	Full size Project	approved
29	Mainstreaming Climate Change Adaptation through Water Resource Management in Leather Industrial Zone Development	Climate Change	UNIDO	Full size project	Approved
30	Delivering the Transition to Energy Efficient Lighting in Residential, Commercial, Industrial, and Outdoor Sectors	Climate Change	UNEP	Medium size project	Approved
31	Snow Leopard and Ecosystem Protection Program	Biodiversity, Land Degradation,	UNDP	Full size Project	Approved
32	Sixth Operational Phase of the GEF Small Grants Programme in Pakistan	Biodiversity, Land Degradation, Climate Change	UNDP	Full size project	Approved
33	Reversing Deforestation and Degradation in High Conservation Value Chilgoza Pine Forests in Pakistan	Biodiversity, Climate Change	FAO	Full size Project	Approved
34	Transforming the Leather Processing Industries towards Low Emissions and Climate Resilient Development Paths in Pakistan	Climate Change	UNIDO	Medium size Project	Concept Approved

Source: Global Environmental Facility (website)[38]

[38] https://www.thegef.org/projects?views%5B0%5D%5Bview_dom_id%5D=89107486ef92fa726e2600698ff3a8c3&views%5B0%5D%5Bview_name%5D=projects_listing_search&views%5B0%5D%5Bview_display_id%5D=page&views%5B0%5D%5Bview_path%5D=projects&f%5B0%5D=-field_country%3A123&index_id=main&search_api_views_fulltext=&facet_field=field_p_implagencies&page=3

8.2.3 Green Climate Fund

The Green Climate Fund (GCF) adopted in 2011 as a financial mechanism of the UNFCCC aims to achieve the climate goals of the international community by assisting the developing countries on adaptation and mitigation measures to counter climate change. It targets to raise climate finance of USD 100 billion per year by 2020.

So far, Pakistan has got only one project, 'Scaling- Up of Glacial Lake Outburst Floods (GLOFs) Risk Reduction in Northern Pakistan,' worth USD 37 million from the Fund.

8.3 Climate Change Projects

A number of projects, which are required to be implemented in the country to effectively tackle the climate change issues and ensure Pakistan's contribution to global efforts on climate change through the implementation of the convention. The table below proposes the climate change projects, including pilot and/or demonstration adaptation projects proposed for financing in the preparation for arranging the provision of technical and financial support.

No.	Sector	Title
1	National Communication	Preparation of Third National Communication- proposal development
2	National Communication	Development of MRV Mechanism
3	GHG Inventory	Data format preparation for Greenhouse Gas (GHG) Inventory Reporting
4	GHG Inventory	Establishment of GHG Inventory management system by developing a lab and data centre
5	GHG Inventory	Generation of future GHG emission scenarios
6	Climate Modelling	Generation of high resolution regional climate change scenarios over Pakistan
7	Climate Extremes	Diagnostic studies on climate extremes and its forecasting
8	Energy	Strengthen the activity data for GHG emission estimates from transport sector
9	Energy	GHG emission measurements and activity data assessment for biomass used for energy purpose
10	Energy	CH_4 emission measurements from the coal mines
11	Energy	GHG emission measurement from petroleum refineries
12	Energy	CH_4 emission measurement from oil and natural gas venting, flaring, and transport
13	Energy	Development of CO_2 emission factors, linking coal beds with power plants, and impacts on their immediate environment- dispersion and transportation of emitted pollutants
14	Energy	Development of mass emission measurement system for GHGs from automotive vehicles
15	Energy	Integrated model development for the assessment of impact on energy sector
16	Energy	Impacts of climate change on energy and infrastructure in the Country
17	Industrial Processes	GHG emission coefficient measurements from industrial Processes
18	Industrial processes	GHG emission measurement from large point sources- steel plants, cements factories
19	Impact Assessment/ Water Resources	To study the impact of climate change on water resources and to develop adaptation strategies
20	Impact Assessment/ Water Resources	Reducing uncertainties in assessing climate change variability and extreme events such as droughts and floods
21	Impact Assessment/ Water Resources	Glacier monitoring and assessment studies using GIS/RS and Hydrological models
22	Impact Assessment/ Agriculture	Assessment of vulnerability of agriculture sector due to impacts of climate change and formulation of adaptation strategies
23	Agriculture	Measurement of N_2O emission coefficients from major soil types
24	Agriculture	Measurement of CH_4 and N_2O emission coefficient from enteric fermentation in animals and manure management
25	Agriculture	Measurement of CH_4 and N_2O emission coefficients for rice Cultivation
26	Agriculture	Nitrous oxide emission from rice fields

No.	Sector	Title
27	Agriculture	Development of conservation strategies in agriculture sector
28	Agriculture	Assessment and development of livestock management systems
29	Agriculture	Development of crop varieties resistant to heat and water stresses
30	Agriculture	Development of animal breeds that are heat tolerant and that produce less Methane
31	Impact Assessment	Assessment of climate change impacts on ecosystems
32	Impact Assessment	Assessment of climate change impacts on human health
33	Impact Assessment	Assessment of climate change impact on coastal zone
34	Urbanization	Development of urban policy response for integrating climate change and sustainable development
35	Mass Awareness	Create awareness about climate change in various factions of the society viz, businessmen, civil society, lawyers, media, parliamentarisms etc.
36	Integrated Impact assessment	Integrated impact assessment, including long- term emission scenarios, GHG abatement policies and adaptation measures
37	Forestry & Land- Use	Estimation of Carbon Sequestration potential and changes and developing models for predicting changes in stocks of different pools in different types of forests
38	Forestry & Land- Use	Evaluation of forest dynamics under climate change through field studies
39	Forestry & Land- Use	Estimation of regeneration potentials of the dominant forest species
40	Forestry & Land- Use	Evaluation and monitoring the impact of climate change on plant diversity in ecotone regions of important forest types.
41	Forestry & Land- Use	Ecological assessment of indigenous tree species for carbon sequestration under different agro- ecological regions
42	Forestry & Land- Use	Valuation of forest ecosystem goods and services.
43	Forestry and Land- Use	Estimation and monitoring of land- use change matrix
44	Forestry & Land Use	Socio- economic adaptation among forest- dependent communities to climate change
45	Forestry & Land- Use	Impact assessment on forests due to climate change
46	Waste	Measurement of emission coefficients from domestic and commercial waste water
47	Waste	CH_4 emission from selected landfill sites
48	Waste	Estimation of potential from waste of energy in Pakistan
49	Energy	Strengthening National Power Grid to evacuate large share of RE

8.4 Opportunities for the implementation of adaptation measures, barriers to implement adaptation measures, country- specific technology needs

Technology Needs Assessment (TNA)– TNA was a country- driven process, which was started to identify the adaptation technology needs of the country (Ministry of Climate Change 2016). The process included:

- Identification of preliminary targets for the technology development and diffusion at sectoral scale
- Description of technology properties and its potential adaptation benefits, categorization of technology either as a market or a public good, and a brief elaboration of its current status in the country.
- Identification of major barriers to the diffusion of technologies through expert opinion; literature review and brainstorming sessions with important stakeholders; development of barrier analysis tools, including problem and objective trees and market mapping tool; categorization of the barriers into financial and non- financial barriers
- Identification measures to overcome the barriers, possible linkage between various technology barriers within a sector and outline a technology enabling framework that would help to overcome barriers and create a supporting environment for the development and successful diffusion of the selected technologies.

STAGE 01

TNA Report- I

Main elements:

- Sector identification and prioritization
- Technology identification and prioritization in each sector

→

STAGE 02

Barrier Analysis and Enabling Framewor Report- II

Main elements:

- Barrier Analysis for each technology and enablers addressing the barriers
- Enabling framework

→

STAGE 03

Technology Action Plans & Project Idea Report- III

Main elements:

- Action Plan for each of the prioritized technology
- Crosscutting Issues
- Specific Project ideas in each prioritized sector

The priority technologies identified through TNA process for water and agriculture sector of Pakistan are given in the table below:

Table 51:

No.	Sector	Barriers	Measures for Enabling Framework
WATER SECTOR			
1	Surface rainwater harvesting	1. High cost of capital 2. Poor technology design 3. Lack of approved water and agriculture policies 4. Insufficient legal and regulatory framework for rainwater harvesting systems 5. Poor inter-departmental interaction and coordination 6. Lack of incentives for community ownership and participation 7. Uncertain frequency of rain and irregular water flows in water conveyance systems 8. Frequent siltation of water storage structures 9. Low preference to research and training 10. Inadequate information on societal benefits of technology 11. Lack of awareness among general masses 12. Limited institutional capacity and management skills of government departments 13. Inequitable distribution of the harvested rainwater among water users 14. Lack of monitoring of floodwater flows 15. Strong focus on the Indus Basin Irrigation System compared to other alternative irrigation systems 16. Conflicted land tenure 17. Health issues arising from water- borne vectors	**Financing:** High capital cost is a key issue in all three water sector technologies. So, the national development planning process should be given required priority for the diffusion of these technologies in the country. Further, as national development funds are limited. 'Economic Affairs Division' should made every effort to obtain project specific grants /soft loans from international donor agencies particularly from international climate financing mechanism such as 'Adaptation Fund', 'Green Climate Fund' etc.
2	Groundwater recharge	1. Lack of approved water policy 2. Lack of technical expertise 3. Limited funding 4. High capital cost 5. Conflicting policies such as low subsidy rate on the renewable energy 6. Political interest and interference 7. Hydrogeological uncertainty 8. Lack of reliable groundwater related data 9. Low institutional capacity 10. Weak coordination among public departments relevant to technology 11. Absence or low participation of groundwater users' in decision- making processes 12. Limited information on groundwater rights and distribution rules 13. Difficulty in assigning property rights 14. Untargeted financial and economic incentives for water users and managers 15. Lack of land- use planning and policy	**R&D Institutional capacity**: Sufficient financial resources should be allocated in the annual budget for R&D Institutions so as to enhance their technical capacity enabling them to undertake feasibility studies to select most suitable sites for surface rainwater harvesting, and groundwater recharge based on hydro-geological conditions. Further, for designing the most appropriate urban stormwater drainage system based on future climate projection also require R&D institutional capacity.
3	Urban storm water management	1. High capital cost of investment 2. Lack of coordination and cooperation among public departments both horizontally and vertically in the existing governance structure 3. Absence of water and land- use planning policies 4. Enforcement challenges of state regulations 5. Inadequate technical expertise 6. Unpredictability of rainfall frequency and intensity in the future 7. Poor knowledge about the stormwater capacity of cities and districts 8. Inadequate information on regional hydrological systems 9. Lack of information on performance and cost-effectiveness of low impact development (LID) infrastructure 10. Public perception of LIDs 11. Lack of guidelines and standards for stormwater management 12. Lack of funding for demonstration projects 13. Limited information and education level of builders and developers on new designs of conventional and green infrastructures 14. Lack of incentives for developers and consumers of green infrastructure	**Operation and maintenance capacity:** To ensure the sustainability of all three water sector technologies, sufficient financial resources need to be made available for enhancing the technical capacity of R&D and other line departments. Further, special training programmes should be undertaken to train local technicians in operation and maintenance of these technologies.

