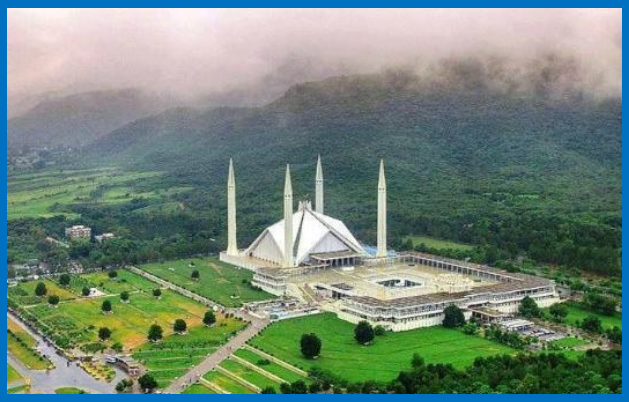

Pakistan Environmental Protection Agency
(Ministry of Climate Change)

National Environment Report

Geomatic Center for Climate Change & Sustainable Development

Foreword

The state of the environment normally relates to an analysis of trends in the environment of a particular place. This analysis can encompass aspects such as quality of drinking and surface water, air pollution, land degradation, land use which keeps on changing with time. The rapid urbanization and motorization make these changes even more severe.

Since the state of the environment directly affects human health, its periodic checking and updating are essential. The first National Environment Report is based on available secondary data.

The report helps in taking timely decisions to avoid any damage, specifically to human health and environmental resources. The information about the National Environment Report also helps policymakers to make informed decisions. The report could apprise legislators to undertake necessary legislation to protect public health and to save natural resources from pollution.

Pak EPA hopes that the report may be of use to policymakers, researchers, consultants, academia, students, print and electronic media as well as general public interested to know about the state of the environment in Pakistan.

We would welcome the suggestion to improve the future annual national report on the environment. We are committed to producing the next edition of National Environment Report of Pakistan will be based on primary as well as secondary data on the environment.

Acknowledgement

The completion of this report depends upon the co-operation, coordination and combined efforts of several resources of knowledge, inspiration and energy. We always knew that in an organization, the work atmosphere yields enormously on an individual's productivity and quality of work. The competence and expertise of people around us was a factor that motivated us to strive and achieve nothing short of perfection.

The concept of this "National Environment Report on the state of environment" is one of the functions of Pak-EPA under section '6' of Pakistan Environmental Protection Act, 1997. In order to prepare the report technical input has been provided by the combined efforts of project "Establishment of Geomatic Centre for Climate Change & Sustainable Development" and Pakistan Environmental Protection Agency. Many other individuals have also contributed to the development of this report.

Above all, the supervision given by Ms. Farzana Altaf Shah, Director General, Pak-EPA especially in its technical formulation is significant that has value-added this report. Thanks to all our technical experts and colleagues for providing constant encouragement and help. We are indebted to them for their timely help and the enthusiasm they expressed in helping us in bringing this project to the fruitful end.

With so many other individuals to be thanked for their valuable comments and exclusive suggestions and assistance provided by our national stakeholders Pakistan Meteorological Department (PMD) and Pakistan Council for Research in Water Resources (PCRWR) is valuable.

Message by Director General

It gives me great pleasure to introduce the First National Environment Report of Pakistan.

The need for the National Environment Report of Pakistan has increased manifolds due to environmental challenges being faced by the country as well as potential climate change impacts in the coming years.

The National Environment Report has highlighted a wide range of Pakistan's environmental challenges and focuses on the set of issues of particular concern in the context of climate change and sustainable development.

The majority of Pakistan's population is dependent on the use of natural resources including land, water, and fisheries. To support and protect the livelihood of the increasing population of Pakistan it is imperative to promote sustainable use of its natural resources.

There is an urgency in addressing Pakistan's environmental problems in the land, air, water, climate change and renewable energy which has become a serious development concern. The accelerated growth rate and rapid urbanization in Pakistan present additional environmental challenges.

The information contained in the report will be used by the policymaker, regulatory compliance monitors, the private sector and civil society organisations dealing with the all aspects of the environment from the generation of environmental pollution up to its management in Pakistan.

I hope that this report will serve as a useful tool and create greater awareness amongst citizen for sustainable management of natural resources of Pakistan and to mitigate climate change impacts.

I warmly congratulate Pakistan Environmental Protection Agency and all those who were involved in preparing the First National Environment Report of Pakistan.

Message by Secretary Ministry Climate Change

It gives me immense pleasure to present Pakistan's First Annual National Report on Environment of Pakistan 2016. The report presents dedication of the Pakistan Environmental Protection Agency's commitment to highlighting environmental and climate change issues and challenges. The key environmental issues identified are; land, air, water, climate change renewable energy and urbanization.

Environment challenges and issues of Pakistan are associated primarily with an imbalanced social and economic development in recent decades. This challenge is further compounded by rapid urbanization due to a shift of population from rural to urban areas of Pakistan.

Pakistan's natural resources and the environment is critical to its future with its immense altitudinal variation. Pakistan ecosystem plays a crucial role in providing a platform for economic development and growth. Agricultural growth in the country is threatened by soil degradation and depleting fertility. The coastal wetlands deprived of water and encroaching deserts are affecting potential productivity. The dependency of Pakistan on its single river the Indus River makes it more vulnerable to the consequences of basin degradation and water pollution.

The extreme weather events have considerably increased their frequency and intensity over the past years. The unpredicted monsoons are causing intense and frequent floods and droughts.

Pakistan's urban air pollution is among the most severe in the world, and it significantly damages human health and the economy mainly due to rapid motorization and increasing energy use.

Notwithstanding frequent, tree plantation campaigns, natural events like flood, landslides, erosion and man-made activities like excessive grazing, deforestation due to reliance on wood as a fuel source and on felling of trees by timber mafia have taken their excessive pound of flesh, and as such, forest cover has not witnessed appreciable expansion.

I am confident that the report will help government agencies, NGOs and Civil Society Organizations in their planning,formulation, monitoring and environmental compliance of laws, rules and regulations.

Executive Summary

The Annual National Report on Environment of Pakistan 2016 is the first report of such nature prepared by Pakistan Environmental Protection Agency (Pak EPA). Geomatic Centre for Climate Change of Pak EPA has initiated the process of preparation of the Annual National Report on Environment of Pakistan 2016 and played a crucial role in preparing this report.

The objective of the Annual National Report on Environment is to address the wide range of Pakistan's environmental challenges and facilitate sustainable development. The State of the Environment Report of Pakistan covers the state and trends of the environment of land, air and water and key issues of climate change, urbanization, renewable energy, as well as environmental policies, legislation and institutional framework and Multilateral Environmental Agreements (MEAs).

Environmental challenges and issues of Pakistan are associated primarily with an imbalanced social and economic development in recent decades. This challenge is further compounded by rapid urbanization from a shift of population from rural to urban areas.

Pakistan is a signatory to a number of Multilateral Environmental Agreements (MEAs)/conventions/protocols and has ratified all of them. The Ministry of Climate Change undertakes serious effort to ensure their implementation.

Patterns of land use in Pakistan have evolved through centuries and have been influenced by environmental and physical factors such as landform, soil, climate, water availability as well as human factors such as population size, growth, economic demands, and cultural practices or customs.

The land use of Pakistan from 2000 to 2016 indicate that present use of land is not quite in accordance with its potential. There is very small and insignificant variation in land use. There is no significant improvement in land use with respect to agriculture and forest. The present land use in the country is based either on the opportunity and economic status or the socio-economic needs of the user.

The main causes of air pollution are inefficient automotive technology, poorly maintained vehicles, use of unclean fuels, uncontrolled emissions of industrial units, the burning of garbage and the presence of dust. The incidence of the so-called "winter fog" phenomenon in Pakistan, which is a cocktail of toxic gases and particulates, also contributes to economic losses, aggravating respiratory and cardiovascular diseases.

Pak-EPA conducted studies on air pollution which revealed that the temporal evolution of atmospheric CO_2 increased from 386.9 to 424.0 ppm in Pakistan from 2011 to 2016. The absolute change of CO_2 concentrations from January 2011 to December 2016 is found to be 10.2 ppm with a total relative change and yearly relative change of 2.61% and 0.43% respectively. The general increase in CO_2 concentration is usually because of fossil fuels burning, deforestation and some natural causes.

The per capita water availability in Pakistan from 1955 to vision 2025 is from 2,490 to 837 cubic metre. The dependency of Pakistan on its single river –the Indus River makes it more

vulnerable to the consequences of basin degradation and water pollution. Pakistan does not have an efficient irrigation system which consumes more than 90% of water. However, the irrigation efficiency is below 40%, and over 60% of irrigation water is lost during conveyance and application in the field.

The overall water quality results of the country show that out of 369 sources, 114 (31%) sources were found safe whereas 255 (69% sources were unsafe when compared with National Standards for Drinking Water Quality.

Pakistan is one of the most vulnerable countries to climate change due to its diverse topographic and demographic settings. The extreme conditions of the weather in Pakistan like the floods in 2010, 2011, 2013 and 2015 testify to the widespread damage climate change can have on Pakistan.

The future projections for climate change indicators show Pakistan's projected temperature increase is expected to be higher than the global average. The projected temperature increase in northern parts is expected to be higher than the southern parts of the country. The frequency of hot days and hot nights are expected to increase significantly. The extreme weather events have considerably increased their frequency and intensity over the past years. The unpredicted monsoons are causing intense and frequent floods and droughts.

Pakistan is one of those developing countries where urbanization is taking place rapidly, and as a result, the share of urban population is increasing significantly. The population in rural areas decreased from 61.4 per cent in 2014 to 60.1 per cent in 2016, whereas, the population in urban areas increased from 38.5 per cent in 2014 to 40.0 per cent in 2016. The exponential growth of urbanization has resulted in a rapid increase in the size of urban areas as well as an increase in the development of slums in the suburbs because of large-scale migration from rural to urban cities.

Pakistan is endowed with renewable energy resource of hydropower, solar, wind, bio-engineering. During 2015-16, a total of 9 solar, wind and bagasse co-generation power plant were operational with a combined installed capacity of 438 MW which generated 802 Gwh of electricity.

The government of Pakistan is conscious of the need for environmental protection and has undertaken a number of measures through enacting legislation, setting standards, developing and implementing policies for a secure and lively environment.

Pakistan's natural resources and the environment is critical to its future with its immense altitudinal variation. Pakistan ecosystem plays a crucial role in providing a platform for economic development and growth. There is a need for sustainable use of vast natural resources. Development of protocols for the collection, analysis and dissemination of data on natural resource management is required as effective interventions are constrained by the paucity of data.

Pakistan needs to strengthen its policy, institutional framework and capacity to mitigate the negative impacts in line with the best international practices. The legislation could pave the way towards the betterment of climate safety measures which would ultimately ensure clean air and water.

Acronyms

AEDB	Alternative Energy Development Board
AJK	Azad Jammu and Kashmir
ALGAS	Asia Least-cost Greenhouse Gas Abatement Strategy
AR5	Fifth Assessment Report
BCM	Billion Cubic Meters
CBD	Convention on Biological Diversity
CCD	Convention to Combat Desertification and Drought
CDM	Clean Development Mechanism
CFCs	Chlorofluorocarbons
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMIP5	Coupled Model Inter-Comparison Project Phase-5
CMS	Conservation of Migratory Species
COD	Commercial Operations Dated
CPB	Cartagena Protocol on Biosafety
DALYs	Disability Adjusted Life Years
EPA	Environmental Protection Agency
ESCAP	Economic and Social Commission for Asia and the Pacific
ESMAP	Energy Sector Management Assistance Program
FAO	Food and Agriculture Organization
FATA	Federally Administered Tribal Areas
GCISC	Global Change Impact Studies Centre
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GLOF	Glacial Lake Outburst Flood
GMOs	Genetically Modified Organisms
GOSAT	Greenhouse Gases Observing Satellite
HFCs	Hydrofluorocarbons
HCFCs	Hydro Chlorofluorocarbons
ICIMOD	International Centre for Integrated Mountain Development
ICOLD	International Commission on Large Dams
IEE	Initial Environmental Examination
IPCC	Intergovernmental Panel on Climate Change
IRSA	Indus River System Authority
IUCN	International Union for Conservation of Nature

JICA	Japan International Cooperation Agency
KIA	Korangi Industrial Area
LIB	Lower Indus Basin
MAF	Million Acre Feet
MEAs	Multilateral Environment Agreements
MELG&RD	Ministry of Environment, Local Government and Rural Development
MtCO2e	Million Tons of Carbon Dioxide Equivalent
NAMA	Nationally Appropriate Mitigation Activities
NBC	National Biosafety Centre
NCCP	National Climate Change Policy
NCCW	National Council for Conservation of Wildlife
NCS	National Conservation Strategy
NEQS	National Environmental Quality Standards
OCO2	Orbiting Carbon Observatory-2
ODS	Ozone Depleting Substances
PCRWR	Pakistan Council of Research in Water Resources
PEP Act	Pakistan Environmental Protection Act
PEPC	Pakistan Environmental Protection Council
PEPO	Pakistan Environmental Protection Ordinance
PM	Particulate Matter
PMD	Pakistan Meteorological Department
POPs	Persistent Organic Pollutants
PPIB	Private Power & Infrastructure Board
RCP	Representative Concentration Pathways
REDD	Reducing Emissions from Deforestation and Forest
SDG	Sustainable Development Goals
SLMP	Sustainable Land Management Programme
SLR	Sea level Rise
SMART	Self-Monitoring and Reporting Tool
TDS	Total Dissolved Solids
UIB	Upper Indus Basin
UNEP	United Nations Environment Program
UNFCC	United Nations Framework Convention on Climate Change
WHO	World Health Organisation
WWF	World Wildlife Fund

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INTRODUCTION

1 Introduction

1.1 Introduction

Pakistan is situated between latitude 25° 35′ north and 37° 05′ north and extends from longitude 61° east to 78° east. The total area of Pakistan is 796,095 square km stretching over 1,600 km from north to south and about 885 km from east to west.

Pakistan is a geographically diverse country with a large number of significant ecological features comprising northern highlands, floodplains, Indus plains, deserts, wetlands and coastal regions supporting diverse and distinct biological inhabitants. Furthermore, it is the highly urbanized country of South Asia with the densely settled land, facing rapid population increase.

Pakistan is the second largest country in South Asia and mainly comprises of dry or cold areas with low production potential. Geography varies across the country, shaping the great variation in the country's climate. The climate ranges from mild winters and hot, dry summers in the north to semi-arid and arid zones in the west and the south. There is a great difference between the day and night temperature in Pakistan.

Pakistan like many other countries is facing environmental challenges and climate change. Pakistan is more vulnerable to climate change due to its diverse topographic and demographic settings. The temperature changes under current circumstances are expected to be higher in Pakistan in the long run than global averages.

In Pakistan, climate change raises concerns about it's tremendous social, environmental and economic impacts. Pakistan is frequently exposed to natural hazards like floods, droughts and cyclones. These hazards when combined with the vulnerabilities in the shape of poverty, exclusion and inappropriate political decisions and actions make people more susceptible to the impacts of hazards.