No.	Sector	Barriers	Measures for Enabling Framework
AGRICULTURE SECTOR			
1	High efficiency irrigation systems for irrigated and rain-fed areas	1. High cost of set up and maintenance and operation process 2. Under- developed, weak supply chain 3. Absence of approved water and agriculture policies 4. Weak water pricing system 5. Water and property rights conflict 6. High cost of energy to run the system 7. Low preference for resource conservation technologies 8. Technical capacity of government institutions and agencies 9. Low technical capacity of consumer groups 10. Absence of cost effectives of technology at field level and in different climate regions 11. Risk of soil degradation due to salinity buildup 12. High maintenance requirement 13. Not suitable for every soil type 14. Communication gap between technology developers, suppliers and consumers 15. Lack of product certification and quality assurance procedures 16. Poor economic viability of technology for small land holders	a) Ensuring appropriate financial mechanism to support development and diffusion of agriculture prioritized technologies to offset the high capital and operation and maintenance cost. For agriculture sector technologies also 'Economic Affairs Division' should made efforts to obtain grants/ soft loans from international donors particularly from international climate financing sources. b) Mainstreaming climate change considerations into relevant sectoral polices, plans and strategies.
2	Drought tolerant crop varieties	1. Inadequate financial resources for research and development 2. Lack of technical expertise, equipment, physical infrastructure for genetic manipulation of crops 3. Difficulty in access to good quality seeds 4. Poor seed storage facilities 5. Limited number of seed testing labs for ensuring quality of seeds. 6. Limited number of registered and certified seed supplier in the market 7. Poor credit facilities. 8. Low seed demand. 9. Delayed release of varieties. 10. Inefficient seed production, distribution and delivery system. 11. Small market size and supplier chain: uncertainty in demand side of the chain. 12. Inefficient / poorly equipped seed testing labs to confirm the quality of seed. 13. New pest issues. 14. Inappropriate communication/ extension approaches. 15. Insufficient data sharing and collaboration among research institutions so high chances of project multiplication. 16. Lack of strong legislation and regulatory framework to control seed market. 17. Inadequate patenting of research findings and disagreement of intellectual property rights.	c) Ensuring that sufficient financial resources are available to R&D institutions for strengthening and undertaking research, training and technology awareness raising activities among stakeholders. d) Strengthening operation and maintenance of institutional capacities at national and sub-national levels. Special training to train local technicians in operation and maintenance of agriculture prioritized technologies.
3	Climate monitoring and forecasting early warning system	1. High initial investment cost of building a dense climate monitoring network, setting- up an advanced forecasting and efficient early warning system 2. High operational and maintenance cost of such an advance forecasting and early warning system 3. Limited expertise to develop and run advanced numerical forecasting models 4. Limited capacity to interpret satellite high- resolution imagery and forecast model output at local level 5. Absence of dense climate monitoring station network 6. Limited research in the area of weather and climate change science 7. Absence of any university offering degree courses in field of meteorology or climate sciences 8 Limited real- time climate and rivers flow observational data availability 9. Absence of free data exchange among national user organizations. 10. Limited cooperation among relevant government agencies such as meteorology department, disaster management, agriculture, irrigation and water management authorities at federal and provincial level	e) Implementation of practical pilot demonstration projects.

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Findings of Working Groups

WG 1 (Climatology, Disaster Prevention and Risk Management):

Work already done or in progress:

(i) GCISC created in 2002 as a dedicated research centre for climate change related research; an R&D Division established at PMD in 2004. Both have developed some capability to use GCMs and RCMS to develop climate change (CC) scenarios and are also using other statistical and dynamical models.

(ii) National Disaster Management Authority (NDMA) was established in 2006, to tackle disasters with emphasis on Disaster Risk Management (DRM); NDM Act was approved in 2010. A national DRM framework was put in place in 2007 covering nine priority areas; it has since been extended to provincial and district levels.

Gaps in Efforts:

(i) Coordination among different institutions, particularly with regard to *sharing of data, information and knowledge* was identified as a serious deficiency. [**Note:** It may be recalled that the same problem was highlighted during the GHG Inventory Workshop].

(ii) CC- related education is generally lacking at college and university levels.

Further Priority areas and Capacity building needs:

(i) Extensive climate modeling activities (including modifications in available models) may be encouraged at relevant institutions, particularly involving academia. For this purpose, high-speed data processing systems would need to be arranged.

(ii) Documentation of climate extremes, and their diagnostic studies using RCMs, should be initiated.

(iii) Modelling capabilities need to be increased, particularly to make seasonal, inter- annual and decadal level climatic projections and to forecast monsoon variability and likely occurrence of extreme events.

(iv) Climate, agro- climate, agro- ecological and watershed zones, prepared by PMD, PARC, GCISC, Survey of Pakistan etc., need to be harmonized.

Potential Contributors to SNC:

PMD, GCISC, NARC, WAPDA, NIO, Meteorology Department of CIIT, IGIS- NUST, NESPAK, SUPARCO, SDPI, IUCN, LEADS, OXFAM, NDMA (for DRM), WWF.

WG 2 (Agriculture, Livestock, Forestry, Rangeland and Biodiversity):

Work already done or in progress:

(i) Development of crop varieties, which are heat and drought tolerant, deep rooted and site specific;

(ii) Increase of water use efficiency through introduction of sprinkler/ drip irrigation etc. [**Note:** this issue was also discussed in Working Group 3].

(iii) Restoration of degraded land like saline, water- logged etc.

(iv) Introduction of special plants like morinaga, caralluma, kallar grass on marginal lands;

(v) Development of vaccines against seasonal diseases in cattle and poultry.

Gaps in Efforts:

(i) Rangelands need to be developed and properly managed.

(ii) Cropping zones need to be re- identified according to the latest agro- ecological conditions in order to map out cropping patterns properly.

(iii) Improper crop rotation should be changed (e.g. from exhaustive to restorative).

(iv) Model- aided assessment of CC impacts on crops, other than wheat, rice and maize, has not been carried out.

(v) Studies on insect pest infestation and land degradation, in CC context, have not been carried out.

(vi) CC impacts on livestock productivity have not been studied.

Further Priority Areas:

(i) Development of risk preparedness strategies.

(ii) Controlling the non- judicious lining of canals and other water channels.

(iii) Development of rangeland by introducing site- specific grass varieties and by controlled grazing.

(iv) Development of gene banks for livestock breeds.

(v) Use of IPNM (Integrated Plant Nutrient Management) and IPM (Integrated Pest Management) systems.

(vi) Introduction of drought and frost resistant and better carbon sequestering tree species for forests; and MPTS (Multi- purpose tree species) for farm lands.

(vii) Reducing methane emissions from paddy fields by better soil and water management.

(viii) Controlling N_2O and CO_2 emissions.

(ix) Development of concentrated feed blocks to reduce enteric methane emission.

(x) Ensuring community participation in adaptation efforts and mitigation measures.

Capacity building and Technology transfer needs:

(i) Academic degree programmes should be introduced in agriculture universities.

(ii) On the job training should be imparted to scientists by organizing appropriate training courses and sending them abroad to reputed institutions.

(iii) The capacity of CC- relevant institutions should be strengthened.

Potential Contributors to SNC:

NARC/ PARC, PFI, Agriculture Universities, IGIS- NUST, GCISC, PMD, Relevant Sections of Planning Commission, SDPI, IUCN, LEADS, OXFAM, NDMA, WWF.

WG 3 (Water Resources, Glaciers, Coastal Areas, and other Fragile Ecosystems**):**

Work already done or in progress:

(i) A National Project on high efficiency irrigation system is being implemented, with a target of placing 294,000 acres of land under sprinkler/ drip irrigation.

(ii) Punjab Govt. has launched a project for bringing upto 40,000 acres in six districts under drip irrigation.

(iii) WAPDA is implementing Snow Runoff Model (SRM) for Jhelum basin; PARC is using SRM and GBHM for Astor basin and Rawal watershed.

(iv) RS/ GIS studies on glaciers are being done by PMD (Siachen, Baltoro, Batura, Biafo, Panmah tributaries), GCISC (Biafo, Bualtar, Gulkin), NDMA (Bhuni, Sanober, Rashun), PARC (Astore River basin glaciers), and SUPARCO (glacier monitoring, air, water and marine pollution). Physical monitoring of glaciers is being done by PMD (Passu, Hinarchi, Baltoro) and WAPDA (Passu). NDMA and PMD are working on GLOF in Chitral; Punjab University at Attabad Lake.

(v) Hydro- meteorological Network: WAPDA has established flow- gauging stations at Passu glacier; High altitude weather stations have been set up by PMD (Passu, Batura), NDMA (Chitral), and SUPARCO (for aerosol and black carbon measurement).

(vi) SUPARCO and WWF are working on mapping of mangroves, sea water intrusion; WWF is also involved in adaptation on coastal areas.