1.2 State of Environment in Pakistan

Pakistan is more vulnerable to climate change due to its diverse topographic and demographic settings. The temperature changes under current circumstances are expected to be higher in Pakistan in the long run than global averages. The state of the environment of air, land and water is described hereunder:

Air

Growth in the industrial zones brings prosperity, but on the other hand, raises the particulate smoke matter and the effluents which have a damaging effect on the environment. Major cities of Pakistan; like Karachi and Lahore have already been termed as among the most polluted cities in Asia.

The continuous fog and smog conditions in Lahore and other areas of Punjab in the winter months, with delayed rainfall, is quite alarming.

Water

Water is a key component in determining the quality of our lives. The stress on water resources of the country is from multiple sources. Rapid urbanization increased industrial activity and dependence of the agricultural sector on chemicals and fertilizers have led to water pollution.

According to the Pakistan Council of Research in Water Resources (PCRWR), the majority of the population in the country is exposed to the hazards of drinking unsafe and polluted water from both surface and groundwater sources.

As one indicator of the magnitude of the problem, it is estimated that 250,000 children in Pakistan die every year due to diarrheal diseases alone. Safe drinking water alone can reduce diarrhoea and other related diseases by up to 50 per cent, but an estimated 62 per cent of Pakistan's urban population and 84 per cent of the rural population do not treat their water. Pakistan's ranking in maintaining water quality standards is 80th out of 122 nations.[1]

According to the UNESCO World Water Developing Report, it is estimated that water-related diseases cause annual national income losses of USD 380-883 million – or approximately 0.6-1.44 per cent of GDP. In this perspective, it is the need of the time to take initiatives to ensure that drinking water is safe to consume.

Land

Pakistan is predominantly an arid to semi-arid country with 68 million hectares of land lying in regions where the annual rainfall is less than 300 mm. One- fourth of the country's land area, which is suitable for intensive agriculture, is threatened by wind and water erosion, salinity, waterlogging, flooding and loss of organic matter.

The important driving forces of land degradation in Pakistan are intensive agriculture, unsustainable cropping pattern, unchecked use of chemical fertilizers and pesticides, limited land resources and population increase.

The agriculture sector is most vulnerable to climate change, and changes in cropping and productivity as a result of weather changes do affect the poor rural communities of the country. The dry land areas, including arid and semi-arid regions, are most vulnerable to these changes, as these regions are already facing significant water shortages and high temperature. The biophysical relationships could also be altered due to seasonal changes in cultivating crops which will consequently lead to changing irrigation requirements, altering soil characteristics and increasing the risk of pests and diseases, thereby negatively affecting agriculture productivity (Mustafa, 2011).

In the Pakistani context, climate change vulnerability is particularly high because of its large population and economic dependence on primary natural resources, being basically an agriculture economy.

The forest of Khyber Pakhtunkhwa and northern areas are a valuable source of timber and provide vibrant ecological services that protect watersheds and maintain soil productivity. The northern highlands of the subcontinent are covered with shrub, pine and conifer

[1] *http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/*

forests, which have been condensed to very little growth in most places. These lands include not only lesser elevation territories of Potohar and Azad Jammu and Kashmir but also the higher elevation areas taking on the foothills of Himalayan, Karakorum and Hindukush mountain ranges. This is superb habitat for wildlife in the form of alpine grazelands, sub-alpine scrub and temperate jungle.

In most of Punjab and Sindh, the Indus plains have many fluvial landforms that support various natural biomes including tropical and subtropical dry and moist broadleaf forestry as well as tropical and xeric shrublands (deserts of Thal in Punjab, Tharparkar in Sindh) and karira (Capparis aphylla) provide firewood. The riparian woodlands grow in narrow belts along the banks of River Indus and its tributaries.

In the south and west of Sindh are Indus River Delta and Great Rann of Kutch in the east. The largest saltwater wetland in Pakistan is the Indus River Delta. Unlike many other river deltas, it consists of clay soil and is very swampy. The Great Rann of Kutch below the Thar Desert is not as swampy and exhibits shrubland vegetation of rather dry thorny shrubs as well as marsh grasses of Apluda and Cenchrus. Other saltwater wetlands are located on the coast of Balochistan such as at Sonmiani and Jiwani.

These and Indus River Delta support mangrove forestry, mainly of species Avicennia marina. There are a number of protected wetlands (under Ramsar Convention) in Pakistan. These include Tanda dam and Thanedar Wala in Khyber Pakhtunkhwa, Chashma barrage, Taunsa barrage and Uchhali complex in Punjab, Haleji Lake, Hub dam and Kinjhar Lake in Sindh, Miani Hor in Balochistan.

Less than 20 per cent of Pakistan's land area is used for intensive agriculture, the waters of Indus River have been used to convert deserts and arid plains into productive farmlands. The Indus River is one of the longest rivers in Asia. The Punjab plains are in the main irrigated by the Indus River and its tributaries, i.e. Jhelum, Ravi, Chenab, Sutlej, and the Beas. These plains of river Indus prolong towards and occupy for the most part of western Sindh. Immense of the Indus floodplains have been unoccupied of natural flora to grow crops. This has resulted in some species being endangered.

The coastal wetlands deprived of water and encroaching deserts are affecting potential productivity. The dependency of Pakistan on its single river –the Indus River makes disadvantageous more vulnerable to the consequences of basin degradation and water pollution.

Mountainous ecosystems are Fragile and more susceptible to climate change and one of the major "experimental fields of nature" because of the steep environmental slope, wilderness and habitat types, and rich for biodiversity and water and they also provide services with tangible economic value. The hotspots of Himalayas, Karakorum and the Hindu Kush have a richness of species, gene pools and ecosystems which have global importance. Human-induced climate change is a predictable threat to species of Himalayas. These mountain environments are strongly affected by climate, due to their vertical (altitudinal) dimension (Ishaq et al., 2015).

Heavy reliance on natural resources and degrading resource base directly affects the poverty in the country with many economic challenges directly related to environmental problems.

1.3 Climate Change, National and Global Challenges

The major environmental challenge of today's world is the unprecedented climate change. Globally climate change is creating immense problems for humans and wildlife. Most climate scientists agree the main cause of the current global warming trend is the human expansion of the "greenhouse effect".[2]

Strong impacts of climate change like devastating storms, hurricanes and severe heat waves could be life-threatening in countries with limited resources. Human activities, including the decomposition of wastes in landfills, agriculture, and especially rice cultivation, as well as ruminant digestion and manure management associated with domestic livestock give rise to methane increment in the atmosphere which is far more active Greenhouse Gas than CO_2.

Another powerful greenhouse gas produced by soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning is Nitrous Oxide. Synthetic compounds entirely of industrial origin used in a number of applications release CFCs which are known for their ability to contribute to the destruction of the ozone layer. They are also greenhouse gases. So, on Earth, human activities are changing the natural greenhouse.

The Inter-Governmental Panel on Climate Change (IPCC), which includes more than 1,300 scientists from the United States and other countries, forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century.

Pakistan like other developing countries remains extremely vulnerable to the impacts of climate change. Environmental challenges and issues of Pakistan are associated primarily with an imbalanced social and economic development in recent decades because Pakistan is more susceptible to the effects of changing climate as it is an agrarian country and highly dependent on natural resources for livelihoods. The temperature changes under current circumstances are expected to be higher in Pakistan in the long run than global averages.

The frequency and intensity of the extreme events especially the floods have caused major damages to the social and economic gains made in the developing countries of South Asia. Heat waves in India and Pakistan have killed many people in recent years and intensity of increased rainfalls during monsoon season with tropical cyclones and prolonged dry spells caused severe impact on the region. The evidence for rapid climate change is compelling.

The dependency of our industrial sector on agricultural raw material indicates that climate change is set to sabotage the supply chain of the industries as well. Consequently, damage to livelihoods will not remain confined to the agricultural sector alone but will also spill over to the industrial markets.

Another significant vulnerability factor for Pakistan is the threat of climate change to human settlements in coastal areas. Rising sea levels coupled with the increased precipitation in some regions wreak havoc on many coastal towns and cities and have the power to submerge them underwater. The northern regions suffer from severe cold, avalanches, heavy rains, precipitation in the form of snow and blizzards.

[2] *https://www.ipcc.ch/report/ar5/syr/*

The challenges of climate change are further compounded with rapid urbanization due to a shift of population from rural to urban areas. Thus, all major cities of Pakistan face haphazard, unplanned expansion leading to an increase in urbanisation which is a contributing factor to environmental degradation. This unchecked growth has also led to the creation of slum areas around city peripheries and low-lying area.

Pakistan has low GHG emission status, but the country provides no safety from the adverse effects of global climate change. Pakistan being an agricultural based economy, lying in the arid and semi-arid region, with heavy dependence on irrigated agriculture is highly vulnerable to climate change. Pakistan is facing the adverse impacts of climate change with higher glacial melt, prolonged droughts, hot winter & early summers which are negatively affecting water resources & overall agricultural productivity. The effect of global warming on the glaciers of Himalayas, Hindus Kush and Karakorum also threatens the inflow of water into the Indus River System.

The projected climate change and global warming have serious implications on the Indus River System, and with increased and intense floods, the siltation of major dams has increased over the years. Future trends of climate change will reduce glacier size thus changing the seasonal flow of the Indus River System.

Extreme events with higher intensity and monsoon pattern's irregularities will increase the frequency of floods and droughts as observed in 2010 flooding.

1.3 Purpose of the Annual National Report on Environment

The prime objective of the Annual National Report on Environment of Pakistan 2016 is to address the wide range of Pakistan's environmental challenges and facilitate sustainable development.

The main audience for the Annual National Report on Environment of Pakistan 2016 is public sector organisation particularly those involved in policy decisions making and regulatory compliance, the private sector and civil society organisations dealing with the environment.

The Annual National Report on Environment of Pakistan 2016 has been prepared on the secondary data of published documents on the environment, climate change and sustainable development prepared by the Government of Pakistan, International donors, International NGOs, UN Agencies and research work carried out by Pakistani and International Universities.

MULTILATERAL ENVIRONMENTAL AGREEMENTS

2 Multilateral Environmental Agreements

2.1 Introduction

The environment is a transboundary subject and a global priority which can only be addressed effectively through international cooperation. The main tool for countries to work together on global environmental issues is to implement multilateral environmental agreements.

In 1972, the Stockholm conference secured a permanent place for the environment on the world's agenda and led to the establishment of the United Nations Environment Program (UNEP). On the twentieth anniversary of the Stockholm Conference on the Human Environment, representatives from 178 nations and non-governmental agencies (NGOs) met in Rio de Janeiro to discuss global environmental issues.

The conference concluded with the Earth Summit, at which the leaders demonstrated their commitment to sustainable development. Many conventions were signed internationally with the aim of protecting the environment from degradation, climate change and unsustainable development. The importance of cooperation among countries to work together in an integrated manner through various conventions/protocols cannot be overemphasised.

In light of a growing consciousness of environmental issues Pakistan has signed and ratified many conventions and protocols, some of the most important MEAs are described below:

2.2 Wildlife-Related Conventions (CITES, Ramsar and CMS)

National Council for Conservation of Wildlife (NCCW) is implementing the obligations of the following three Conventions to which the Government of Pakistan is a signatory:

- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
- Convention on Wetland of International Importance Especially as Waterfowl Habitat (Ramsar).
- Convention on the Conservation of Migratory Species of Wild Animals (CMS).

A ban on the commercial export of species named in Appendix I of CITES and II was implemented with the limited exception of those species necessary for scientific use. Similarly, the export of mammals and reptiles, which are not common in the country, remained closed.

The commercial export of common birds, mostly captive bred species was encouraged. This policy was regulated by NCCW in collaboration with the Ministry of Commerce and Provincial Wildlife Departments. Pakistan now has 19 Ramsar sites covering 1,343,627 hectares, and the Convention's 1,283 sites now cover a surface area of 108,751,595 hectares.

NCCW has also encouraged the Provincial Wildlife Departments to implement the obligations of the Convention on Conservation of Migratory Species of Wild Animals (CMS), which is also known as the Bonn Convention.

NCCW, as an obligation of MOU signed under CMS, is attempting to implement measures to protect the threatened Siberian crane in collaboration with the WWF Pakistan and the Khyber Pakhtunkhwa Wildlife Department.

An additional Conservation Plan and Memorandum of Understanding is under consideration for the conservation of marine turtles. NCCW is also trying to minimize the hunting pressure on the Chaubara bustard and falcon species in collaboration with Chaubara/Falcon Foundation International-Pakistan.

2.3 Montreal Protocol

Montreal Protocol, formally Montreal Protocol on Substances that Deplete the Ozone Layer, an international treaty, was adopted in Montreal on Sept. 16, 1987, with the aim to regulate the production and use of chemicals that contribute to the depletion of Earth's ozone layer. Initially signed by 46 countries, the treaty now has nearly 200 signatories.

Pakistan joined the Montreal Protocol and became a Party to the Montreal Protocol by ratifying the Protocol and its London Amendments on 18th December 1992. The subsequent amendments are known as the Copenhagen Amendments, and they provide for the acceleration of the phase-out dates, which is central to the achievements envisaged by the Montreal Protocol.

The ozone-depleting substances (ODS) are predominantly utilised in Pakistan in processes for the manufacture and use of deep-freezers, refrigerators, car air-conditioners, foam, dry-cleaning, fire extinguishers and solvents.

The ODS consumption during the years 1995, 1996 and 1997 was recorded at a level of 3,188; 2,510 and 2,352 metric tons respectively, which translates to approximately 0.02 kg per capita. As Pakistan's per capita consumption of ODS is less than 0.3 kg, Pakistan falls within the category of Article 5 (I) Parties.

In light of Pakistan's commitments to the international community, an Ozone Cell has been established. This Cell comes within the project entitled ―Institutional strengthening for the Implementation of the Montreal Protocol for the phase-out of Ozone Depleting Substances - which is facilitated by the provision of financial assistance by the Multilateral Fund of the Montreal Protocol.

2.4 Basel Convention

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal is an international treaty designed to reduce the movements of hazardous waste between nations, and specifically to prevent the transfer of hazardous waste from developed to less developed countries. It, however, does not address the movement of radioactive waste. Pakistan ratified Basal Convention during July 1994.

2.5 United Nations Framework Convention on Climate Change (UNFCCC)

Pakistan is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992 and ratified this Convention in July 1994.

The ratification of the Convention had the effect of triggering a series of activities in Pakistan regarding climate change issues. These activities included the Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS) project, which was completed in 1998 and was the first comprehensive national project on climate change.

This strategy was central to addressing many of the global concerns regarding the climatic change, particularly, it covered both quantification of emissions and the establishment of a long-term emission reduction program.

The Country Case Study on Climate Change Impacts and Adaptation Assessments in Pakistan were also completed in 1998, which assessed the impact of climate change on four major sectors of the economy being agriculture, forestry, water resource, and meteorology.

A number of mitigation and adaptation measures and actions has already being undertaken with domestic resources. These measures and actions did intensify the availability of international climate finance, technology development and transfer, and capacity building.

2.5.1 Kyoto Protocol

The Kyoto Protocol focused on promoting low-carbon development through the Clean Development Mechanism (CDM). Although the CDM has undoubtedly resulted in some low carbon investment that would not have otherwise occurred; it has not prompted fundamental shifts in development patterns. The United Nation Environment Programme is the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system.

The UNEP has launched several initiatives, including the Global Bio-energy Partnership (GBEP) to support the deployment of biomass and biofuels, and the Solar and Wind Energy Resource Assessment (SWERA).

2.5.2 Clean Development Mechanism (CDM)

The Kyoto Protocol to UNFCCC was adopted at the 3rd Meeting of the Parties held in Kyoto, Japan, in 1997. Under the Protocol, developed countries agreed to reduce their combined greenhouse emissions.[3]

CDM is the only instrument that is available for developing countries to assist them in achieving sustainable development and contributing to the ultimate objective of the Convention. CDM, Pakistan from 2005-2014, has accorded Host Country Approval to 71 CDM Projects out of which 38 projects are registered with UNFCCC (United Nations Framework Convention on Climate Change) which will generate Certified Emissions Reductions (CERs).

[3] *https://cdm.unfccc.int/EB/governance.html*

The estimated amount of GHG mitigation/year from these 38 registered projects is 4.91 million tons of CO_2, total GHG mitigation/project period for 38 registered projects is 91.17 million tons of CO_2.

2.5.3 Pakistan's Intended Nationally Determined Contribution (Pak-INDC)

As part of the international climate policy regime, national governments are obligated to submit their Intended Nationally Determined Contributions to achieve stabilization of GHG in the atmosphere, with a timeframe that adequately allows for adaptation to climate change.

Pakistan's vulnerability to adverse impacts of climate change is well established and widely recognized. Despite Pakistan's diminutive contribution to global GHG emissions, it is among the top ten most climate-affected countries of the world, as indicated by the Global Climate Risk Index developed by German watch. Moreover, these adverse impacts of climate change are not in the distant future but are imminent. Indeed, these are already occurring as Pakistan has started suffering from ever-increasing frequency and ferocity of climate-induced catastrophes.

Pakistan's Intended Nationally Determined Contribution (Pak-INDC) is rooted in the country's strategic plan 'Vision 2025'. It is aligned with the respective policies, plans and sectoral growth targets set by various ministries and other government entities. Similarly, potential impacts of key development plans and projects, such as measures being undertaken to address current energy shortages and contributions to economic growth partly due to China-Pakistan Economic Corridor (CPEC) have been taken into consideration.

Pak-INDC presents the overall GHG emissions profile and future emission projections, by considering both the present and future socio-economic parameters, changes in the demographic dynamics and emerging energy needs. It also describes mitigation and adaptation measures already being implemented in Pakistan and discusses the challenges and difficulties being faced and those likely to be confronted in the coming years.

2.5.4 Nationally Appropriate Mitigation Actions

Nationally Appropriate Mitigation Actions (NAMA) is a set of government prioritized policies, strategies, programmes and actions aimed at reducing or limiting GHG emissions. The government can initiate the NAMAs through the collaboration of relative departments and the private sector. It also emphasizes financial assistance from developed countries to developing countries to reduce GHG emissions.

The following seven NAMA proposals were submitted to the UK German NAMA facility during its second call and UNFCCC NAMA Registry to seek International funding:

- Accelerating the market transformation to energy efficient lighting
- Supporting mechanisms for promoting distributed generation (net metering, wheeling, banking etc.) in Pakistan to put a 3 GW Alternative and Renewable Energy (ARE) projects in the next seven years.
- Strategizing for grid strengthening/improvement for evacuation of power from solar power projects

- Strategizing for grid strengthening /improvement for evacuation of power from wind power projects
- Development and installation of carbon dioxide sequestration technologies in Pakistan
- Harnessing municipal waste of big cities of Pakistan to generate electricity
- Bio-energy generation and greenhouse-gases mitigation though organic-waste utilization.

These seven NAMA projects will reduce 12.16 million tons per year GHG emission if climate finance to the tune of € 101.62 million is available through international climate finance.

2.6 Reducing Emissions from Deforestation and Forest Degradation (REDD$^+$)

Reducing emissions from deforestation and forest degradation (REDD$^+$) is a mechanism that has been under negotiation by the United Nations Framework Convention on Climate Change (UNFCCC) since 2005, with the objective of mitigating climate change through reducing net emissions of greenhouse gases through enhanced forest management in developing countries. Pakistan ratified REDD$^+$ in 2007.

UNFCCC has provided a platform to the international community to negotiate and take measures for climate change mitigation. REDD$^+$ emerges as an incentive-based mitigation mechanism to address the potential role of forestry up to 17 - 25 % reported share towards GHG emissions reduction.

Under the UN Framework Convention on Climate Change, a new mechanism Reducing Emissions from Deforestation and Forest Degradation (REDD$^+$) was adopted in Cancun in 2010.

Pakistan has the vast potential of controlling deforestation under REDD$^+$ by paying compensation to forest communities with the finance of free market and non-market resources.

Ministry of Climate Change has constituted a National Steering Committee on REDD$^+$ to guide and steer REDD$^+$ in the country. Pakistan became a member of the United Nations REDD$^+$ programme (UN-REDD programme) in 2011 and the World Bank's Forest Carbon Partnership Facility (FCPF) in 2014. The UN-REDD and FCPF financial mechanisms support developing countries to undertake readiness activities to be eligible result based payments.

The FCPF grant for REDD$^+$ readiness is being utilized for the preparation of a national REDD$^+$ strategy, a national forest monitoring system, and a system of social and environmental safeguards to implement REDD$^+$.

2.7 Convention on Biological Diversity

Biodiversity is defined as ―the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species

and of ecosystems (Convention on Bio-Diversity (CBD) 1992). A United Nations Convention on Biological Diversity (CBD) was developed in June 1992 and ratified by Pakistan in July 1994.

The objectives of this Convention, which are to be pursued in accordance with its relevant provisions, include; the conservation of biological diversity, the sustainable use of its components and fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including appropriate access to genetic resources and appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

The Fifth National Report to Convention on Biological Diversity (CBD) was prepared as a part of the National Biodiversity Strategy and Action Plan (NBSAP) revision process that is being conducted through a Global Environment Facility Trust Fund project entitled "Support to Pakistan for the Revision of the NBSAPs and Development of Fifth National Report to the CBD". The 5th national report was submitted to CBD secretariat in 2014.

Previous Biodiversity Action Plan was prepared in 1999, and new revision intends to align the NBSAP with the strategic plan of CBD 2011-2020, and it's Aichi Biodiversity Targets.

The Biodiversity Directorate is currently revising NBSAP. An agreement with IUCN Pakistan was signed to take up the assignment of Revision of the National Biodiversity Strategy and Action Plan. Keeping in view the experience of preparation of the first Biodiversity Action Plan, the project is being executed in collaboration with IUCN Pakistan.

Establishment of provincial focal committees for monitoring, implementation and coordination of CBD in all the provinces including Azad Jammu and Kashmir (AJK) and Gilgit-Baltistan have been proposed in the plan.

The Cabinet approved the Summary for Accession to Nagoya Protocol on Access and Benefit Sharing (ABS) arising from the utilization of genetic resources under Convention on Biological Diversity on 28th July 2015. The instrument of Accession to Nagoya Protocol on ABS was signed by the President of Pakistan on 12th October 2015.

2.8 Convention to Combat Desertification and Drought (CCD)

Desertification is a global problem, particularly as it affects more than 100 countries and has the dire consequences of environmental degradation, loss of soil fertility, loss of biodiversity and reduction in land productivity.

United Nations established an Inter-Governmental Negotiation Committee (INC) to investigate this problem, and after a series of meetings, the INC developed the United Nations Convention to Combat Desertification (CCD). This Convention was adopted in October 1994 and was signed and ratified by Pakistan in February 1997.

Pakistan has developed the National Action Plan to Combat Desertification in Pakistan (NAP), which has been prepared with the financial and technical support of United Nations Environmental Program and the Economic and Social Commission for Asia and the Pacific (ESCAP). The proposed Plan identifies the factors contributing to desertification and the

various practical measures necessary to combat desertification and mitigate the effects created by the drought.

The plan envisages the participatory process as well as the coordination of the results of research with other efforts to formulate national policies for sustainable development. Some technological interventions to address the issue of desertification have been successfully implemented in different parts of Pakistan and these include: Rangelands Utilization Model in Potohar Plateau, Gully Land Management through Soil Conservation and Water Harvesting, Range Improvement through Community Participation, Salinity Control and Reclamation of Affected Areas, Rehabilitation of Desert Ranges through Reseeding, Forage Reserve, Establishment in Arid Highland Balochistan, Reclamation of salt-affected areas, Desertification Control in Cholistan and Restoration of Land Productivity in Barani Lands.

2.9 Cartagena Protocol on Biosafety to the Convention on Biological Diversity

The Cartagena Protocol on Biosafety to the Convention on Biological Diversity is an international agreement on biosafety as a supplement to the Convention on Biological Diversity effective since 2003. The Biosafety Protocol seeks to protect biological diversity from the potential risks posed by genetically modified organisms resulting from modern biotechnology.

Pakistan is party to the Cartagena Protocol on Biosafety (CPB) to the Convention on Biological Diversity (CBD) since May 31, 2009. The setup of the implementation system in the country was mandatory to regulate Genetically Modified Organisms (GMOs) and their products related activities. National Biosafety Centre was established in Pakistan Environmental Protection Agency (Pak-EPA), Ministry of Environment (defunct) in April 2006 to meet the obligations of CPB.

Pakistan Biosafety Rules, 2005 had been devised under the Pakistan Environmental Protection Act, 1997 (PEPA, 1997) and notified by Pak-EPA (then Ministry of Environment) to regulate GMOs and their products. National Biosafety Guidelines, 2005 were developed and notified to explain the procedures and protocols to the applicants.

The National Biosafety Centre has processed more than 200 cases of GMOs and their products related to Laboratory Genetic Manipulation Work, Field Trials for Research and Development (R&D), Import and Export, Commercialization (Sale and Purchase). The Centre has been regulating the R&D and commercialization of Genetically Modified (GM) Cotton, Corn and other crops (Sugarcane, Chili, Tobacco, and Wheat etc.).

2.10 Comprehensive Reduction and elimination of Persistent Organic Pollutants in Pakistan (POPs)

The main objectives of this project are reducing human health and environmental risks by enhancing management capacities and disposal of POPs in Pakistan through:

- The development and implementation of regulatory, policy and enforcement system to reduce POPs releases and to regulate POPs waste disposal;
- Capacity building to reduce exposure and releases of POPs;

- Collection, transport and disposal of 300 tons of Poly Chlorinated Biphenyls (PCBs) and 1,200 tons of POPs Pesticides.

The elimination of POPs pesticide stockpile became even more urgent after the 2010 floods which damaged some of the storage sites of hazardous chemicals and pesticides. The facilities are to be upgraded, tested and permitted in compliance with the Stockholm Convention Best Available Techniques (BAT) and Best Environmental Practices (BEP).

2.11 United Nations Conference of Parties on Climate Change (COP-22)

United Nations Conference of Parties on Climate Change (COP-22) was in Marrakech, Morocco in November 2016 to put environmental changes into perspective and find solutions. Pakistan delegation for Climate Change also attended the 22nd Session of Conference of Parties (COP22).

The actions were taken by the government, including the National Climate Change Policy, along with a framework for its implementation, and a National Disaster Risk Reduction Policy has been highlighted. Pakistan has also developed a National Sustainable Development Strategy, and the National Assembly of Pakistan has passed a resolution adopting the SDGs agenda as its own national development agenda.

2.12 Paris Agreement and its rectification

Pakistan ratified the Paris Agreement on Climate Change at United Nations Headquarters in New York, becoming the 104th country in the world to ratify the landmark deal.

The agreement obliges member states to keep global warming below 2 centigrade regarded as the threshold for safety by experts and scientists. Pakistan's ratification is in line with its firm commitment to the purposes and objectives of the Climate Convention. It also highlights the resolve of Pakistan to remain fully committed to the implementation of the Paris Agreement.

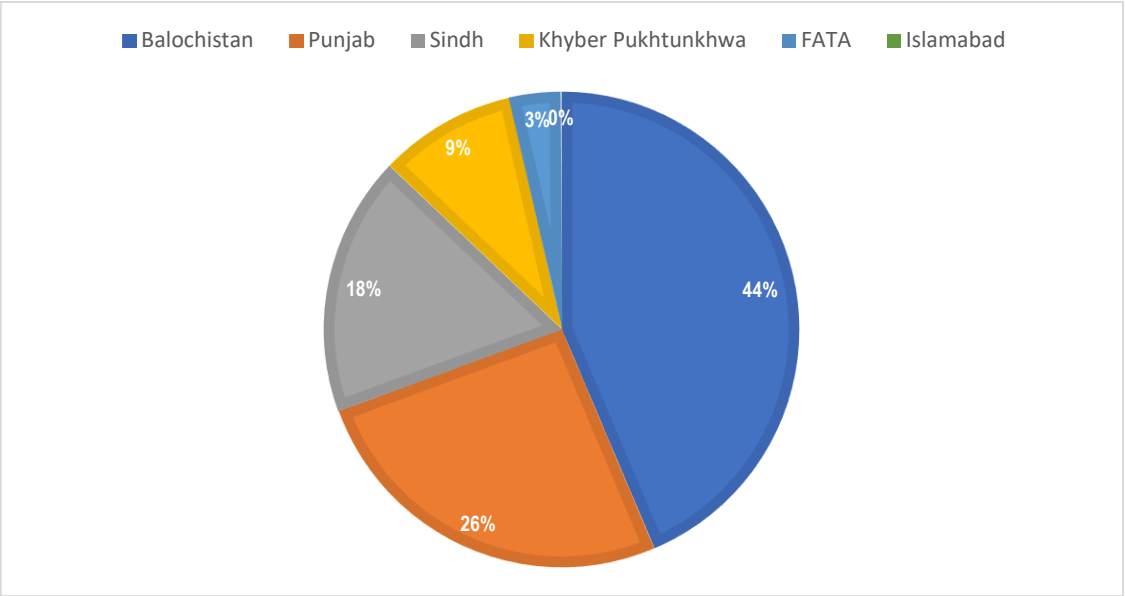
LAND

3 Land

3.1 Introduction

Pakistan, with a total area of 796, 095 sq. km. in which land acquires about 770,875 sq. km and water about 25,220 sq. km. The 44% area of Pakistan is in Baluchistan, 26% in Punjab, 18% in Sindh, 9% in Khyber Pakhtunkhwa and 3 % in FATA and Islamabad.

Figure 3.1: Distribution of area of Pakistan



Pakistan is mainly a dry-land country where 80 per cent of its land area is arid or semi-arid, about 12 per cent is dry sub-humid, and the remaining 8 per cent is humid. Pakistan has been divided into three major geographic areas: the northern highlands, the Indus River plain in the centre and east, and the Balochistan Plateau in the south and west.

Pakistan is divided into ten agro-ecological zones based on physiography, climate, land use and water availability (Khan et al., 2012).

Zone-I - Indus Delta: The climate is an arid tropical marine. The mean monthly summer rainfall is 75 mm and winter rainfall less than 5 mm. The mean daily temperature is between 34 °C and 40 °C in summer and between 19°C and 20 °C in winter. The soils are clayey and salty.

Zone-II - Southern Irrigated Plain: The Lower Indus Plain. The climate is arid and subtropical. The mean monthly summer rainfall is 18 mm in the north and 45 to 55 mm in the south. The soils are silty and sandy loam, but the upper areas of the floodplain are calcareous loamy and clayey.

Zone-III - Sandy Desert (a): The maximum rainfall is 300 mm. The soils are sandy and loamy fine sand.