(vii) Watershed management is being undertaken by PARC, Punjab University, WWF and WAPDA at different locations.

(viii) Education programmes are underway at various institutions e.g. MS in Mountain Conservation and Watershed Management at Punjab University; MS in RS/ GIS at IGIS- NUST; RS/ GIS training at SUPARCO in collaboration with Chinese Academy of Sciences; Community based training and awareness by WWF, Community based disaster management by NDMA in collaboration with UN- One.

(ix) Studies of changes of river flows in the Indus River System (IRS) resulting from likely glacier melt and climatic changes are being done by GCISC using various Watershed models.

Gaps in Effort:

(i) Low density of high altitude observation networks and stream gauges.

(ii) Absence of precipitation radar system for early warning system on high mountains.

(iii) Disaster prevention needs attention.

(iv) Repetition and overlapping of work; lack of prioritization.

(v) Deficiency of coordination and data/ knowledge sharing among national institutions; lack of mechanism for information sharing with international organizations.

(vi) Weak functional linkage among educational institutions, research organizations and industry.

(vii) Absence of research environment, incentives for professionals and performance review of organizations.

Additional High Priority Areas:

(i) Conservation of water resources; wastage awareness.

(ii) Encouragement of community participation in work of common interest.

(iii) Focal institution for promotion of innovation in engineering and technology.

(iv) Watershed management; increase of water storage capacity, including small dams.

(v) Glacier mass balance studies.

(vi) Dedicated institutions for monsoons and droughts.

(vii) Centralized national institution for metadata sharing and management.

(viii) Inadequate expertise in various organizations in advanced RIS/ GIS techniques (for glacier monitoring) and watershed modeling techniques (for studying changes in river flows).

Capacity building and technology transfer needs:

(i) Focused PhD/ Masters programmes in climatology, glaciology etc.

(ii) Community based training for disaster risk management.

(iii) Improved management practices/ extension services for fisheries, irrigation.

(iv) Payment for eco- environmental service; monetizing of natural resources.

(v) Joint studies on international water sharing; review of water laws and accords.

Potential Contributors to the SNC Effort:

WAPDA, PCRWR, GCISC, PMD, SUPARCO, NARC, NDMA, Relevant Sections of Planning Commission, IGIS- NUST, Karakoram International University, Centre of Excellence in Water Resources of UET Lahore, Institute of Integrated Mountain Research of Punjab University, ICIMOD, IWMI, IUCN, WWF Pakistan.

WG 4 (Energy):

Work done or in progress:

(i) Establishment of Alternative Energy Board (AEDB); strengthening of Pakistan Council for Renewable Energy Technologies (PCRET) through PSDP.

(ii) Policy Initiatives: Policy for development of power generation 2006; Bio- diesel Policy Recommendations, 2008; National Energy Conservation Policy, 2006 and NEC Fund; National Environmental Policy, 2005; Mid- term policy updating 2006; Alternative and Renewable Policy (in process); Pakistan Clean Air Programme; Energy Efficiency and Conservation Act, 2011; LNG Policy, 2006; LPG Production and Distribution Policy; Pakistan Petroleum Exploration and Production Policy; Tight Gas E & P Policy.

(iii) Regulatory Authorities: The government has separated the policy and regulatory functions, and established the following independent regulatory authorities: NEPRA, OGRA, NGRA.

(iv) Planning and Vision Documents: Mid- Term Development Framework, 2005 (with a chapter on Energy Security; Integrated Energy Modelling; Hydropower Projects Vision, 2025.

(v) Adaptation and Mitigation Measures for Oil: specification improvement, subsidy reduction, promotion of clean fuels.

(vi) Move towards competitive real price; Provision of alternate transport fuels (CNG, LPG, Biofuels).

(vii) Mitigation measures in Power Sector: Reduction of T&D losses; Improvement in revenue collection; Appliance efficiency projects (CFLs, water pumps, fans).

(viii) Mitigation for Coal: In- situ gasification; clean coal technologies; coal bed methane capture.

(ix) Mitigation through Nuclear Power: Expansion in nuclear power plants (650 MW added; 340 MW in pipeline) resulting in annual reduction of upto 3 million tons CO_2 emissions.

(x) Mitigation through Renewable Energy: Promotion of wind/ solar/ biofuels; energy from waste; small hydro projects.

(xi). Overall Practices for Adaptation: Infrastructure improvement; competitive tariff; two weekly holidays.

Gaps in Effort:

(i) Lack of integrated Energy policies.

(ii) Coordination between line ministries and organisations is missing.

(iii) Energy sector equipment is not standardized.

(iv) Non- availability of authentic data.

(v) Lack of awareness and low level of ethics.

Other Priority areas for further work:

(i) Intensify oil and gas exploration.

(ii) Move towards clean energy in the energy mix.

(iii) Mainstreaming of renewables.

(iv) Provision of conducive work environment and promotion of investment.

(v) Facilitate urban and inter- city mass transit.

(vi) Encourage R&D activities.

Capacity building and Technology transfer:

(i) Institutional capacity building: training in internationally accepted methodologies for adaptation and mitigation in energy sector.

(ii) Adoption of best practices from region; transfer of energy efficient technologies.

(iii) Certification of energy managers; accreditation of energy auditing firms.

(iv) Improvement of university- R&D- industry interaction in CC- related projects.

(v) Attract and retain qualified professionals through incentives and career planning.

Potential Contributors to SNC Project:

Energy Wing of Planning Commission, WAPDA, PEPCO, AEDB, PCRET, ASAD- PAEC, ENERCON, GCISC, HDIP, NARC, NEPRA, OGRA, NGRA, Gas and electricity utility companies, Downstream oil sector including Marketing and Transportation, OCAC; oil refineries.

Universities; NGOs; Private sector

WG 5 (Education, Mass Awareness, Health, and Economic Costing of Climate Change)

Work done or in progress:

Education and Awareness:

(i) PMD publishes Agro- met Bulletin (monthly), Pakistan Journal of Meteorology, and Climatological Bulletin (6- monthly).

(ii) PMD issues real time weather data every 3 hours on its web page; also daily weather forecast and monthly/ seasonal climatological forecast for general public; has also established a TV station to provide real time weather information to the public.

(iii) NTRC has conducted more than 16 training courses/ workshops for officers and experts on importance of mass transportation.

(iii) SUPARCO provides GIS information on climate change issues.

(iv) PASTIC conducts training/ awareness seminars on different issues; also publishes "Pakistan Science Abstracts" in 10 disciplines including Earth and Environmental sciences.

(v) GCISC has been creating awareness of the CC issues among the inteligentia as well as general public through seminars, presentations in Round Table Discussions, articles in Newspapers and interviews and public appearances in electronic media.

Health and Economics:

(i) Pollen monitoring in different areas by PMD in collaboration with health agencies.

(ii) LEAD Pakistan recently completed a study on health effects of climate change.

(iii) Interrelationship of dengue fever growth in certain parts of Pakistan with changing climatic parameters being studied by GCISC.

(iv) Sub- national planning for adaptation.

(v) NEEDS study recently done.

Gaps in Efforts:

Education and Awareness:

(i) Science syllabi in schools, colleges etc. do not mention climate- related issues or the link of climate change with agriculture etc.

(ii) Need to make youth aware of fuel efficiency

(iii) Inefficient modes of transport cause 15 billion rupees loss every year.

(iv) There is no networking of stakeholders e.g., farmers, industry, educational institutes.

(v) Weather information is essential for livestock management in rangeland and rain- fed areas.

Health and Economics:

(i) Need based research regarding health hazards due to climate change.

(ii) There is no study on autonomous adaptation to climate change.

(iii) Economics of adaptation at local level.

(iv) Socio- economic impacts of climate change on different sectors.

Other Priority Areas:

Education and Awareness:

(i) Syllabus development for educational institutions.

(ii) Need to develop modal split with due share of road, railway and air transport for a least- cost and efficient solution. NTRC has moved in this direction with its Pakistan Transport Plan study 2020.

(iii) Regular bulletin should be issued on CC issues by GCISC.

Health and Economics:

(i) Role of basic health services in building climate resilience.

(ii) Work on cost- benefit analysis of adaptation and mitigation strategies.

Capacity Building:

Education and Awareness:

(i) Investment on experts to develop curricula for educational institutions.

(ii) PMD and GCISC may consider launching an FM radio channel.

(iii) SUPARCO may help develop capacity of different institutes in remote sensing and GIS technologies for CC related work.

Health and Economics:

(i) Develop research capability for understanding climate change impact on human health.

(ii) Need to pay attention to basic training and education for livelihood diversification.

Potential Contributors to SNC Project:

GCISC, PMD, SUPARCO, NTRC, PASTIC, PMDC, NIH, HEC, NUST, PIDE, ISET (Institute for Social and Environmental Transition), LEAD Pakistan.

Framework for Implementation of National Climate Change Policy

- To promote the preparation of provincial water conservation strategies
- To improve water conservation through reduction in irrigation system losses and update and rationalize country's gross water availability estimates
- To identify and implement most efficient irrigation techniques such as sprinklers and trickle irrigation, etc.
- To enhance capacity of line departments and private sector to develop indigenously low cost energy and water efficient devices such as trickle and sprinkle irrigation system
- To complete the ongoing canal lining on priority to reduce irrigation losses
- To revisit the existing cropping pattern to conserve maximum water
- To allocate sufficient resources in the annual Development Plan for implementing climate change-related actions
- To promote laser land levelling of agriculture fields to reduce water losses
- To enhance capacity of departments concerned for silt and salt management in Indus Basin
- To introduce and improve agricultural drainage system in Sindh
- To promote reuse of drain water in rural and urban areas of Sindh
- To undertake periodic proper de-siltation of the canal system
- To facilitate technology transfer to small farmers by giving them incentives through subsidies, etc.
- To take appropriate measures for the construction of additional storage capacity while ensuring minimum base flows in all rivers
- To organize integrated command area development for the existing and planned dams.
- To design and implement projects (e.g. afforestation, gabion's structures, etc.) that reduce land erosion and avoid silting of dams.
- To explore the option of fixing the irrigation water pricing to generate financial resources for the regular sustainability of irrigation infrastructure.