Zone-III- Sandy Desert (b): Sand ridges and dunes. The rainfall is between 300 and 350 mm. The soils are sandy and loamy fine sand.

Zone-IV -Northern Irrigated Plain (a): Floodplains and bar uplands. The climate is semi-arid to arid. The mean annual rainfall is 300 to 500 mm in the east and 200 to 300 mm in the southwest. The soils are sandy, loam-clay and loam.

Zone IV - Northern Irrigated Plain (b): Alluvial valleys of Peshawar and Mardan. The climate is semi-arid. The mean monthly rainfall is 20 to 30 mm. The soils are silty clays and clay loams.

Zone V - Barani (rainfed) Lands: This covers the Salt Range and the Potohar Plateau. In the north, the mean monthly rainfall is 200 mm in summer and 35 to 50 mm in winter. The climate in the southern part is semi-arid and hot. The mean monthly rainfall is 85 mm in summer and 30 to 45 mm in winter.

Zone VI - Wet Mountains - High Mountains: The mean monthly rainfall is 235 mm in summer and 116 mm in winter. The soils consist of silt loams to silty clays. A small area is under rain-fed agriculture, but most of it is under forest.

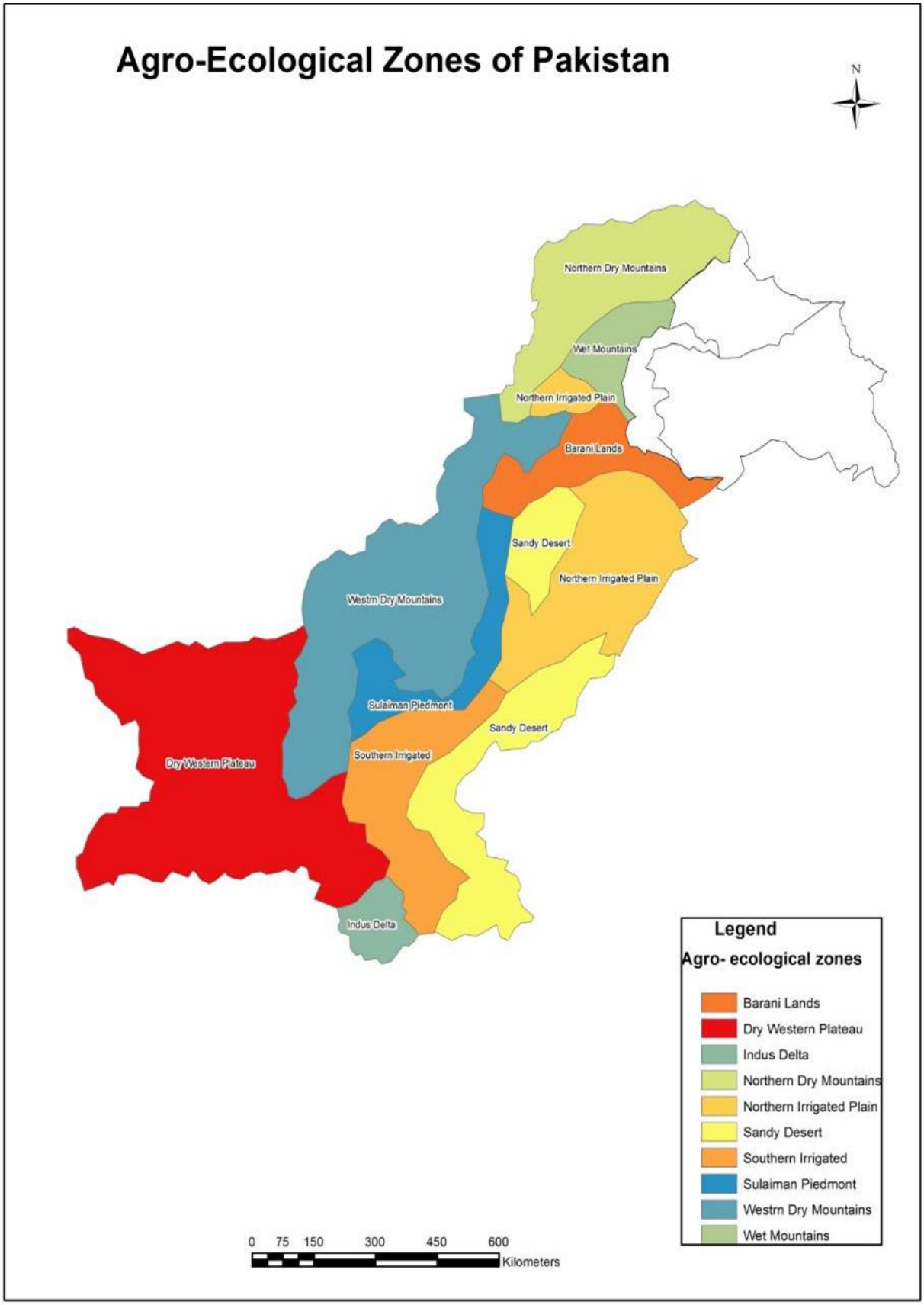
Zone VII - Northern Dry Mountains: The mean monthly rainfall is 25 to 75 mm in winter and 10 to 20 mm in summer. The valley soils are deep and clayey.

Zone VIII -Western Dry Mountains: They are composed of barren hills with steep slopes. The mean monthly rainfall is 95 mm in summer and 63 to 95 mm in winter. The soils in the valleys are deep and loamy. Most of the land is used for grazing.

Zone IX - Dry Western Plateau: Mountainous areas. The mean monthly rainfall is 37 mm in summer. The coastal belt receives a sea breeze. The land is used mainly for grazing.

Zone X - Sulaiman Piedmont: It extends from D.I Khan in KP to Dera Ghazi Khan in Punjab and Dera Bugti, Kachhi and Nasirabad in Balochistan. The mean monthly rainfall is less than 15 mm. Irrigation relies on floods of the hill torrents. Arid and sub-tropical climate characterized by hot summer, mild winter and low humidity.

Figure 3.2: Agro-ecological zones of Pakistan


Agro-Ecological Zones of Pakistan
N
Northern Dry Mountains
Wet Mountains
Northern Irrigated Plain
Barani Lands
Sandy Desert
Northern Irrigated Plain
Westrn Dry Mountains
Sulaiman Piedmont
Sandy Desert
Southern Irrigated
Dry Western Plateau
Indus Delta
0 75 150 300 450 600
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Agro- ecological zones
Barani Lands
Dry Western Plateau
Indus Delta
Northern Dry Mountains
Northern Irrigated Plain
Sandy Desert
Southern Irrigated
Sulaiman Piedmont
Westrn Dry Mountains
Wet Mountains

3.2 Land Cover of Pakistan

Patterns of land use in Pakistan have evolved through centuries and been influenced by environmental and physical factors such as landform, soil, climate, water availability etc. as well as human factors such as population size, growth, economic demands, and cultural practices or customs.

The land cover/land use classification using ten categories in Pakistan developed from Landsat ETM image data. The forest cover including scrub, riverine, mangroves and plantation is 5.4 % in the country. Agricultural land including irrigated, rainfed and rodkohi agriculture extracted from spectral reflectance of crop cover is about 19.9 %. It does not include the fallow land which has been covered by open space/ground class covering 10% area of the country.

Rangelands covered over 26.9 % areas, while exposed rock occupies 24.5% of the country. The snow/glacier coverage is 2.2 %. Deserts have 9.7 % area, and other uses are 0.4% built-up area, 0.5% waterlogged and saline land and 0.5 % water bodies.

The interprovincial variations depict the influence of these factors. For example, in Khyber Pakhtunkhwa and Northern Areas, which are comparatively high altitude hilly regions, with relatively higher rain show a higher level of snow and glacier coverage (13 per cent), as compared to none in other provinces. Likewise, Khyber Pakhtunkhwa also has higher forest coverage about 17 per cent as against 4 Percent in Punjab, 1.5 per cent in Balochistan and some 6 per cent in Sindh. Balochistan, on the other hand, has comparatively larger grazing area as in that province; besides rangeland, even the exposed rocks during rains gets some vegetation cover, which provides forage for livestock.

On the contrary, in Punjab (about half the area of the Province) and Sindh (about a third area of the Province), agricultural land is predominant, primarily because of an extensive system of canal irrigation which has developed through history and seen large expansion during the British and post-independence period.[4]

Under the growing population and increasing anthropogenic pressure, the ecosystems are heavily strained and are thus degrading. The rangelands which cover the bulk of the landmass, sustain a growing livestock industry. All these ecosystems have played a crucial role in providing a platform for economic development and growth.

The coastal zones of Sindh and Balochistan are highly productive ecosystems, with species of marine fish and shrimp.

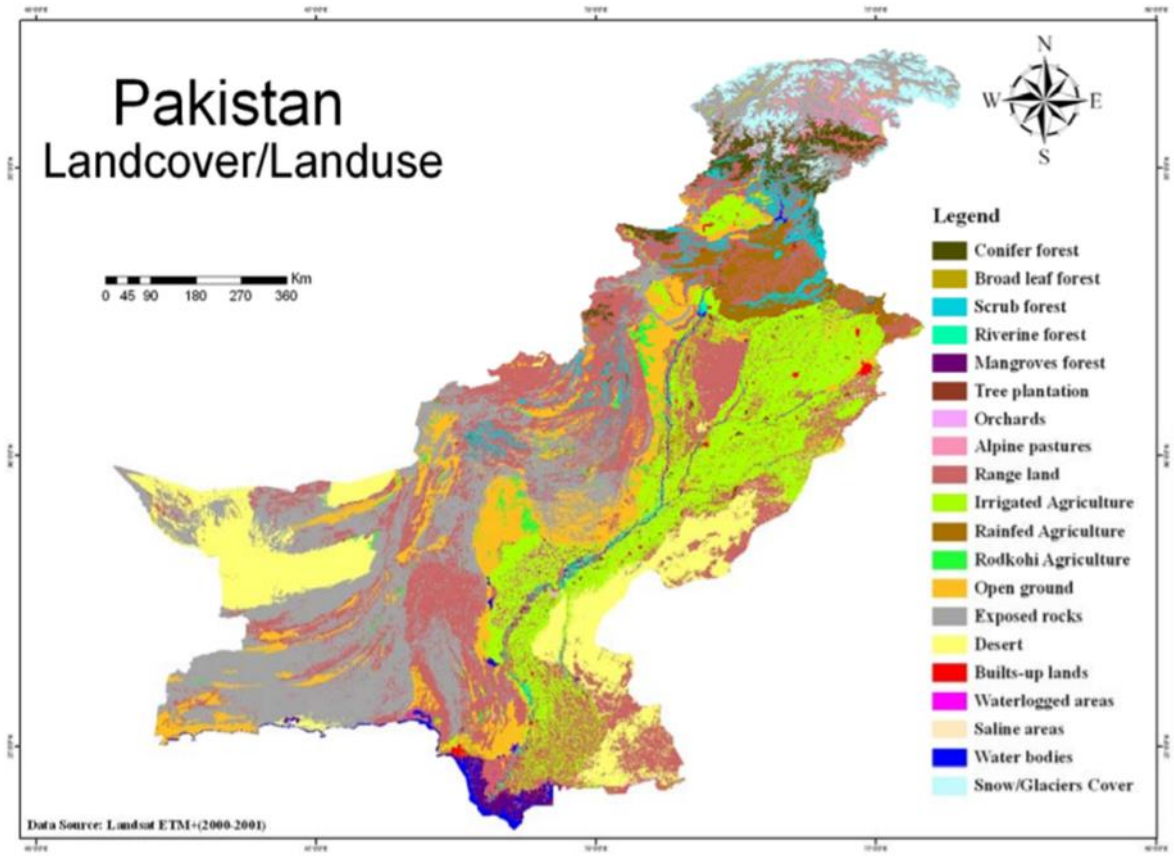
[4] *http://wedocs.unep.org/bitstream/handle/20.500.11822/9393/-Land_Use_Atlas_of_Pakistan-2009Pakistan_LandUseAtlas_2009.pdf.pdf?sequence=3&isAllowed=y*

Table 3.1: Land Cover/Land Use of Pakistan (000, Hectares)

No	Land Use/Land Cover	Balochistan	Sindh	Khyber Pakhtunkhwa	Punjab	Pakistan	%
1	Forest	508.1	848.3	2,311.9	855.1	4,523.4	5.4
2	Rangeland	9,255.8	3,961.1	3,848.7	5,385.7	2,2451.3	26.9
3	Agricultural land	822.2	4,465.0	1,174.1	10,143.4	16,604.7	19.9
4	Open Ground/ Fallows	4,494.7	911.5	1,290.5	1,618.8	8,315.5	10.0
5	Exposed Rocks	1,6425.1	201.4	3,451.1	318.4	2,0396.0	24.5
6	Deserts	3,189.4	3,140.8	-	1,796.9	8,127.1	9.7
7	Built-up Area/Land	6.7	90.2	26.4	196.6	319.9	0.4
8	Water Logged and Saline Land	15.2	294.3	0.2	130.4	440.1	0.5
9	Water Bodies	1.8	178.9	57.1	179.8	417.6	0.5
10	Snow/Glaciers	-	-	1,829.6	-	1,829.6	2.2
	Total	**34,719.0**	**1,4091.4**	**13,989.7**	**2,0625.1**	**83,425.2**	**100.0**

Source: *Land Use Atlas of Pakistan, Ministry of Environment, Government of Pakistan, 2009*

Figure 3.3: Land Cover/Land Use of Pakistan (2009)



Source: *Land Use Atlas of Pakistan*

3.3 Land Use of Islamabad

The pattern of land use in Islamabad have evolved through years and have been influenced by environmental and physical factors such as landforms, climate, and water availability as well as human factors such as population size, growth, economic demand and cultural practices or customs.

The Landsat images (30 meters) for the year 1990,2000 and 2016 were acquired, processed and analysed for the generation of land use maps for Islamabad. The thematic layers generated include bare soil, natural vegetation, water bodies and human settlements.

Natural vegetation includes scrub, forest, and plantation which are about 38.15% in Islamabad in 2016. Bare soil covers more than 46 %. The built-up area covers 15.14% of the total while water is only 0.44%.