Developing local rainwater harvesting measures

- To estimate rainwater capturing potential of areas near villages and agricultural farms.
- To promote rain harvesting both in rural and in urban areas as well as at household level.
- Strengthen community capacity in rainwater harvesting practises at house hold/ village/ local level.
- Identify areas for building new rainwater harvesting infrastructure for irrigation and household use (e.g. in Balochistan: Rakshan river, Zhob river, Pishin lora basin, Nari river, Panjgur river, Anambar river, Barkhan district, Musakhel district).
- Initiate programmes aimed at promoting the use of flood water for irrigation in Balochistan.
- Plant tree species in watersheds that are not negatively affecting the water table.
- Incorporate rain water harvesting systems in building bye- laws.

Increase awareness to adapt to changing water resource situation due to climate change

- Plan regular media campaigns and hold seminars and workshops to highlight importance of conservation and sustainable use of water resources at all levels.
- Support the NGOs and Civil Society organizations to highlight conservation and judicious use of water resources.
- Initiate joint ventures, involving the line departments, civil society, academia as well as print and electronic media, to create mass awareness among the general public regarding water conservation, water availability, drainage system and other water related issues.
- Facilitate and provide guidelines to NGOs for adopting right policies that directly benefit the communities.
- The importance of conservation and sustainable use of water resources be added to schools and madrersas curriculum.

Safeguarding Pakistan's rights on trans-boundary water inflows according to international norms and conventions

- Identify the amount of water that could be diverted from existing river resource by regional nations due to increasing local demand.
- Identify the economic cost of such water diversion by neighbouring countries.
- Setup a task force on water, comprising relevant experts to study all relevant issues including international laws and convention to develop strategy to safeguard Pakistan's rights on trans-boundary water.
- Setup a mutual interest council to identify the possibilities of water treaty between Afghanistan and Pakistan to ensure continued and sustained water availability in River Kabul.
- Setup another mutual interest council to identify and handle issues of post Indus Basin water Treaty (IBWT) between India and Pakistan in the light of emerging environmental and climate change concerns.

Promoting integrated watershed management practices in uphill watersheds

- To identify the environmental threats to the uphill watershed and catchment areas of the rivers flowing in the plain regions of Pakistan.
- Identify the technical possibilities like artificial glacial recharge to improve water quantity and quality.
- Provide training to local community to identify sites and to manage artificial glacial recharge.
- Ensure that the basic norms of watershed management are followed to protect erosion.

Develop and enforce required legislative and regulatory framework to protect water resources from climate change related vulnerabilities

- Review all relevant existing legislation to identify deficiencies in relation to water conservation and management.
- Amend and enact new laws, wherever

needed, to achieve effective water resources management in agriculture, domestic and industrial sectors.

- Ensure strict enforcement of laws regulating the groundwater exploitation.
- Cap the subsidy given to agriculture tube wells and ban installation of new in most threatened aquifers in Balochistan.
- Effectively enforce all environmental laws, concerning water conservation and water protection, through provincial/ state EPAs.
- Constitute environmental tribunals at district level covering water related issues.
- Conduct review and harmonize existing legislations, polices and plans in water sector to include climate change adaptation and mitigation measures.
- Bring all individual Water concerning laws in different sectors into a single section, called “Water Laws”.

Enhance capacity to manage the country’s hydrological system

- Design provincial and regional plans for undertaking scientific studies for preparation of comprehensive inventory of all water resources in Pakistan to support an efficient water management system in the country.
- Prepare Water Statistics Handbook for Pakistan.
- Ensure the availability and use of technologically advanced equipment and measurement techniques for preparation of comprehensive inventory of country’s surface and ground water resources, as the accuracy of this inventory is vital for future planning.
- Update the Indus Drainage Basin Atlas-2005 prepared by WAPDA and includes vulnerable water resources in the wake of climate change.

Developing and extending technologies and techniques of domestic and drinking water saving as well as sea water utilization

- Introduce and popularize domestic and drinking water conservation techniques and technologies.
- The government line departments will ensure that new technologies and techniques for domestic water saving are made available in a cost-effective way in all urban areas.
- Setup institutional arrangements for developing and installing local sea water de-salinization plants in coastal urban areas to ensure ample water supply.
- Promote installation of water meters to check the indiscriminate use of drinking water supplies.
- Enforcement of the National Drinking Water Quality Standard.
- Promote cost effective and appropriate technologies options for water supply systems.

To develop climate change resilient water infrastructure in the country and strengthen it according to the needs

- Take measures to enhance the life of existing water storage particularly, Mangla and Tarbela dams.
- Identify new potential dam sites in the country including AJK.
- Undertake detailed seismic survey of these potential dam sites.
- Ensure that these sites are not used for construction projects other than agriculture and forestry, to keep options open to develop new dams, should they be needed.
- Undertake detail study to assess the country’s need for additional water storage for irrigation and hydropower generation.
- Undertake detailed feasibility and design studies with cost estimates of the proposed new dams.
- Identify the source of funding and ensure its availability to WAPDA for expeditious completion of on- going and future dam projects.

Developing infrastructure to harness the hill torrents potential

- Identify the potential hill torrents sites and estimate the amount of hill torrents water that can be harnessed at each potential site.

- Undertake detailed analysis of socio-economic cost of constructing such infrastructure.
- Identify the sources of funding and its timely availability for constructing infrastructure to harness the full potential of hill torrents

Summary of Government Initiatives to address Climate- related Issues

2001 Preparation and adoption of Hydropower Projects Vision 2025 (WAPDA, 2001);

2002 Preparation of Pakistan's Country Assessment Report for the World Summit on Sustainable Development 2002 (Ministry of Environment, 2002);

2002 Establishment of Global Change Impact Studies Centre (GCISC), an autonomous body supervised by a Board of Governors under the Climate Change Division of Cabinet Secretariat, to specifically conduct climate change related research;

2004 Establishment of an R&D Division within Pakistan Meteorological Department (PMD); (Both GCISC and PMD have developed the capability to use Global Circulation Models (GCMs), Regional Climate Models (RCMs) and other statistical and dynamical tools to develop medium- to high- resolution Climate Change (CC) scenarios for different regions.)

2005 Incorporation of the Millennium Development Goals (MDGs) into important macroeconomic frameworks (Government of Pakistan, 2005);

2005 Formulation of National Environmental Policy and its approval by Federal Cabinet (Government of Pakistan, 2005a).

2005 Establishment of Prime Minister's Committee on Climate Change (PMCCC) as an overarching body to monitor the climate change related developments taking place in Pakistan and the world over to provide an overall policy guidance;

2005 Establishment of Clean Development Mechanism Cell at the Ministry of Climate Change;

2005 Launch of Pakistan Clean Air Programme (Government of Pakistan, 2005b);

2005 Preparation of Medium Term Development Framework 2005- 2010 (Government of Pakistan, 2005);

2006 Formulation of National Energy Conservation Policy (ENERCON, 2006);

2006 Formulation of Policy for Development of Renewable Energy for Power Generation (AEDB, 2006);

2006 Establishment of a National Disaster Management Commission with prime minister as its chair and setting up National Disaster Management Authority (NDMA) under the commission at the federal level with the corresponding disaster management bodies at provincial and districts level so as to cover both the disaster preparedness and disaster management aspects in respect of any sorts of disasters, including earthquakes and extreme hydro-meteorological events;

0000 Setting up of an Inter-ministerial Committee on Climate Change through which the federal government agency responsible for taking up climate change issues at national and international level (previously the Ministry of Environment/ Ministry of Climate Change and now Climate Change Division (CCD) of the Cabinet Secretariat coordinates with other ministries and related organizations in connection with climate- related plans and policies;

2008 Establishment of National Biosafety Centre by Pakistan Environment Protection Agency (PEPA) as a project to cater for the Obligation of Cartagena Protocol on Biosafety;

2008 Preparation of Bio- diesel Policy Recommendations (AEDB, 2008),

2009 Establishment of a multi- stakeholder Core Advisory Group to advise the Ministry of Climate Change, the then Ministry of Environment / Climate Change Division on the country's position in international climate negotiations and to provide needed technical inputs;

2008 Setting up a Task Force on Climate Change (TFCC) by the Planning Commission; (The Final Report of TFCC released in February, 2010 (Government of Pakistan, 2010) is a seminal document consulted frequently in shaping the government policies and plans to address national climate change related issues)

2009 Preparation of the Greenhouse Gas Inventory of Pakistan for the year 2007- 08 to update the corresponding information for the year 1993- 94 provided in the Initial National Communication (INC) submitted to UNFCCC in 2003 (ASAD- PAEC, 2009);

2009 Preparation of draft National Sustainable Development Strategy and its finalization in 2012 (Government of Pakistan, 2012b);

2009 Implementation of National Impact Assessment Programme 2009- 2014 for strengthening Environmental Impact Assessment (EIA) and introducing Strategic Environmental Assessment (SEA) in development planning (Government of Pakistan, 2009);

2011 Preparation of National Economic and Environmental Development Study (NEEDS); (The study compares losses of various disasters over the last few decades and provides estimates of financial needs for mitigation and adaptation (Government of Pakistan, 2011);

2011 Energy Efficiency and Conservation Act (ENERCON, 2011);

2012 **Establishment of Glacier Monitoring Research Center under WAPDA**

2012 Formulation and approval of National Climate Change Policy (Government of Pakistan, 2012a);

2013 Formulation of the Framework (2014- 2030) for National Climate Change Policy Implementation (Ministry of Finance, 2013);

2013 Initiation of a project 'Tracking Adaptation and Measuring Development (TAMD)' by Climate Change Division in collaboration with the International Institute for Environment and

Development (IIED), UK;

2013 National Power Policy (Ministry of Finance, 2013)

2013 Separation of policy and regulatory functions in the Energy sector and establishment of independent regulatory authorities for electric power (NEPRA) and oil & gas (OGRA)

2013 Establishment of Climate Change Division (CCD) in the Federal Government Cabinet Secretariat to specifically focus on climate change related issues after the passage of 18th Constitutional Amendment in 2011 resulting in devolution of the subject 'Environment' from federal government to provincial governments.

2013 Launch of National Awareness Campaign on Energy and Environment Conservation by the Government of Pakistan

2014 Preparation of Work Plan for Climate Change Adaptation and Mitigation in Pakistan: Priority Areas (Government of Pakistan, 2014);

Other Initiatives include:

- Initiation of and participation in a number of internationally supported projects addressing specific environmental issue,s e.g. those related to improvement of urban air quality (e.g. through control of vehicle exhausts);
- Management of forests & reforestation of degraded forests (e.g. REDD+);
- Sustainable land management to combat desertification;
- Mountain eco- systems (e.g. GLOF);
- Implementation of a national project on high efficiency irrigation system with a target of placing 294,000 acres of land under sprinkler/ drip irrigation;
- Coastal ecosystems (e.g. restoration of mangroves);
- Loss of biodiversity & extinction of species;
- Projects under the Clean Development Mechanism (CDM);
- Launch of UN Habitat's Cities and Climate Change Initiatives (CCCI) programme;
- Establishment of high altitude Hydro- meteorological Network involving setting up of flow- gauging stations at Passu glacier by the Water and Power Development Authority (WAPDA), and high-altitude weather stations at Passu and Batura glaciers by PMD;
- Large-scale tree plantation activities, particularly in the coastal areas of Sindh, some of which resulted in Pakistan setting new Guinness World Records in July, 2009 and June, 2013 by planting highest number of saplings in a single day;
- Preparation of a study, 'Pakistan Transport Plan' by National Transport Research Centre in 2006 to develop modal split with optimum shares of road, railways and air transport for a least- cost and efficient solution

Clean Development Mechanism (CDM) Projects in Pakistan

Total Registered Projects: 40

Registered	Title	Host Parties	Other Parties	Methodology *	Reductions**	Ref
5- Nov- 06	Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Pakarab Fertilizer Ltd (PVT) in Multan, Pakistan	Pakistan	Japan	AM0028	1050000	557
31- Jan- 09	The 84 MW New Bong Escape Hydropower Project, Azad Jammu and Kashmir (AJK), Pakistan	Pakistan	Germany	ACM0002 ver. 6	218988	2098
1- May- 09	Construction of additional cooling tower cells at AES Lal Pir (Pvt.) Limited. Muzaffar Garh, Pakistan.	Pakistan	Netherlands	AMS- II.B. ver. 9	11179	2401
29- Oct- 09	Community- Based Renewable Energy Development in the Northern Areas and Chitral (NAC), Pakistan	Pakistan	Canada Netherlands Italy Denmark Finland Sweden Luxembourg Switzerland Austria Germany Belgium Japan Norway Spain	AMS- I.A. ver. 12	87477	1713
21- Dec- 09	Pakarab Fertilizer Co- generation Power Project	Pakistan	Sweden Germany	AM0014 ver. 4	119481	2687

Registered	Title	Host Parties	Other Parties	Methodology *	Reductions**	Ref
5- Apr- 10	Composting of Organic Content of Municipal Solid Waste in Lahore	Pakistan	Belgium Denmark Sweden Italy Germany	AM0025 ver. 11	108686	2778
3- Jun- 10	ICI Polyester Co- generation Project	Pakistan	Switzerland	AMS- II.D. ver. 11	21486	2922
14- Jul- 10	Almoiz Bagasse Cogeneration Project	Pakistan	United Kingdom of Great Britain and Northern Ireland	ACM0006 ver. 8	23319	3300
28- Aug- 10	Waste Heat Recovery based 15 MW Power Generation Project at Bestway Cement Limited, Chakwal, Pakistan	Pakistan	Japan Sweden	AMS- III.Q. ver. 2	48060	3555
9- Nov- 10	Gul Ahmed Combined Cycle Gas Turbine Project	Pakistan	United Kingdom of Great Britain and Northern Ireland	AMS- II.D. ver. 11	35656	3213
2- Dec- 10	"Biogas- based Cogeneration Project at Shakarganj Mills Ltd., Jhang, Pakistan"	Pakistan	Switzerland United Kingdom of Great Britain and Northern Ireland	AMS- I.C. ver. 14	18703	3230
19- Apr- 11	DHCL Gas Turbine based Cogeneration Project	Pakistan	Switzerland	AMS- II.D. ver. 12	31552	4596
9- Nov- 11	DGKCC Waste Heat Recovery and Utilization for 10.4 MW Power Generation at Dera Ghazi Khan Plant	Pakistan	Switzerland	AMS- III.Q. ver. 3	33845	4591
Rejected	Waste Heat Recovery and Utilization for Power Generation at Lucky Cement Limited Pezu Plant	Pakistan	Switzerland	AMS- III.Q. ver. 4	29918	5516
1- Apr- 12	Fatima N2O Abatement Project	Pakistan	Norway United Kingdom of Great Britain and Northern Ireland	ACM0019	458114	5461
30- Jul- 12	Compost from Municipal Solid Waste in Peshawar, Pakistan	Pakistan		AM0025 ver. 12	105334	5460
31- Oct- 12	Waste heat recovery and utilization for power generation at DG Cement Khairpur Plant	Pakistan	Switzerland	AMS- III.Q. ver. 4	28542	7845
6- Nov- 12	Substitution of coal with alternate fuels at DG Khan Cement Company Limited, Khairpur Plant	Pakistan	Switzerland	ACM0003 ver. 7	132439	6642
Rejected	Waste Heat Recovery and Utilization for Power Generation at Lucky Cement Limited, Karachi Plant	Pakistan	Switzerland	AMS- III.Q. ver. 4	42992	5521
Rejected	Waste Heat Recovery and Utilization for Power Generation at Cherat Cement Company Limited, Nowshera, Pakistan	Pakistan	Switzerland	AMS- III.Q. ver. 4	25761	5673
14- Nov- 12	Sapphire 49.5 MW Wind Farm Project	Pakistan	United Kingdom of Great Britain and Northern Ireland	ACM0002 ver. 12	75637	8163
16- Nov- 12	Partial substitution of coal with alternate fuels at DG Cement, Khofli Sattai Dera Ghazi Khan Plant	Pakistan	Switzerland	ACM0003 ver. 7	162135	8192

Registered	Title	Host Parties	Other Parties	Methodology *	Reductions**	Ref
20- Nov- 12	Reduction of Heavy Fuel Oil usage for Power Generation at Lucky Cement, Pezu, Pakistan	Pakistan	Switzerland	AMS- III.AH.	18884	8201
26- Nov- 12	Waste Heat Recovery CDM Project at Attock Cement Pakistan Ltd.	Pakistan	United Kingdom of Great Britain and Northern Ireland	AMS- III.Q. ver. 4	34417	6730
30- Nov- 12	Grid connected combined cycle power plant project in Qadirpur utilizing permeate gas, previously flared	Pakistan	Sweden	AM0074 ver. 3	467041	7727
5- Dec- 12	Biomass based cogeneration in Engro foods Supply Chain (Pvt.) Ltd. IRPC (Integrated Rice Processing Complex), Muridke, Pakistan	Pakistan	United Kingdom of Great Britain and Northern Ireland	AMS- I.C. ver. 19	38597	8482
24- Dec- 12	Patrind Hydropower Project	Pakistan		ACM0002 ver. 12	269278	6560
24- Dec- 12	Yunus Energy Limited 50 MW Wind Farm Project	Pakistan	United Kingdom of Great Britain and Northern Ireland	ACM0002 ver. 12	85756	9039
31- Dec- 12	Waste Heat Recovery and Utilization for Power Generation at Maple Leaf Cement Factory Limited, Iskanderabad, Pakistan	Pakistan	United Kingdom of Great Britain and Northern Ireland	AMS- III.AL. AMS- III.Q. ver. 4	49785	5406
31- Dec- 12	Foundation Wind Energy- I Limited 50 MW Wind Farm Project	Pakistan	United Kingdom of Great Britain and Northern Ireland	ACM0002 ver. 13	89214	9268

Source: https://cdm.unfccc.int/Projects/projsearch.html

* AM- Large scale, ACM- Consolidated Methodologies, AMS- Small scale
** Estimated emission reductions in metric tonnes of CO_2- eq. per annum (as stated by the project participants)

Mitigation Actions

ENERGY SECTOR:

Strategy 1.1	Giving preferential status to development and promotion of hydropower generation	
Actions		
1.1.1	Develop provincial consensus on promotion and development of hydro power generation in the country	Short Term
1.1.2	Undertake pre-feasibilities on potential hydel power project sites	Priority
1.1.3	Develop and promote run- of- river hydel power projects on rivers and canals on massive scale	Short Term
1.1.4	Strengthen engineering and design capacities of relevant institutions for preparation of feasibilities and later to supervise the development of hydel power projects	Medium Term
1.1.5	Create a mechanism to ensure stable funding for new hydro power projects through international financial lending institutions	Short Term
1.1.6	Incorporate policies in line with the procedures followed by other countries / international norms where hydel power projects are undertaken	Priority
1.1.7	Undertake survey of water resources in provinces including AJK and GB to assess, and accordingly, enhance their potential in generating energy	Short Term
1.1.8	A uniformed tariff, as set for other provinces, is recommended for AJK in the form of subsidy	Short Term
1.1.9	Ensure that rights of local population are protected wherever the hydro power projects are launched	Short Term
1.1.10	Constitute a framework to legislate the water usage and water rights involving all stakeholders at provincial/ state level	Short Term
1.1.11	Develop consensus at national level to divert funds to Gilgit Baltistan so that hydel projects be initiated that will equally benefit communities of other provinces of the country	Short Term