Table 3.2: Temporal Variations of Land use of Islamabad

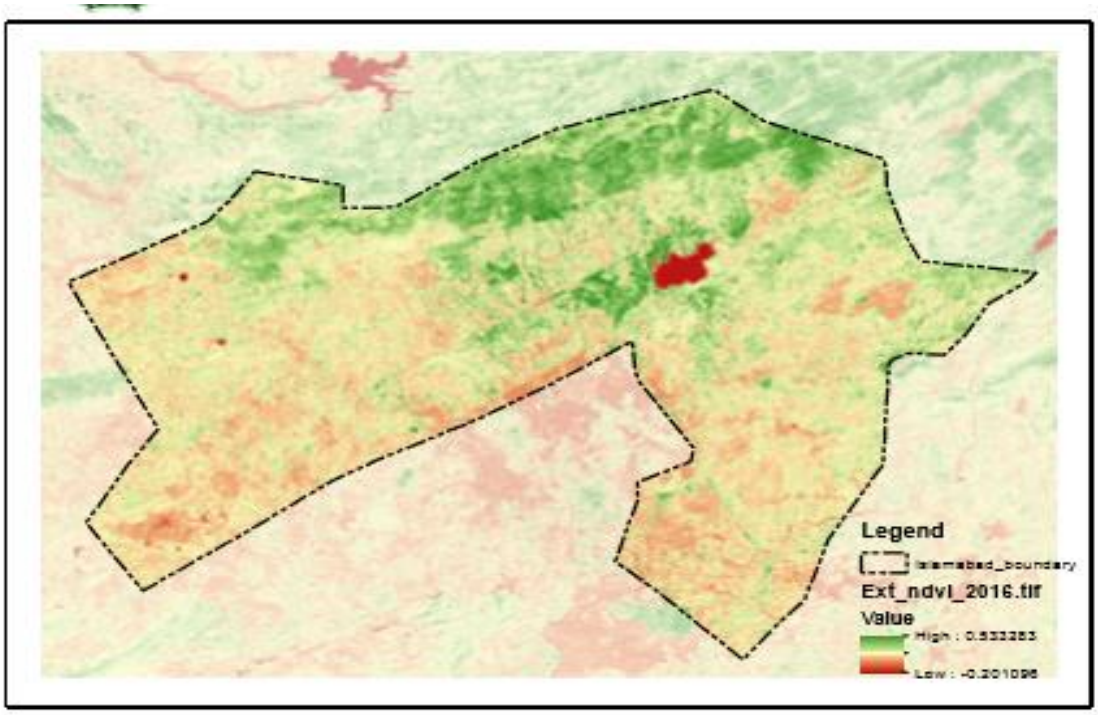
S. No.	Class	Area in Percentage %			
		1990	**2000**	**2010**	**2016**
1	Permanente Vegetation	24.27	34.35	36.199	38.15
2	Urban Areas	3.70	3.84	7.125	15.144
3	Bare Soil	71.42	61.34	56.2	46.26
4	Water	0.60	0.46	0.45	0.44

The Normalised Difference Vegetation is a standardized index allowing the generation of an image displaying greenness. This index takes advantage of the characteristics of two bands from a multispectral raster dataset-the chlorophyll pigments absorption in the red band and the high reflectivity of plant materials in the near-infrared (NIR) band.

An NDVI is often used worldwide to monitor and predict agricultural production, assist in predicting hazardous fire zones, and map desert encroachment.

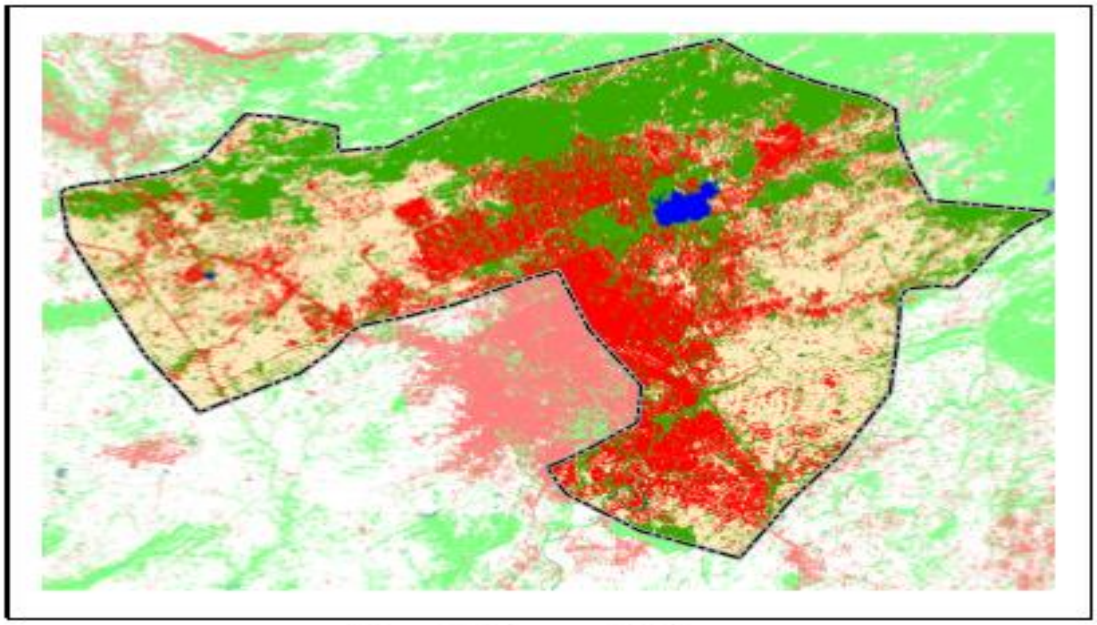
The differential reflection in the red and infrared (IR) bands enables one to monitor the density and intensity of green vegetation growth using the spectral reflectivity of solar radiation. The index output values between -1.0 and 1.0, mostly representing greenness, where any negative values are mainly generated from clouds, water and snow, and values near zero are mainly generated from rock and bare soil. Very low values (0.1 and below) of NDVI correspond to barren areas of rock, sand, or snow. Moderate values (0.2 t 0.3) represent shrubs and grassland, while high values (0.6 to 0.8) indicate temperate and tropical rainforests.

For the analysis of vegetation and its variation over the years, NDVI for 1990, 2000, 2010 and 2016 are calculated showing the rise in the vegetation of Islamabad over the years. The calculations were made using Landsat image for the month of June. Green Colour represent vegetation while red and tones represent other features.



NDVI 2016

***Source**: Digital Environmental Atlas of Islamabad, Geomatic Centre for Climate Change and Sustainable Development*



Classified Image 2016

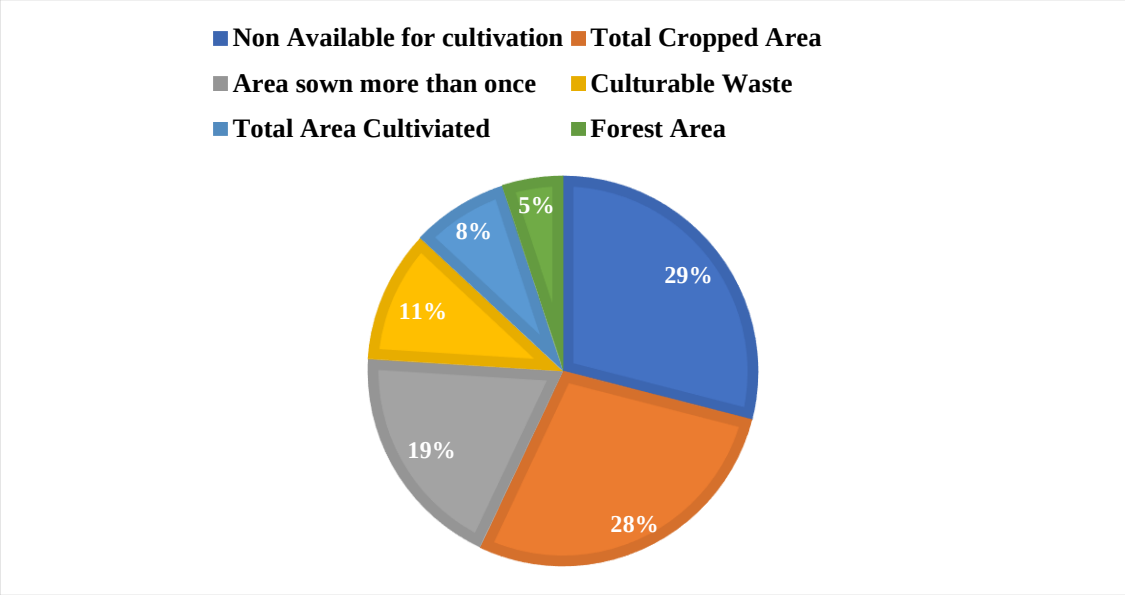
***Source**: Digital Environmental Atlas of Islamabad, Geomatic Centre for Climate Change and Sustainable Development*

The land use for agriculture/forest of Pakistan from 2000 to 2016 containing total area, report area, forest area, non-available area for cultivation, culturable waste, cultivated area (current fallow, the net area sown and total cultivable area), area sown more than once, and the total cropped area has been analysed.

The land use of Pakistan for agricultural use does not show any significant changes with respect to land use from 2000 to 2016.[5]

The average land use for the last 16 years from 2000 to 2016 show that 29% of the land is not available for cultivation, 28% is the total cropped area, 19% is the area sown more than once, 11% is a culturable waste, 8% is the total cultivated area, and 5% is forest area. Furthermore, there is very small and insignificant variation in land use data for the last 16 years. This shows that there is no significant improvement in land use with respect to agriculture and forest.

Figure 3.4: Percentage of average land use of Pakistan from 2000 to 2016



Source: *Pakistan Economic Survey 2015-16*

[5] *http://www.finance.gov.pk/survey_1617.html*

Table 3.3: Land Use for Agriculture/Forest from 2000 to 2016 (Mha)

Year	Total Area	Reported Area	Forest Area	Non-Available for cultivation	Culturable Waste	Cultivated Area			Area Sown More Than Once	Total Cropped Area
						Current Fallow	Net Area Sown	Total Area Cultivated		
2000-01	79.61	59.44	3.77	24.37	9.17	6.73	15.4	22.13	6.64	22.04
2001-02	79.61	59.33	3.8	24.31	8.95	6.6	15.67	22.27	6.47	22.12
2002-03	79.61	59.45	4.04	24.25	8.95	6.61	15.6	22.21	6.25	21.85
2003-04	79.61	59.46	4.01	22.23	9.1	6.23	15.89	22.12	7.05	22.94
2004-05	79.61	59.48	4.02	24.39	8.94	6.86	15.27	27.13	7.51	22.78
2005-06	79.61	57.22	4.03	22.87	8.21	6.72	15.39	22.11	7.74	23.13
2006-07	79.61	57.05	4.19	22.7	8.3	5.72	16.16	21.87	7.4	23.56
2007-08	79.61	57.08	4.21	23.41	8.19	4.93	16.34	21.17	7.51	23.85
2008-09	79.61	57.21	4.21	23.27	8.15	5.04	16.34	21.38	7.78	24.12
2009-10	79.61	57.21	4.23	23.49	8.09	5.2	16.2	21.4	7.67	23.87
2010-11	79.61	57.64	4.26	23.37	7.98	6.38	15.65	22.03	7.07	22.72
2011-12	79.61	57.73	4.26	23.25	8.19	7.05	14.98	22.03	7.52	22.5
2012-13	79.61	57.79	4.26	23.06	8.21	7.04	15.22	22.26	7.34	22.56
2013-14	79.61	57.91	4.55	23.01	8.27	6.68	11.4	22.08	7.33	22.73
2014-15 P	79.61	57.99	4.55	23.01	8.25	6.75	15.35	22.1	7.33	22.67
2015-16 R	79.61	57.99	4.55	23.01	8.25	6.75	15.35	22.1	7.33	22.67
Average	**79.61**	**58.12**	**4.18**	**23.38**	**8.45**	**6.33**	**15.39**	**22.27**	**7.25**	**22.88**

Source: *Pakistan Economic Survey 2015-16* The total area reported is the total physical area of the villages, tehsils or districts etc.

- Forest area is the area of any land administered as forest under any legal enactment dealing with forests. Any cultivated area which may exist within such forest is shown under heading "cultivated area".
- Area not available for cultivation is that uncultivated area of the farm which is under farm homesteads, farm roads and other connected purposes and not available for cultivation
- Culturable Waste is that uncultivated farm area which is fit for cultivation but was not cropped during the year under reference nor in the year before that.
- Cultivated area is that area which was sown at least during the year under reference or during the previous year. Cultivated Area = Net Area sown + Current Fallow.
- Current fallow (ploughed but uncropped) is that area which is vacant during the year under reference but was sown at least once during the previous year
- Net area sown is that area which is sown at least once during (Kharif & Rabi) the year under reference.
- The area sown more than once is the difference between the total cropped area and the net area sown.
- Total cropped area means the aggregate area of crops raised in a farm during the year under reference including the area under fruit trees.
- P is Provisional, and R is Repeated (previous values repeating)

3.4 State of Land Use

Pakistan is predominantly arid to a semi-arid country with 68 million hectares of land lying in regions where the annual rainfall is less than 300 mm. Agriculture is one of the major sectors likely to be adversely affected by climate change in Pakistan.

Crop simulation models based studies show that Wheat yields will be reduced by 3.4 to 12.5 per cent in the semi-arid irrigated areas (Faisalabad and Sheikhupura), 3.8 to 14 percent in arid areas (Multan & Bahawalpur, Badin and Hyderabad) and up to 16 percent rainfed (Chakwal) areas under both A2 and B2 scenarios towards the end of 21st century.

Similarly, in the Basmati rice tract, the yield is expected to be reduced by 10.4 per cent, 16.5 per cent and 17.8 per cent under the B2 scenario by 2020s, 2050s and 2080s, respectively. Under the A2 scenario, the yield is expected to decline by 11.4 per cent, 15.8 per cent and 21.5 per cent, respectively by 2020s, 2050s and 2080s.

In general, an increase in temperature will lead to shortening of growing season length for wheat and rice crops in all the selected wheat growing districts and Basmati rice tract of the country. The results suggest that the aggregate impact of climatic parameters, i.e., changes in temperature and rainfall exerted an overall negative impact on cereal crop yields, given that the management practices and use of technology remain unchanged (Iqbal et al., 2009).[6]

Pakistan has two crop seasons, "Kharif" being the first sowing season starting from April-June and is harvested during October-December. Rice, sugarcane, cotton, maize, moong, mash, bajra and jowar are “Kharif" crops. "Rabi", the second sowing season, begins on October-December and is harvested in April-May. Wheat, gram, lentil (masoor), tobacco, rapeseed, barley and mustard are "Rabi" crops. Pakistan’s agricultural output is closely linked with the availability of irrigation water.

During 2015-16, the availability of water for Kharif 2015 stood at 65.5 million acre-feet (MAF) showing a decrease of 5.5 per cent over Kharif 2014 and 2.4 per cent less than the normal supplies of 67.1 MAF. During Rabi season 2015-16, the water availability remained at 32.9 MAF, which is 0.6 per cent less than Rabi 2014-15 and 9.6 per cent less than the normal availability of 36.4 MAF. (Table 2.2).

Free grazing of livestock, aridity and prolonged drought in arid lands have affected the biodiversity in various regions. Forests play an important role in the ecological and economic life of a country. Pakistan is one of the lowest forest cover countries with only 5 per cent of the land area under forest and tree cover. Major forest types include coastal mangroves, riverine forests, sub-tropical scrub forests, moist and dry temperate conifer forests and irrigated plantations.

The Government of Pakistan is trying to combat the situation, and the first phase a comprehensive Sustainable Land Management Programme (SLMP) has been completed, and 2nd phase with the total cost of Rs.1, 666.68 million has been approved and started its activities for selective districts in four provinces of Pakistan.

The government has planned to manage all types of forests by the ecosystem approach. This will enable the conservation of forest biodiversity, provide sustainable livelihood to forest-dependent communities and contribute to mitigating global environmental problems.

The land use of Pakistan from 2000 to 2016 (ref: Table 3.2) indicate that present use of land is not quite in accordance with its potential. In fact, at present, there is no organisation in the country responsible for coordinating and monitoring the use of land according to its potential. This makes the quantitative assessment of the impact of land misuse in Pakistan extremely difficult.