1.1.12	Improve recovery procedures from individuals / departments that are not paying utility bills and thus eliminate mismanagement from government side and introduce strict monitoring system to generate revenue	Priority
1.1.13	Build capacities of all concerned departments to develop project proposals on need assessment and actual understanding of problems at governance level	Short Term
1.1.14	Construct small dams as abundant water is available in Gilgit Baltistan for power generation and supply to other parts of the country.	Short Term
1.1.15	Develop projects for energy generation by diverting river into energy production units	Medium Term
1.1.16	Develop and promote hydropower projects through dams in Khyber Pukhtunkhwa (KPK)	Short Term
1.1.17	Develop mechanism to support the public private partnership in mobilizing, financing and enabling investments in hydel power projects and make sure its implementation through proper legislation	Short Term
1.1.18	Promote latest / advanced energy technologies	Priority
1.1.19	Ensure construction of hydropower structures at appropriate sites in Punjab to cover its power shortfall	Short Term
1.1.20	Identify appropriate sites as well as financial resources for establishing wind mills and hydro turbines in Punjab	Short Term
1.1.21	Explore possibilities for generating solar energy in Punjab	Short Term
1.1.22	Promote simplistic lifestyle of low energy consumption (and discourage intensive energy consumption lifestyle)	Short Term
1.1.23	Utilize the link canal water in Punjab for generation of hydropower	Priority

Strategy 1.2	Promoting development of renewable energy resources and technologies such as solar, wind, geothermal, small hydropower and biofuel energy	
Actions		
1.2.1	Undertake extensive survey to map country's wind and solar power potential	Short Term
1.2.2	Identify potential wind corridor in different parts of Balochistan for installing wind power projects	Short Term
1.2.3	Identify potential sites for installation of small hydro-power projects in mountain areas as well as along major irrigation canals	Short Term
1.2.4	Strengthen capacities of scientific and engineering technology public sector institutions and universities to develop and design renewable energy technologies for solar, wind, geothermal, small hydropower and biofuel energy resources	Short Term
1.2.5	Provide incentives for introducing solar water heaters in the country	Priority
1.2.6	Introduce investment friendly incentives to attract private sector interest in renewable energy projects	Short Term
1.2.7	Develop mechanism to support the private sector in mobilizing, financing and enabling public sector investment in renewable energy projects that are independent of the government	Medium Term
1.2.8	Create clean energy disciplines in universities to raise awareness and promote use of clean energy alternate sources	Short Term
1.2.9	Constitute a team of technical experts to develop methods of alternate energy resources; enhance their capacities and provide them incentives in terms of scholarship etc.	Short Term

1.2.10	Promote local manufacturing of power generation equipments.	Medium Term
1.2.11	Create/ reorganize power development board into / with subsections of hydropower unit, wind power unit, solar power unit comma biomass unit and geothermal unit under the relevant ministry (i.e. Ministry of Water and Power)	Short Term
1.2.12	Establish a database including experts from all sectors related to energy	Short Term
1.2.13	Promote public private partnerships for power sector projects	Short Term
1.2.14	Develop and encourage indigenous low-cost technology (renewable energy) through research and development activities	Medium Term
1.2.15	Arrange renewable energy exhibition in the country to get low carbon emission ideas & techniques.	Short Term

Strategy 1.3	Promote design of buildings with solar panels for energy security, especially in public sector buildings	
Actions		
1.3.1	Identify and introduce energy efficient building materials, designs and technologies	Short Term
1.3.2	Initiate wind energy projects in Gilgit Baltistan as it has a lot of potential and there are areas where these projects shall prove fruitful for energy generation	Short Term
1.3.3	Promote enterprises to produce energy efficient products and ensure availability of the same in the local market	Short Term
1.3.4	Increase awareness at every level for promoting best practices of energy conservation	Priority
1.3.5	Adopt strategy to promote and install solar panels in both public and private sector buildings to conserve energy	Priority
1.3.6	Set appropriate building construction criteria/ codes according to climate conditions for energy conservation	Short Term

Strategy 1.4	Planning the necessary expansion of nuclear power for Pakistan’s energy security	
Actions		
1.4.1	Plan expansion of nuclear power in the country to reduce its dependence on imported fossil fuels	Long Term
1.4.2	Revisit the safety standards on our present nuclear facilities to ensure that they are foolproof	Short Term
1.4.3	Strengthen capacities of relevant local scientific institutions to design and operate nuclear power reactors	Short Term
1.4.4	Develop plans and recommend safety measures in case of any emergency nuclear accidents; build capacities of the local government to mitigate such calamities through trainings and awareness programs	Short Term
1.4.5	Develop standards for proper disposal of nuclear waste	Priority

Strategy 2.1	Obtaining technological know-how and its transfer for installing the near-zero emission clean coal technologies	
Actions		
2.1.1	Develop and obtain technological know-how and its transfer for installing the Near Zero Emission Technology (NZET) for utilization of vast coal reserves in Pakistan	Short Term
2.1.2	Strengthen capacities of local scientific institutions to develop pulverized coal integrated gasification combined cycle systems (IGCC)	Priority
2.1.3	Ensure that new coal fired power stations perform at high efficiency level and are design in such a way that they can be easily retrofitted for carbon capture and storage	Medium Term
2.1.4	Develop strategies to utilize all fossil fuels, including coal, at highly efficient and low emission levels	Short Term
2.1.5	Develop technological and scientific capacities of relevant institutions to develop and operate coal fired power stations with carbon capture and storage facility	Long Term
2.1.6	Develop indigenous capacity to technologies such as waste heat recovery and cogeneration, coal bed methane capture, coal fluidized bed combustion and combined cycle power generation	Medium Term
2.1.7	Promote clean development mechanism projects in Khyber Pukhtunkhwa and other provinces.	Short Term

Strategy 2.2	Obtaining technological know-how and its transfer for installing the near-zero emission clean coal technologies	
Actions		
2.2.1	Strengthen capacities of all municipal agencies to install waste to heat conversion plants	Short Term
2.2.2	Involve local and provincial energy providers to ensure efficiency of energy supply transmission from these plants	Short Term
2.2.3	Undertake research on waste conversion into energy; develop major units and provinces to generate power through waste so as to promote alternate energy practices	Priority
2.2.4	Encourage private sector to install waste to energy conversion plant at local, district and provincial levels	Short Term
2.2.5	Restrict and discourage import of substandard technology used for conversion of waste into energy	Priority
2.2.6	Encourage the use of low carbon and low sulphur fuel	Priority

Strategy 2.3	Promoting and providing incentives for activities required for energy-mix and fuel-switching program to low carbon fuels	
Actions		
2.3.1	Design economic incentives and feasible options for energy mix in fuel switching program to low-carbon fossil fuels and other sources, ensuring flexible, reliable innovative strategies and technologies that reduce emissions	Medium Term
2.3.2	Equip local universities and research institutions so that they design and develop indigenous and hybrid technology for carbon dioxide capture and storage	Medium Term
2.3.3	Develop plans and install infrastructure to turn waste into heat by all municipalities	Short Term
2.3.4	Develop coal bed methane capture technology locally for future energy needs	Long Term

Strategy 3.1	Conserving energy and improving energy efficiency	
Actions		
3.1.1	Design energy audit methods to improve energy efficiency during transmission	Priority
3.1.2	Provide economic incentives to conserve energy in the form of replacing high energy consuming machineries with energy efficient machineries in the industrial sector	Medium Term
3.1.3	Develop new strategies for the transport sector to increase both fuel conservation and fuel efficiency	Short Term
3.1.4	Provide subsidy for promotion of low energy consuming devices for household and commercial uses such as energy saver lights	Priority
3.1.5	Ensure proper maintenance of energy generating material, e.g. power plants	Short Term

Strategy 3.2	Introducing Green Fiscal Reforms in different sectors of economy including energy, water waste / sewage etc. to achieve carbon emission reduction objective	
Actions		
3.2.1	Design financial incentives for carbon emissions reduction plans by improving efficiency of the carbon fuel-based machines and engines	Short Term
3.2.2	Develop green fiscal reforms for introduction of polluter pays / carbon tax	Medium Term
3.2.3	Plan green fiscal reforms to introduce subsidies for renewable technology transfer, local innovations of renewable technology, efficiency improvement for carbon fossil fuel-based technologies	Medium Term
3.2.4	Strengthen fiscal reforms and incentives for green technologies in water and wastewater sector	Short Term
3.2.5	Develop fiscal reforms for the introduction of carbon credit market	Short Term
3.2.6	Develop greenhouse gas emissions “monitoring reporting and verification system” (MRV) capacity	Short Term

Strategy 3.3	Enacting and enforcing energy conservation legislation and audit standards	
Actions		
3.3.1	Design energy conservation legislation by enacting energy sector specific laws that ensure to control the energy wastage	Priority
3.3.2	Strengthen the existing legal system that ensures energy efficiency audits and energy conservation	Priority
3.3.3	Provide market-based incentives, such as emission trading credits to private energy produces to help reduce carbon emissions	Short Term
3.3.4	Ensure proper implementation of policy and legislation at each level with identified checks and balances	Short Term

Strategy 3.4	Ensuring quality management of energy production and supply, including reduction in transmission and distribution losses	
Actions		
3.4.1	Design auditing of energy supply and transmission system to control distribution losses	Short Term
3.4.2	Strengthen quality management system of energy production to improve efficiency	Priority

Strategy 3.5	Improving energy efficiency in building and use of energy efficient electric appliances	
Actions		
3.5.1	Improve energy efficiency in buildings to standardize building construction and performance codes	Short Term
3.5.2	Develop plans for legislation / creating incentives for retrofitting	Priority
3.5.3	Encourage modification of building design for better insulation	Priority
3.5.4	Encourage design and manufacturing of energy efficient boilers and appliances	Short Term
3.5.5	Design energy efficient ground water pumping units for agricultural, industrial and domestic uses	Short Term
3.5.6	Introduce incentives for energy efficient products which often cost more than the less efficient versions, especially when they are first introduced to the markets	Priority
3.5.7	Strengthen public awareness programs relating to energy efficiency	Priority

Transport Sector:

Strategy 1.1	Sensitizing public to the importance of proper vehicle maintenance for fuel efficiency enhancement and reduction of emissions	
Actions		
1.1.1	Initiate media campaigns to create public awareness that how proper maintenance of vehicles can contribute to the fuel efficiency and reduction of emissions	Priority
1.1.2	Involve civil society and the corporate sector to join in the campaign for emission reduction and fuel efficiency by proper vehicle maintenance	Priority
1.1.3	Arrange regular vehicle maintenance technician courses in all urban centers of the country	Short Term
1.1.4	Set up vehicle maintenance service centers in all urban areas	Short Term

Strategy 1.2	Ensuring the provision of efficient public transport system in the country	
Actions		
1.2.1	Develop and provide quality efficient public transport system in the country to encourage people to transition from the use of private cars to the public transportation system	Medium Term
1.2.2	Encourage foreign investment to start and maintain high quality public transport in all major urban areas of Pakistan	Short Term
1.2.3	Develop public private partnership for the provision of fuel efficient local transport	Short Term

Strategy 1.3	Setting up and enforcing vehicle emission standards	
Actions		
1.3.1	Set up state of the art vehicle emission testing stations in all districts of KPK	Priority
1.3.2	Update and strictly enforce vehicle emission standards	Priority
1.3.3	Develop law enforcement system with a clear mandate to enforce vehicle emission standards	Priority

Strategy 1.4	Examine and implement actions required for the use of biofuel for local transport	
Actions		
1.4.1	Identify the bio fuels that can be used in conjunction with fossil fuels in Pakistan	Short Term
1.4.2	Make these biofuels available at least in important urban centers of Pakistan	Medium Term
1.4.3	Develop technology to modify the existing vehicles to run on a mixture of gasoline and bio fuels	Medium Term

Strategy 1.5	Planning and developing mass transit system in metropolitan cities	
Actions		
1.5.1	Undertake detailed feasibility studies through foreign consultants to develop an efficient mass transit system in all metropolitan cities of Pakistan	Priority
1.5.2	Explore the possibility to fund the development of these mass transit system through Green climate fund	Priority
1.5.3	Complete some of these projects through public private partnerships	Short Term
1.5.4	Apply subsidized price or cost control for customers to popularize mass transit systems over the use of individual cars	Short Term

Strategy 1.6	Supporting the private transport sector through incentives for reducing emissions and promoting environment friendly transport services	
Actions		
1.6.1	Identify and design financial incentives for the private commercial transport sector to reduce emissions	Short Term
1.6.2	Identify financial resources to fund systematic replacement of all public transport vehicles with technologically advanced reduced emission engines	Medium term
1.6.3	Promote the use of low rolling resistance tyres	Short Term
1.6.4	Create public awareness that improperly inflated tyres decrease fuel efficiency and result in great emissions	Priority
1.6.5	Promote proper inflation of tyres to improve mileage and reduce emissions	Priority

Strategy 1.7	Promoting the development and adoption of environment friendly technologies	
Actions		
1.7.1	Identify funding resources to develop environment friendly transportation technologies	Short Term
1.7.2	Promote awareness in collaboration with civil society and corporate sector to adopt environment friendly technology	Short Term

Strategy 1.8	Securing financing for technology innovations for urban planning and the transportation sector, specifically to address the mitigation issues	
Actions		
1.8.1	Use CDM and other funding sources to develop and adopt emission control technologies for the transport sector	Short Term
1.8.2	Utilize CSR to involve the corporate sector in fundraising for transport technology innovation in the country	Short Term
1.8.3	Special fund needs to be set aside for technology innovations that have direct impact on human health like emission control and water quality	Short Term

Strategy 1.9	Developing a pipeline for efficient transportation of oil in the country	
Actions		
1.9.1	Undertake a detail study to assess the cost effectiveness of transporting oil from sea port to the north of the country through pipeline instead of road transportation	Short Term
1.9.2	Train and enhance the capacity of technicians to build and maintain fuel pipelines	Medium Term

Strategy 2.1	Increasing national and other local airline to give the consideration to the fuel efficient new technologies in aircraft, causing minimum carbon emissions while planning new fleet	
Actions		
2.1.1	Keep close track of new emerging fuel-efficient aircraft engine technologies for adaptation at the right time	Priority
2.1.2	Assess the financial needs of the national airlines for introducing new aircraft with innovative fuel-efficient technologies	Short Term
2.1.3	Identify the funding sources for technology development to improve efficiency in aviation	Short Term
2.1.4	Keep a close watch on the results of recent experiments of 50-50 biofuel blend used in aviation sector for emission reduction	Short Term

Strategy 2.2	Supporting International Civil Aviation Organisation's (ICAO) initiative for carbon emission reduction through improved air traffic management	
Actions		
2.2.1	Enhance coordination with ICAO's initiative for carbon emission reduction through improved air traffic management	Priority
2.2.2	Undertake a detailed study to assess the benefits of improved weather services and free flight air routes instead of defined routes for reduced flight time and thus less fuel consumption	Short Term

Strategy 2.3	Participating actively in ICAO activities and initiatives for ensuring that new strategies and policies may not hurt the economic interest of country's aviation industry	
Actions		
2.3.1	Undertake study to assess the financial implications for the national airline if in the future carbon tax is imposed on old generation fuel inefficient aircraft	Priority
2.3.2	Develop a dedicated team of experts to actively participate in ICAO initiatives to minimize carbon emissions from the aviation sector	Priority

Strategy 3.1	Ensuring the provision of efficient railway system in Pakistan	
Actions		
3.1.1	Assess the amount of cargo and passengers that have been shifted to road transport in the country during the last 10 years and develop the strategy to change this trend	Short Term
3.1.2	Develop railway efficiency plan to improve the quality of service for systematic shift of cargo and passengers back from road to rail transport	Short Term
3.1.3	Arrange sufficient financial resources for purchase of new train engines and cabins to make rail journey efficient and comfortable	Priority

Strategy 3.2	Upgrading and expanding railway network in the country	
Actions		
3.2.1	Identify fuel efficient engines for trains	Priority
3.2.2	Build infrastructure to improve the quality of train services	Medium Term
3.2.3	Identify new routes and build rail lines connecting areas that are not easily accessible	Long Term
3.2.4	Build rail lines parallel to roads to reduce the cargo load and emission control	Long Term

International/ National Financial Resources

Sr. #	Organization	URL /Website
1.	Clean Development Mechanism (CDM)	http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php
2.	United Nations Environmrnt Programme	https://www.unenvironment.org/
3.	World Bank i. Clean Technology Fund ii. Forest Investment Program iii. Pilot Program for Climate Pesilience iv. Scaling Up Renewable Energy Program v. Carbon Funds Facility	https://www.climateinvestmentfunds.org/ http://www.worldbank.org/en/topic/climatechange/brief/worldbankcarbonfundsfacilities
4.	United Nations Development Programme	http://www.undp.org/content/undp/en/home.html
5.	United Nations Industrial Development Organizations	https://www.unido.org/
6.	PFAN	http://pfan.net/
7.	Global Climate Fund	http://www.greenclimate.fund/home
8.	World Resource Institute	http://www.wri.org/
9.	Asian Development Bank	https://www.adb.org/
10.	Nordic Investment Bank	https://www.nib.int/
11.	Islamic Development Bank	https://www.isdbpilot.org/
12.	United States Assistance for International Development	https://www.usaid.gov/
13.	The Finnish Government	http://www.formin.finland.fi/public/default.aspx?contentid=367482&contentlan=2&culture=enUS

Sr. #	Organization	URL /Website
14.	International Finance Cooperation	http://www.ifc.org/wps/wcm/connect/corp_ext_content/ ifc_external_corporate_site/home
15.	Multilateral Fund for the implementation of the Montreal Protocol	http://www.multilateralfund.org/default.aspx
16.	Global Environment Facility	https://www.thegef.org/
17.	International Monetary Fund	http://www.imf.org/external/index.htm
18.	Special Climate Change Fund	http://unfccc.int/cooperation_and_support/financial_me chanism/special_climate_change_fund/items/3657.php
19.	Least Developed Countries Fund	http://unfccc.int/cooperation_and_support/financial_me chanism/least_developed_country_fund/items/4723.php
20.	Adaptation Fund	https://www.adaptationfund.org/
21.	Japan International Cooperation Agency	https://www.jica.go.jp/english/

National Financial Resources

Sr. #	Organization	Fund	Links / URL
1.	National Energy Efficiency & Conservation Authority	Energy Conservation Fund	http://www.enercon.gov.pk/home.php
2.	Higher Education Commission	Technology Development Fund (TDF)	http://hec.gov.pk/english/Pages/Home.aspx
		Pakistan Program for Collaborative Research (PPCR)	
		Pak-France PERIDOT Research Program	
		Startup Research Grant for Fresh PhD Holders	
3.	Pakistan Science Foundation	Research Support Programme	http://www.psf.gov.pk/
		Pak-US Natural Sciences Linkage Programme (NSLP)	
		R&D Industry Programme	
4.	Environment Protection Agency	Clean Environment Fund	http://environment.gov.pk/
		Provincial Sustainable Development Fund	
		Financial Assistance for NGOs	
5.	Punjab Small Industries Corporation	Loaning Scheme	http://www.psic.gop.pk/
6.	State Bank of Pakistan	Green Banking/ Financing Scheme	http://www.sbp.org.pk/
7.	Global Change Impact Studies Centre	Grants for Research Projects	http://www.gcisc.org.pk/
8.	Pakistan Climate Change Act, 2017	Climate Change Fund	http://www.na.gov.pk/uploads/documents/1 485513841_966.pdf
9.	World Wide Fund for Nature- Pakistan Pakistan	Small Grants Programme	http://www.wwfpak.org/

Sr. #	Organization	Fund	Links / URL
10.	Pakistan Agriculture Research Centre	Research for Agricultural Development Program (RADP)	http://www.parc.gov.pk/index.php/en/
		Agriculture Research Endowment Fund	
11.	Rural Support Programme Network	Taps grants from Govt. for rural development using RE technologies	http://www.rspn.org/
12.	Ignite	National Technology Fund	https://ignite.org.pk/
13.	Planning Commission	PSDP Projects	http://www.pc.gov.pk/
14.	Aga Khan Rural Support Programme	Taps grants from Govt. of KP, PPAF, Swiss Agency for Development, USAID and Cooperation (SDC) for rural development using RE technologies	http://akrsp.org.pk/
15.	National Clean Production Center	Different Funds	http://www.ncpc.com.pk/
16.	Govt. of Pakistan	PPAF	http://www.ppaf.org.pk/

Environmentally Sound Technologies

Most of the world's environmental problems are due to the lack of understanding of the impact of human activity upon the environment. New management methods and decision support tools must therefore be developed and applied. In this scenario, the importance of the effective dissemination and use of environmentally sound technologies (ESTs) is increasing as climate change is a hot issue and the environment related technologies play an integral role in tackling climate change.