The present land use in the country is based either on the opportunity and economic status or the socio-economic needs of the user. The key issues of land degradation and desertification in Pakistan are as follows:

- Land on the steep slopes of mountains, suitable only for forestry or rangeland, has been subjected to ploughing to meet the food requirements of the population. Good and very good arable land in the Indus plains remains under irrigated forests or is used for non-agricultural purposes. Areas in the Thal and Thar have been overgrazed and are now gravely threatened by desertification.
- Poor use of soil resources is emphasised when efforts are made to bring marginal or non-agricultural land into arable use, at the expense of large tracts of potentially arable land in the Indus plains that remain under-utilized primarily because of water and economic constraints created by the diversion of resources to relatively unimportant land.
- Not only are there imbalances between the current and potential use of land, but also there are problems in crop planning for areas with high agricultural value. Consequently, land optimality suitable for one crop is used for growing a less suitable one.
- Agriculture is the only sector which is entirely dependent on the quality of natural resources for sustaining higher productivity. Exploitation of these resources for the development of the nation is making people suffering from droughts, disease epidemics, low agricultural productivity and poor standard of living, all indications of poverty.
- The soils in the Indus basin are new and undeveloped, and the mountains surrounding the area have some of the world's steepest and largest slopes. Intense summer rainfalls, along with melting snow in high mountains contribute to the soil erosion hazards.
- Sedimentation of canal irrigation system decreases water and land use efficiency. The upstream riverside infrastructure is destroyed, and topsoil is washed away declining productivity of the area. In downstream, the sedimentation reduces the efficiency of hydropower generation and irrigation systems.
- Land degradation by wind erosion is quite common in the sandy deserts of Thal, Cholistan, Tharparkar and sandy areas along Mekran Coast. Erosion is significant in areas around habitations and watering points trampled by livestock. Here, the major degrading factor is the over-exploitation of rangelands for fuel-wood cutting and livestock grazing.

- There is only 5.4 % area under forests, which is too low to meet the environmental, as well as the socio-economic needs of the country. Due to deforestation, forest cover is shrinking by 3.1% annually and woody biomass, by 5% annually (Behnassi et al., 2014).
- Due to the ever-increasing human and livestock population, there is enormous pressure on natural vegetation in almost every agro-ecological region of the country. Overgrazing of rangelands has extensively decreased the carrying capacity.
- Some areas have also been affected by waterlogging and salinity is damaging the natural flora. Aridity and prolonged drought in arid lands have affected the vegetation cover in these areas. As a result of natural habitat degradation and illegal hunting, 31 species of mammals, 20 species of birds and 5 species of reptiles are listed as an endangered species in the country.

AIR

4 Air

4.1 Introduction

Quality of air is one of the basic indicators of the overall quality of the environment. Air pollution has become a local as well as a regional issue of big cities, industrial centres and surroundings of transport routes, especially roads and highway. The increasing development of human activities has given rise to a significant increase in atmospheric pollutants which may have an impact on human health (Mansouri, 2011).

The continuous fog and smog conditions in Lahore and other areas of Punjab in the winter months, with delayed rainfall, is a worrisome factor. In Pakistan, vehicular traffic along with the industrial sector is the leading contributor to poor air quality.[7] To reduce car emissions and increase mobility the government has introduced a modern mass transit system in major cities The Bus Rapid Transit System under metro projects are providing better transportation services to the masses with lower carbon dioxide emissions. This facility has been provided only in three cities (Lahore, Rawalpindi and Islamabad) and therefore, has a marginal impact on the environment and expansion of this service may have far-reaching positive effects on air pollution.

Pakistan's urban air pollution is among the most severe in the world (Ali et al., 2015), and it significantly damages human health and the economy due to rapid motorization and energy utilization. As a result, a substantial rise has taken place in the types and number of emission sources of various air pollutants: PM, SO_2, O_3, CO, NO_2 and Pb.

The incidence of the so-called "winter fog" phenomenon in Pakistan, which is a cocktail of toxic gases and particulates, has contributed to economic losses, aggravating respiratory and cardiovascular diseases, as well as increased cardiac arrest rates[8].

Recent studies on air quality in the Asian region has shown that levels of various air pollutants are typically in excess according to WHO guidelines and ambient air quality standards, in high-income countries.

4.2 Sources of Air Pollution

Though some of the deterioration of air quality is due to natural sources, most are as a result of human activities. The most serious issue relating to air pollution in Pakistan is the presence of excessive suspended particulates matter (SPM).[9]

The stationary sources of air pollutant emissions in Pakistan include thermoelectric power plants, textile industries, tanneries, sugar mills, cement manufacturers, fertilizer companies, brick kilns, and burning of agricultural and municipal solid waste. Area source pollution also

[8] *http://www.mocc.gov.pk/moclc/userfiles1/file/MOC/Events/Chapter-05-.pdf*
[9] *https://www.greenleft.org.au/content/severe-air-pollution-chokes-pakistan*

has substantial cumulative emissions; examples include residential water heaters, small engines, and consumer products, such as barbecue lighter fluid and hairspray.

Almost all metropolitan cities have industrial estates, where a cluster of industries of different type of industries exists. The cement, fertilizer, sugar units, and power plants are considered to be the most air polluting industries of Pakistan.

A wide range of small to medium scale industries (including steel re-rolling, steel recycling, tobacco curing and plastic moulding) cause a disproportionate share of pollution through their use of dirty "waste" fuels, such as paper, wood and textile waste.

Brick kiln's emission which emits COx, NOx, SOx, hydrocarbons, and particulates (dust) are adversely affecting the environment of its surroundings (Khan et al., 2015). The release of toxic substances from these brick kilns adversely affects soil, plant, amenity and heritage in their vicinity.

The use of low-grade coal and old tires in brick kilns generates dense black smoke and other kinds of emissions. The use of coal increased by 34.3 per cent for brick kilns in 2012-13 when compared with the year 2001-02.[10] The use of coal will further increase due to planned coal-based power plants to be constructed under the China Pakistan Economic Corridor (CPEC).

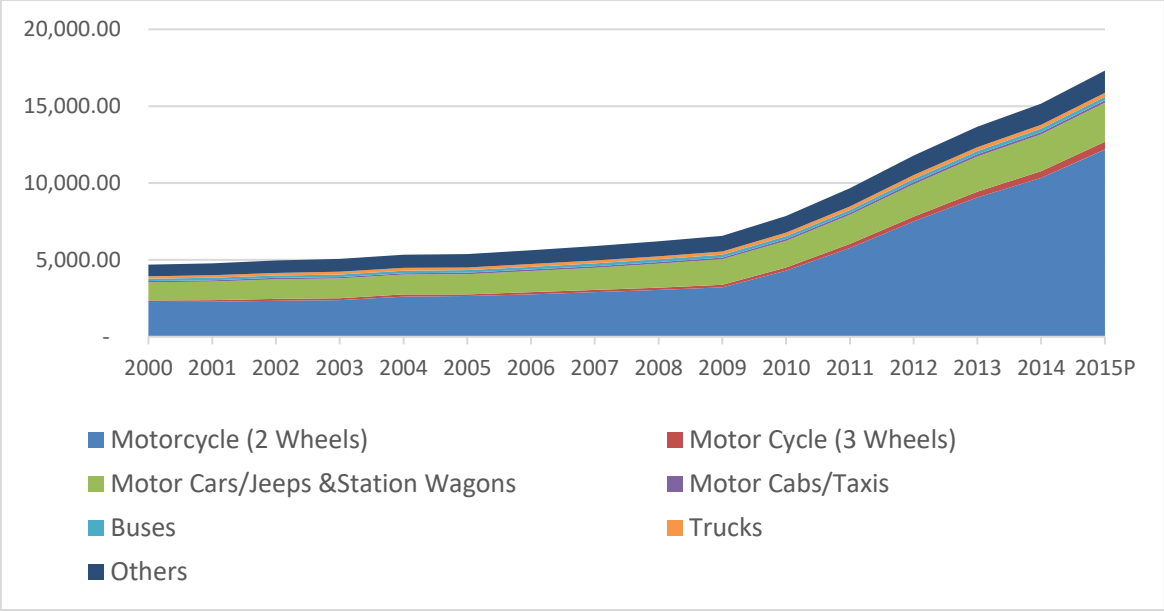
The mobile sources of air pollution in Pakistan include all the automobiles on-road and off-road sources (gasoline and diesel-powered, aircraft, marine vehicles and powerful engines.

Vehicular emissions are treated as one of the important sources of total emissions in Pakistan. The surge in demand for private vehicles originates from the increasing affordability and availability of vehicle financing from the banking system. Diesel vehicles using crude diesel oil are of most serious concern. Due to overloading, faulty injection nozzles and weak engines, diesel vehicles emit excessive carbon (visible smoke) whereas motorcycles and rickshaws, due to their two-stroke engines, are the most inefficient in burning fuel and thus contribute most to emissions.

The registration of a number of vehicles in Pakistan has jumped from 4.7 million in 2000 to 17.3 million in 2015 showing an increase of 368%.

[10] *http://www.finance.gov.pk/survey_1213.html*

Figure 4.1: Number of Motor Vehicles Registered in Pakistan (2000-2015) in 000



Source: *Ministry of Communication (NTRC), 2016*

Based on available information (which represents a partial inventory of possible emission sources), the road transport sector is responsible for 85% of the particulate matter of fewer than 2.5 microns ($PM_{2.5}$) total emissions and 72% of the particulate matter of fewer than 10 microns (PM_{10}) emissions.

In addition, emissions linked to burning fossil fuels (for running electric power plants and various industrial operations) are collectively linked to pollution in the form of particulates, as well as NOx and SOx, and carbon monoxide (CO).

Transboundary air pollutants also affect the cities in Pakistan, particularly due to secondary aerosols during winter. The sulphate particles also facilitate haze/fog formation during calm and highly humid conditions, and thus reduce visibility and increase the incidence of respiratory diseases encountered annually[11]. Such events also cause marked reductions in visibility, disrupted transportation, and increased injury and death (Hameed et al., 2000).

The main causes of air pollution are inefficient automotive technology, poorly maintained vehicles, use of unclean fuels, uncontrolled emissions of industrial units, the burning of garbage and the presence of dust.

4.3 Smog in Pakistan

Burning of agricultural waste, smoke emitting traffic, uncontrolled pollution, poor implementation of environmental laws, improper disposal of industrial waste, indifference from the general public and numerous other factors have all played their part into the formation of smog in Pakistan.

[11] *https://www.researchgate.net/publication/300126548_Air_Pollution_in_Pakistan/download*

Air pollution is an issue that needs to be urgently addressed as Lahore is now considered amongst the most polluted cities in Asia. Every December, thick fog descends upon Punjab particularly in Lahore, blocking out the winter sunshine, closing off the motorway after dusk and preventing flights from landing at the international airport at night.

The heavy smog in different parts of Pakistan is affecting everyday life very badly. It is causing numerous health issues as people are being exposed to increased levels of polluted smog.

As visibility reduces significantly due to smog, unprecedented traffic issues are also being caused. The distance of minutes has to be covered in hours because of poor visibility during the night, early morning and evening. Several casualties are being reported in traffic accidents during peak hours of smog. Power outages have also increased because of it.

In the winter months, with delayed rainfall, the cold and continued dry conditions concentrate all the pollutants in the lower levels of the atmosphere, causing the smog to spread all over Punjab.

4.4 SMART

Existing monitoring programs have proven unable to provide information on the emission of pollutants from stationary sources in Pakistan. In order to monitor air pollutants from industrial sources, the Government of Pakistan established the voluntary Self-Monitoring and Reporting Tool (SMART).

The level of reporting on air pollutant emissions is low, as only 99 out of 6,417 industrial facilities have registered their emissions under the SMART program. The ineffectiveness of the SMART program to disclose emissions of air pollutants in Pakistan is similar to those of voluntary programs implemented in other countries, including in the European Union and in the United States (Blackman et al., 2005).

4.5 Status of Air Quality in Pakistan

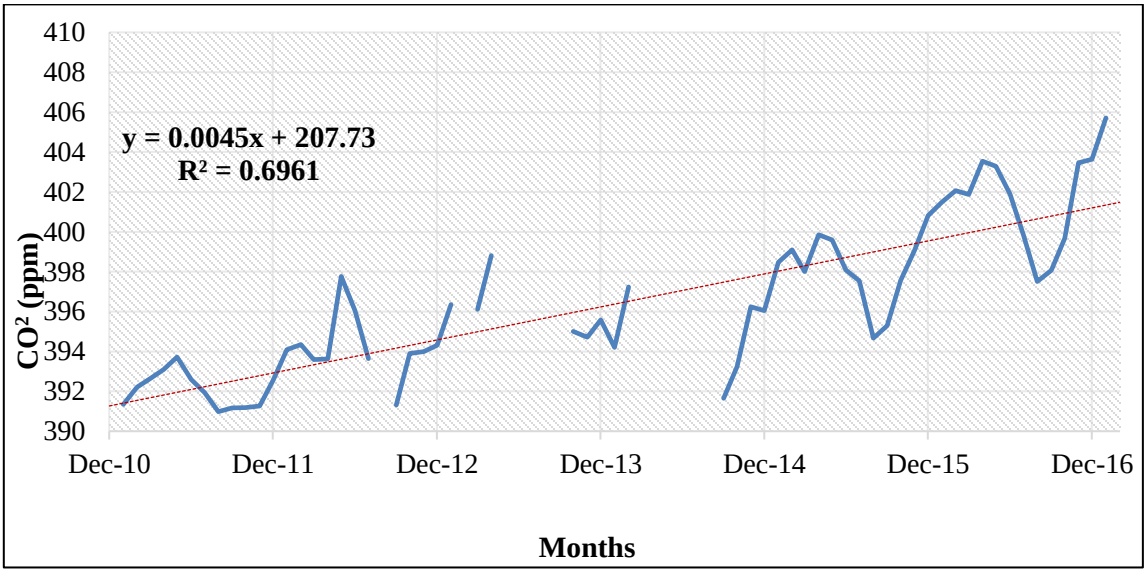
Pakistan Environmental Protection Agency (Pak-EPA) has conducted a number of studies to investigate the ambient air quality in the major cities of Pakistan. Some of these studies were technically and financially supported by the Japan International Cooperation Agency (JICA).

The limited air quality data available for Pakistani cities makes it quite difficult to provide a conclusive remark on the major pollutants of concern in Pakistan. However, a number of research studies on air pollution have been conducted in Pakistan by the Government of Pakistan, International Donors and Universities. The temporal evolution of atmospheric CO_2 levels over Pakistan was studied through two satellite instruments, i.e. GOSAT and OCO-2 for a time period of six years from 2011 to 2016.[12]

[12] *CO_2 Virtual Science Data Environment, Jet Propulsion Laboratory, California Institute of Technology, USA, https://co2.jpl.nasa.gov/*

The monthly analysis of CO_2 over Pakistan shows the increase in monthly and seasonal CO_2 concentration over six years.

Figure 4.2: Monthly mean averages of CO_2 over Pakistan from 2011-2016



The curve shown in **Figure 4.2** is termed as the Keeling curve. Peaks in the curve are termed as maxima whereas depths are termed as minimal. Minima and maxima correspond to the minimum and maximum concentration of carbon dioxide during winter and spring respectively.

The absolute change of CO_2 concentrations from January 2011 to December 2016 is found to be 10.2 ppm with a total relative change and yearly relative change of 2.61% and 0.43% respectively. Annual trend of CO_2 concentrations over Pakistan from 2011 to 2016 can be seen in the graphs given below **(Figure 4.3** and **4.4)**.

Figure 4.3: Annual mean averages of CO_2 over Pakistan from 2011-2016

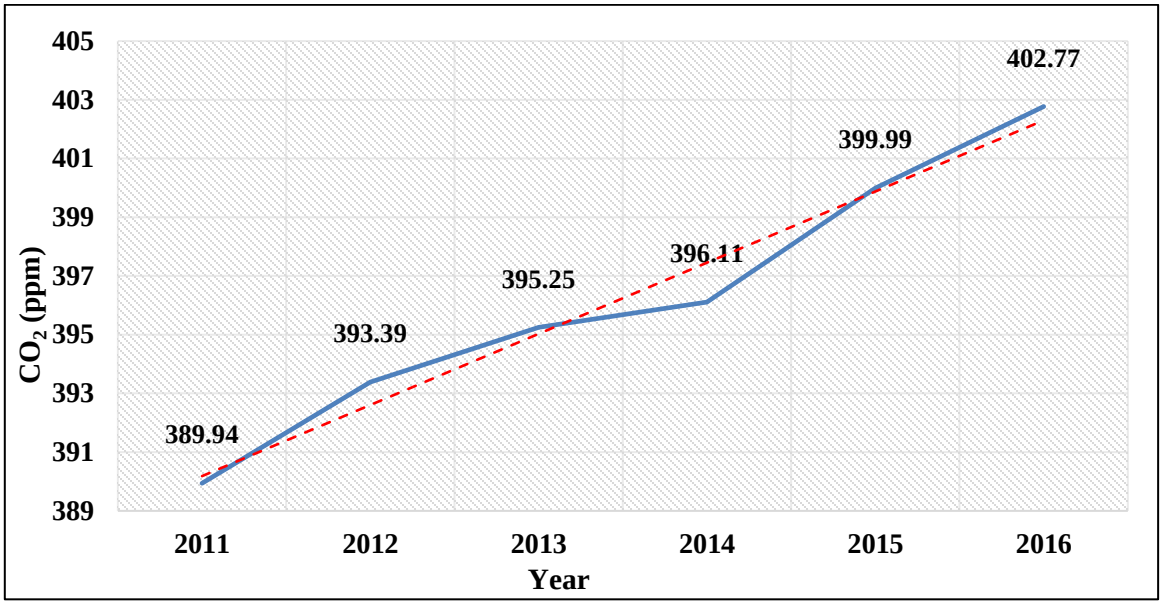
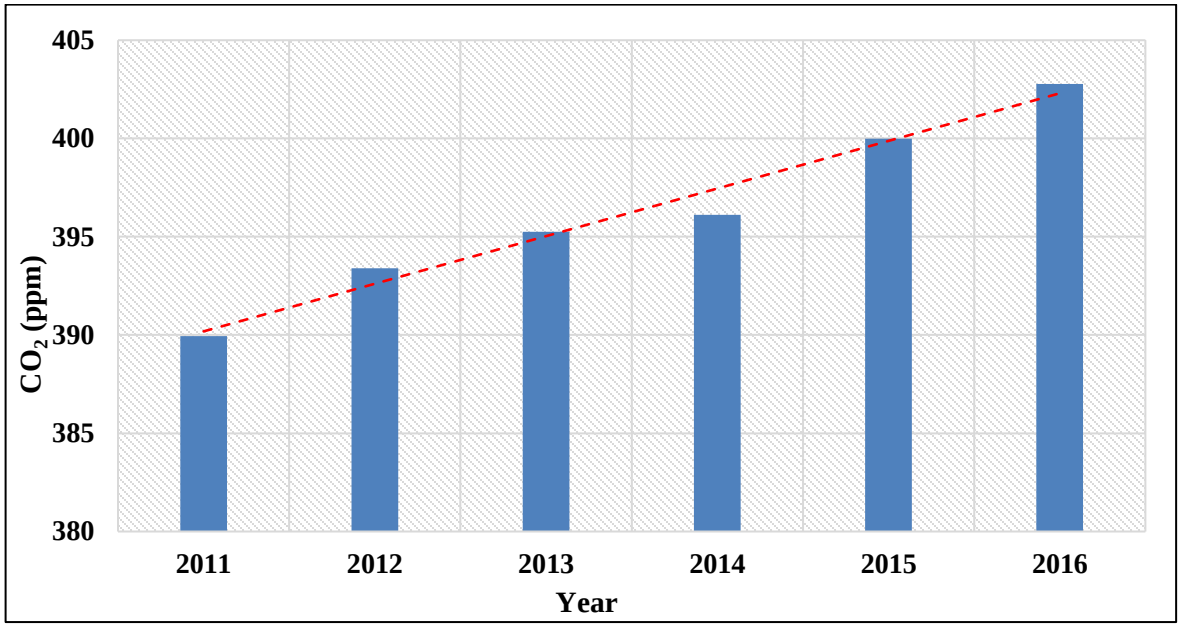


Figure 4.4: Annual mean averages of CO_2 over Pakistan from 2011-2016



The general increase in CO_2 concentration is usually because of fossil fuels burning, deforestation and natural causes. The fossil fuel emission trends of Pakistan (2009-2014) are represented as graphs in **Figure 4.5** and **4.6.**[13]

[13] *http://cdiac.ess-dive.lbl.gov/trends/emis/tre_coun.html.*

Figure 4.5: Annual Mean CO_2 emissions from fossil fuel over Pakistan from 2009-2014

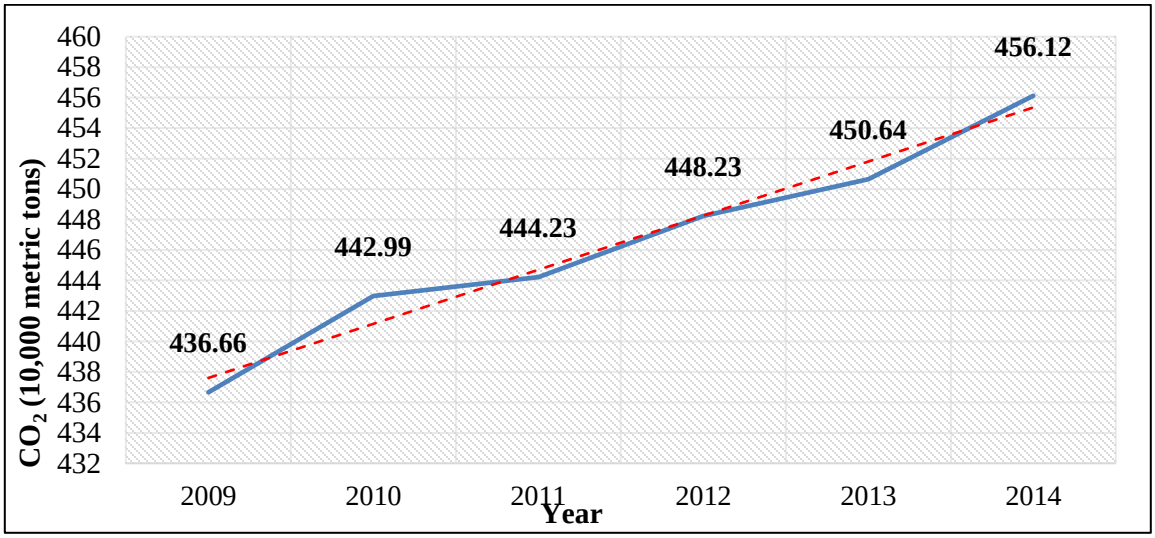
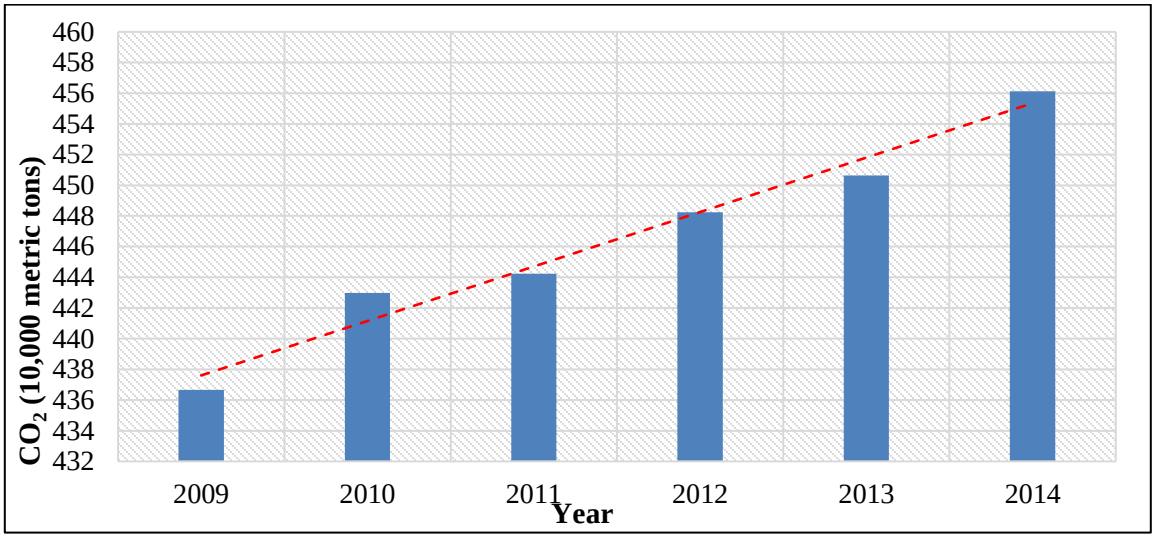


Figure 4.6: Annual Mean CO_2 emissions from fossil fuel over Pakistan from 2009-2014

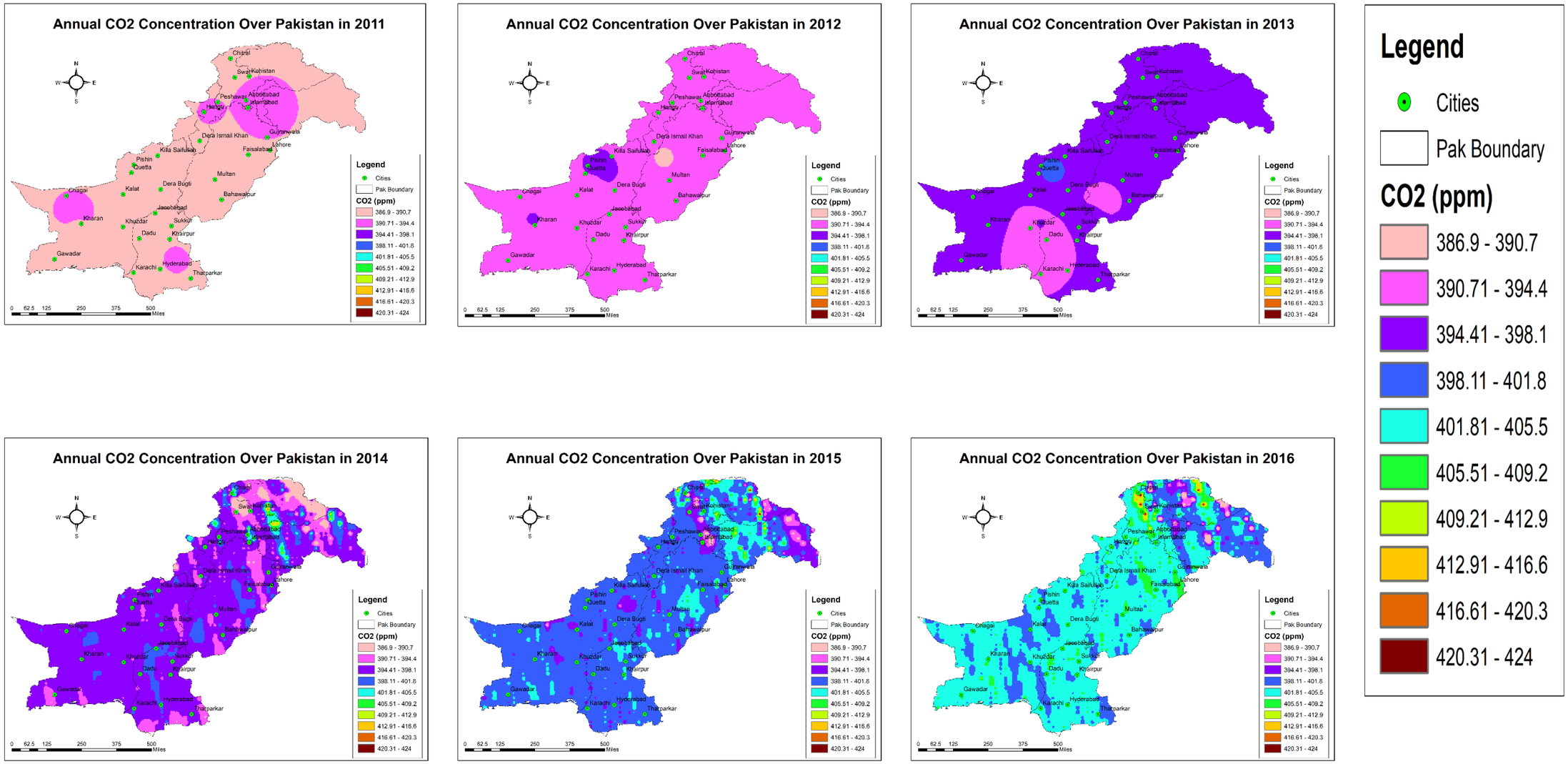


The absolute change of CO_2 emissions from fossil fuels from 2009 to 2014 is found to be 17.7 ppm with a total relative change and yearly relative change of 4.04% and 0.67% respectively.

Figure 4.7 shows the annual mean maps of CO_2 concentrations over Pakistan from 2011 to 2016 prepared using ArcGIS 10.3. The figure depicts the gradual increase in CO_2 concentration in ppm from 2011 to 2016.

The colour codes depicted in the legend varies downwards from pink to maroon indicating the CO_2 increase from 386.9 to 424.0 ppm. The maps below show the gradual change of colour from pink to cyan over Pakistan indicating the CO_2 increase from 2011 to 2016 as per legend shown.

Figure 4.7: Annual mean maps of CO_2 concentrations fuel over Pakistan from 2011-2016



WATER

5 Water

5.1 Introduction

Water is globally a scarce commodity. The optimum utilization of water resources is of utmost importance because the world as a whole is suffering from water shortages. Pakistan has the fourth largest irrigated area of the world (19.49 Mha) after India (60.85 Mha), China (57.78 Mha) and USA (22.39 Mha) and the largest contiguous irrigation system.

The country is the declining contribution of agriculture to the national GDP as 23%, which was 53% at the time of independence. Though agriculture's contribution to national GDP is diminishing due to a number of reasons yet it remains to be its mainstay, employing more than 45% of its population (FAO, 2008).

The major sub-sectors of water use in Pakistan are domestic, agriculture, industry and environment. Water availability in Pakistan is largely from precipitation (rainfall and snow), the river flows from snow and glacier-melt and runoff from summer and winter rains from the watersheds. Some of the water from precipitation and surface water flows to recharge the aquifer in terms of large storage of groundwater in the Indus basin.