Environmentally Sound Technologies (ESTs) are technologies that have the potential for significantly improved environmental performance relative to other technologies. ESTs protect the environment, are less polluting, use resources in a sustainable manner, recycle more of their wastes and products, and handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes. ESTs are not just individual technologies. They can also be defined as total systems that include knowhow, goods, services, and equipment, as well as organizational and managerial procedures.

Questions

1. Identify the sector, your organization is operating in:
   - ☐ Power
   - ☐ Water
   - ☐ Transport
   - ☐ Agriculture
   - ☐ Industries
   - ☐ Waste Management
   - ☐ Forestry
   - ☐ Other, please specify

2. On a scale of 0 to 10, how would you rate the awareness level of employees in your organization about ESTs?

Low → High

0	1	2	3	4	5	6	7	8	9	10

3. Does the mandate of your organization deals directly with climate issues
   - ☐ Yes
   - ☐ No
4. Identify the existing as well as possible ESTs in the relevant sector.
   - ☐ Renewable Energy Technologies such as solar, hydro, wind, biomass etc…
   - ☐ Energy efficiency, conservation and management
   - ☐ Water management
   - ☐ Precision agriculture and other innovative methods related to agriculture.
   - ☐ Waste to energy / Waste management
   - ☐ Environmental management systems
   - ☐ Others, please specify
5. What is current status of ESTs in your organization
   - ☐ Fully in operation
   - ☐ Partially operation
   - ☐ Not operational
6. What steps are being taken by the organization for development and deployment of ESTs?
   - ☐ ESTs are part of organization's current policy and operations
   - ☐ ESTs are considered in future planning
   - ☐ ESTs are neither part of current operations nor part of future policy and planning
7. What are and can be the benefits of using ESTs in your sector?
   - ☐ Reduced operational costs
   - ☐ Fulfilling Corporate Social Responsibility
   - ☐ Access to international markets such as EU etc…
   - ☐ Increased employee satisfaction
   - ☐ Compliance with national and international standards
   - ☐ Others, please specify
8. What are or can be the main hurdles for development and transfer of ESTs in your organization?
   - ☐ Financial
   - ☐ Technical

- ☐ Social
- ☐ Lack of awareness and education about ESTs
- ☐ Others, please specify

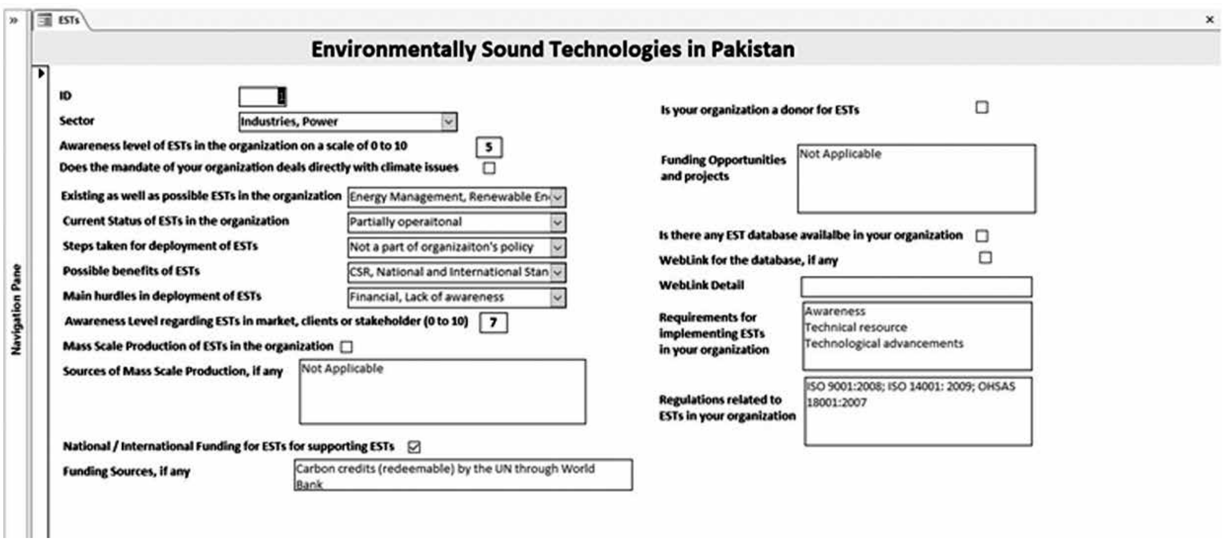
9. What is the awareness level regarding ESTs in market, clients or stakeholder of your organization?

Low → High

0	1	2	3	4	5	6	7	8	9	10

10. Is there any mass scale production of ESTs in the organization / sector?
    - ☐ Yes
    - ☐ No
11. If yes, then please identify the sources for mass scale production.
12. Is there any funding (national / international) available for support of ESTs?
    - ☐ Yes
    - ☐ No
13. Please name the funding resources, if any.
14. Does your organization itself provides funding or supporting projects related to ESTs?
    - ☐ Yes
    - ☐ No
15. If yes, please name the funding opportunities and / or project
16. Is there any known database available w.r.t ESTs
    - ☐ Yes
    - ☐ No
17. If yes, please name them and provide the link.
18. What are the requirements for implementing ESTs?
19. Any voluntary or compulsory government regulation, international law or international standard related to environment protection implemented or planned to be implemented in your organization / sector

Database on Environmentally Sound Technologies

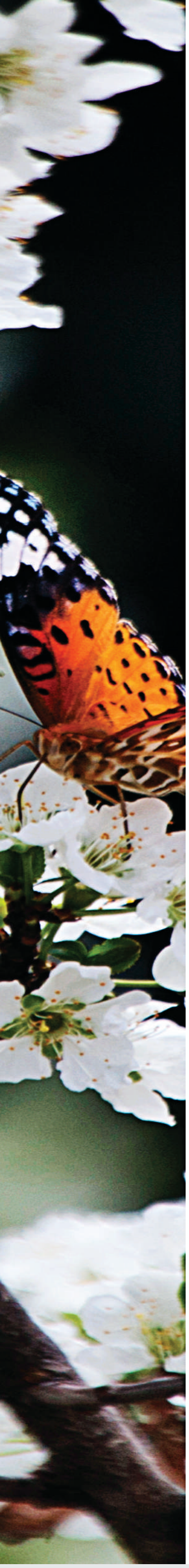

ESTs

Environmentally Sound Technologies in Pakistan

ID
Sector: Industries, Power
Awareness level of ESTs in the organization on a scale of 0 to 10: 5
Does the mandate of your organization deals directly with climate issues: ☐
Existing as well as possible ESTs in the organization: Energy Management, Renewable En
Current Status of ESTs in the organization: Partially operaitonal
Steps taken for deployment of ESTs: Not a part of organizaiton's policy
Possible benefits of ESTs: CSR, National and International Stan
Main hurdles in deployment of ESTs: Financial, Lack of awareness
Awareness Level regarding ESTs in market, clients or stakeholder (0 to 10): 7
Mass Scale Production of ESTs in the organization: ☐
Sources of Mass Scale Production, if any: Not Applicable
National / International Funding for ESTs for supporting ESTs: ☑
Funding Sources, if any: Carbon credits (redeemable) by the UN through World Bank

Is your organization a donor for ESTs: ☐
Funding Opportunities and projects: Not Applicable
Is there any EST database availalbe in your organization: ☐
WebLink for the database, if any: ☐
WebLink Detail
Requirements for implementing ESTs in your organization: Awareness; Technical resource; Technological advancements
Regulations related to ESTs in your organization: ISO 9001:2008; ISO 14001: 2009; OHSAS 18001:2007

Navigation Pane



PAKISTAN'S SECOND NATIONAL COMMUNICATION ON CLIMATE CHANGE

TO UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

Pakistan signed the Untied Nations Framework Convention on Climate Change (UNFCCC) in June 1992, ratified it in June 1994 and entered into force in August, 1994. Pakistan is also a signatory to Kyoto Protocol and all subsequent agreements/ amendments under the same.

Pakistan's Second National Communication on Climate Change has been prepared by Ministry of Climate Change, Government of Pakistan, to fulfill the obligatory requirements under Article 4(1) of UNFCCC. This document has been prepared under the guidance of "UNFCCC's Guidelines (year 1996) for the preparation of national communications from non-Annex I Parties (revised in year 2002)".

The Second National Communication SNC contains an updated information till the year 2015, about the efforts identified and undertaken by Pakistan in different thematic areas related to climate change. It also highlights vulnerabilities of the country and presents an inventory of the emission sources and sinks. It also encompasses the aspects related to climate change research, technology, capacities and awareness, besides other areas of climate change communications.

The content of the document is outcome of rigorous consultations and expert input by six Technical Working Groups, i. e., i) Greenhouse Gas Inventory, ii) Vulnerability & Adaptation Assessment, iii) Mitigation Analysis, iv) Environmentally Sound Technologies, v) Research & Systematic Observations and vi) Climate Change Education, Training, Information Sharing & Networking and Public Awareness, etc. The information has been extensively consulted, reviewed, compiled and presented.

Ministry of Climate Change
Government of Pakistan
Local Government Complex
Sector G-5/2
Islamabad, Pakistan