Pakistan Vision 2025 envisages increasing the access to improved water supplies to all citizens. However, it is a gigantic task as "Safe" means that complying with National Drinking Water Quality Standards and "Access" means the supply of 45 – 120 litres per day (Kahlowan & Majeed, 2014).

The excessive use of pesticides, insecticides and herbicides, unprotected water sources and intermittent water supply are aggravating the situation. The water shortage and increasing competition for multiple uses are other factors which have adversely affected the quality and availability of water.[14]

The main factor behind worsening water availability and food security situation in the country is exponential population growth. In addition, climate change is causing recurrence of extreme events, by which frequent flooding and droughts are confronted. This is mainly due to inadequate storage facilities. The water storage capacity is just for 30 days of river inflows (9% of the average annual flow against 40% of the world's average). The Pakistan Vision – 2025 envisages a target of 90 days of storage by 2025.

The storage capacity of existing reservoirs is reducing due to sedimentation at a rate of 0.2 MAF/annum. In the backdrop of low water availability, the country should have an efficient irrigation system which consumes more than 90% of water. However, the irrigation efficiency is below 40%, and over 60% of irrigation water is lost during conveyance and application in the field.

The Pakistan vision 2025 envisages improving the efficiency of uses in agriculture by 20%. Other constraints include lack of centralized water resources database as it leads to inappropriate policy and agenda formulations at the national level. Waterlogging, salinity,

[14] *http://www.pcrwr.gov.pk/Publications/Water%20Management/National%20Research%20Agenda%20on%20Water%202016-25.pdf*

brackish groundwater and seawater intrusion are the major constraints in the Lower Indus Plain.

5.2 Water Resources

The water resources of Pakistan include groundwater and surface water. The extent of availability of these resources is location specific.

Pakistan's renewable water resources include direct precipitation and surface waters. Part of the rainfall and surface waters recharge the groundwater aquifer from where it is pumped out and is used as water for supplementary irrigation and for meeting drinking water requirements in urban and rural areas. The areas of Pakistan where groundwater is known to be available can be divided into the following regions:

- The Indus Plain
- The Pothowar Plateau
- The Valleys and Plains of Khyber Pakhtunkhwa
- The Valleys and Plateaus of Balochistan
- Hard Rock Aquifers, Quetta and Kalat
- The Deserts of Cholistan, Tharparkar and Kharan

In Pakistan groundwater is mostly used for drinking and industrial water consumption. In several cities, the level of groundwater is lowered due to the increased pressure on groundwater. The water table has dropped more than ten meters. Thus, the quality of groundwater is influenced by the continuous use of groundwater and contamination.

The groundwater is being contaminated due to unplanned urbanization, industrialization, over-exploitation of the natural resources and discharge of hazardous wastes into the surface water without proper treatment is one of the major concerns.

Surface water resources of Pakistan are mainly based on the flows of the Indus River and its tributaries. The Indus River has a total length of 2,900 sq.km, and the drainage-area is about 966,000 sq. km of which 47 per cent lies in Pakistan, and the other 53 per cent in China, Afghanistan and India.

Rivers in Pakistan have individual flow characteristics, but all of them generally start to rise in the spring and early summer, with the monsoon rains and snow melting on the mountains and have a combined peak discharge in July and August.

The water statistics in Pakistan is vital for the distribution of water across provinces and its efficient use. There are several agencies which claim as custodian of water statistics, but the number never add up.

Five major tributaries joining its eastern side are Jhelum, Chenab, Ravi, Beas and Sutlej; besides, three minor tributaries are the Soan, Harow, and Siran, which drain in mountainous areas. A number of small tributaries also join the Indus River towards its western side. The largest of such tributaries is River Kabul. **Figure 5.2** shows a map of rivers in Pakistan.

Figure 5.1: Rivers in Pakistan

5.3 Water Availability

The water resources of the country are mainly derived from the Himalayan watershed of about 400,000 sq. km., with glaciers and snowmelt feeding the mighty Indus River System and nurturing agriculture in the Indus Plains (GOP, 2009).

Groundwater has become a major supplemental source (30% of surface inflows), yet most of it takes birth within the boundaries of the country from seepage losses in the irrigation network.

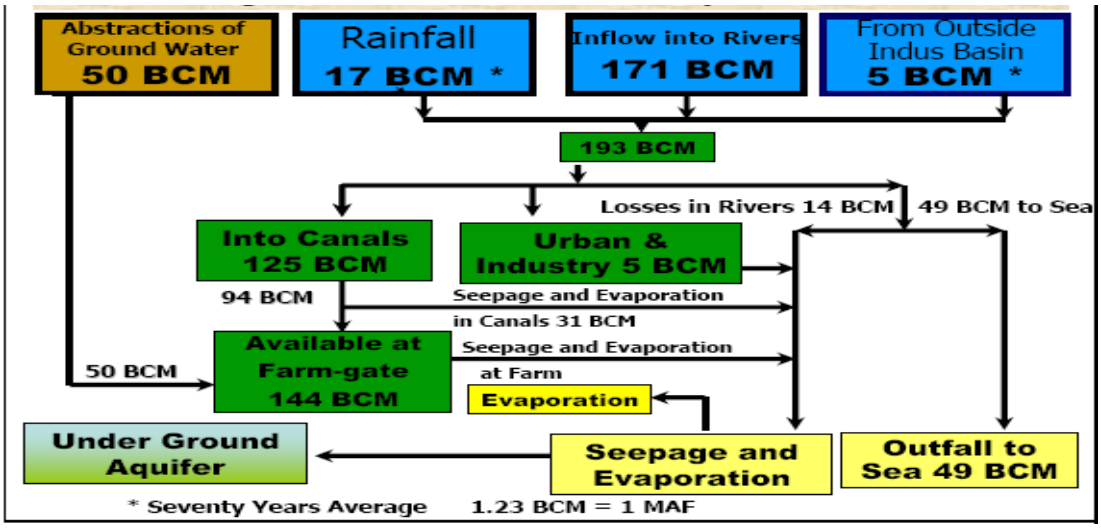
Pakistan's renewable water resources include direct precipitation and surface waters. Part of the rainfall and surface waters recharge the groundwater aquifer from where it is pumped out and is used as water for supplementary irrigation and for drinking water purposes in urban and rural areas (Kahlowan & Majeed, 2014).

Major water resources of the country are rainfall, water resources of Indus Basin, eastern rivers contributions, western rivers contributions, water resources of Kharan closed basin, water resources of Makran coastal basin, groundwater, water resources of hill torrent areas and water resources of desert areas.

In Pakistan, different sources contribute to average water availability. The total inflow is 193 BCM, i.e., rainfall brings 17 BCM, 171 BCM inflow due to Indus River Basin and 5 BCM from outside Indus Basin. A total of 125 BCM flows into Canals, 5 BCM is for Urban and Industrial use, 14 BCM is losses in Rivers and outfall to Sea is 49 BCM. The abstraction of groundwater is 50 BCM. The seepage and evaporation in canals are 31 BCM. The seepage and evaporation at the farm of 1.23 BCM go back to underground water aquifer.

Therefore, 144 BCM water is available for Farm gate for irrigation purposes in Pakistan. Irshad et al. (2012) have projected water requirements for Pakistan as 141.6 MAF for the year 2030.

Figure 5.2: Average water availability in Pakistan



Source: *Khalid Mohtadullah, Water Management Challenges & Opportunities. 2014, Meeting on Water, Lead Pakistan.*

According to Falkenmark et al. (1992), a country is termed as water scarce when water shortage hampers health and well-being of the people for which the threshold limit is 1,000 m^3/capita/annum, and Pakistan has almost approached that.

It may, therefore, be categorized water insecure, which has been defined as, "capacity of a population to safeguard access to adequate quantities of water of acceptable quality for sustaining human and ecosystem health on a watershed basis, and to ensure efficient protection of life and property against water-related hazards – flood, landslides, land subsidence and droughts" (UNESCO, 2012).

The per capita water availability in Pakistan has touched the figure of 1,000 m^3 per year in 2010 as projected by Briscoe et al. (2005), due to a gradual increase in population at 2.03% per annum (Basharat & Hashmi, 2010).

The per capita water availability in Pakistan from 1955 to vision 2025 is from 2,490 to 837 cubic metre (Kahlowan & Majeed, 2014). Pakistan is moving from a water-stressed region to a water-scarce region and is continuously approaching the low-level limits of its water resources.

Table 5.1: Per Capita water availability in Pakistan from 1955 to vision 2025

1955	1990	2025
	1,672	837

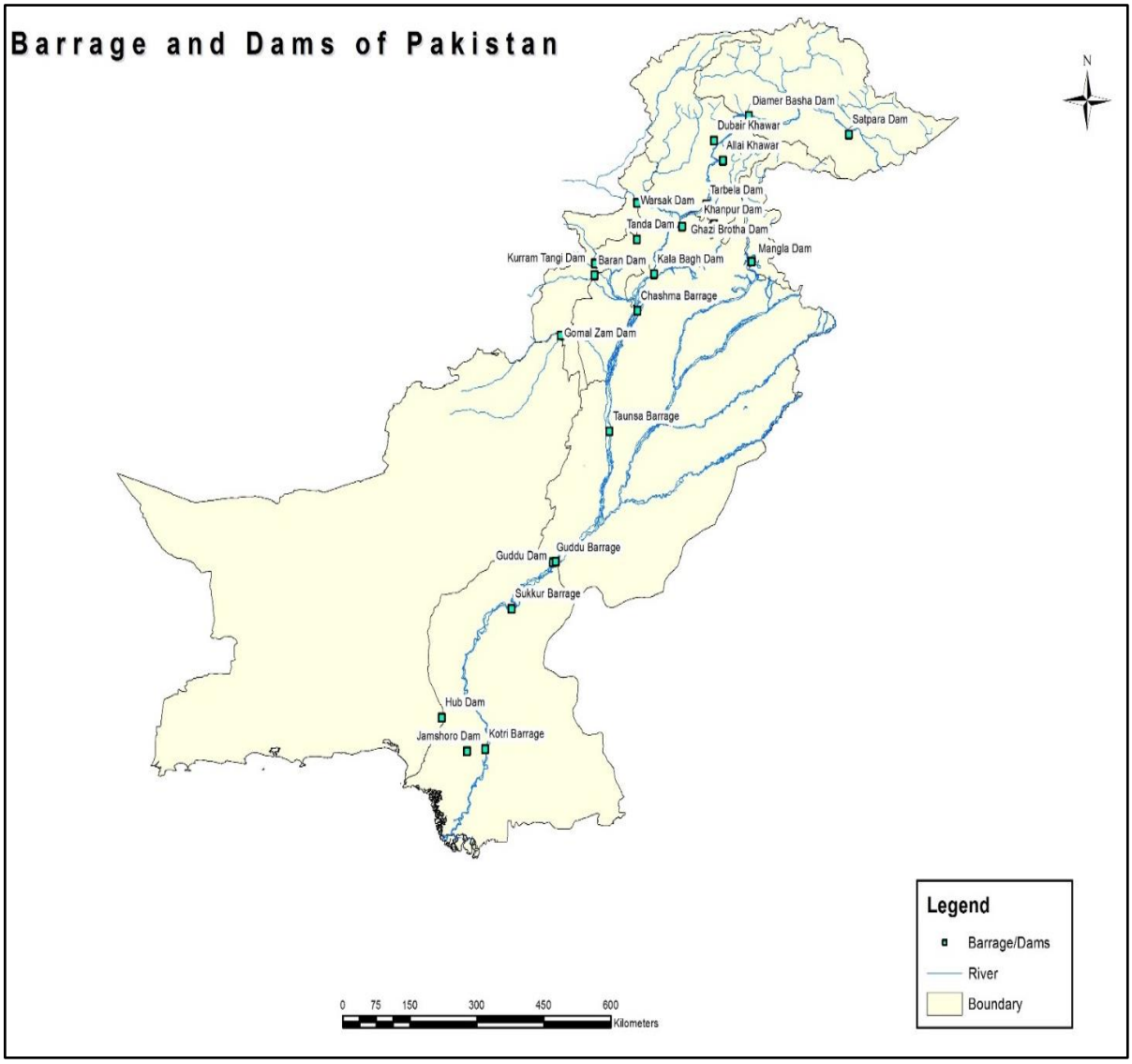
Source: *Muhammad Akram Kahlowan and Abdul Majeed, Pakistan Water Resources Development and Management. 2014, Pakistan Council of Research in Water Resources (PCRWR): Islamabad, Pakistan.*

5.4 Water Reservoirs

The number of major rivers on the Indus basin is 5; Indus, Jhelum, Chenab, Ravi and Satluj. A number of major reservoirs are 3 while barrages account to 23 in number. There are 45 main canal system and 12 interlink canals. The length of canals is 60800 km, and the length of watercourses is 1.6 million km[15].

[15] *http://www.lead.org.pk/attachments/summerschool/day1/Hydrology%20of%20Pakistan%20by%20Sohail%20Babar%20Cheema.pdf*

Figure 5.3: Spatial distribution of barrages and dams of Pakistan



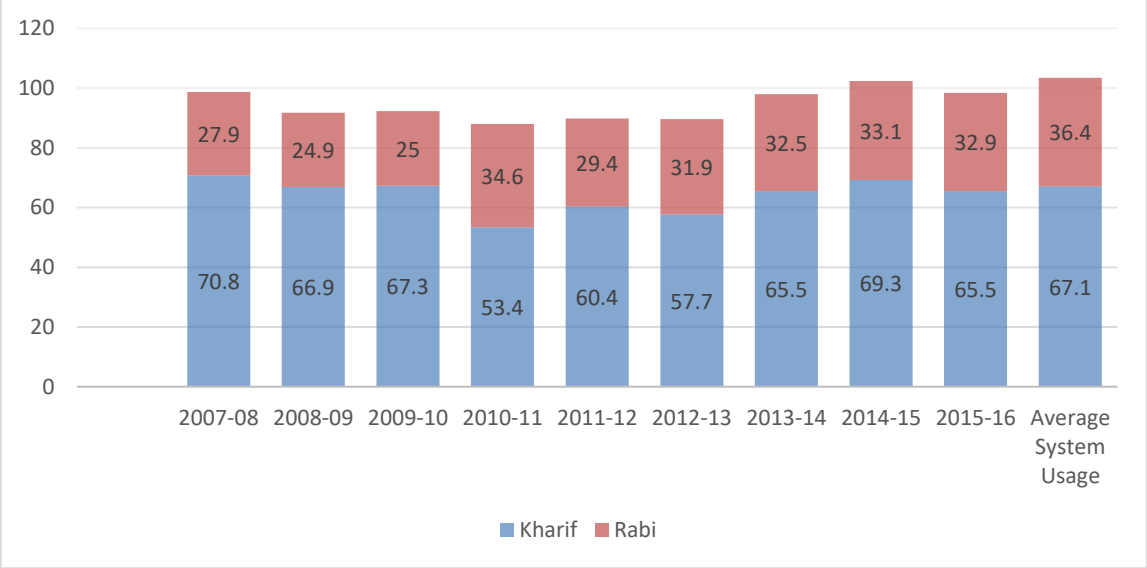
5.5 Status of availability of Water for Agriculture

Pakistan's agricultural output is closely linked with the availability of irrigation water.

During 2015-16, the availability of water for Kharif 2015 stood at 65.5 million acre-feet (MAF) showing a decrease of 5.5 per cent over Kharif 2014 and 2.4 per cent less than the normal supplies of 67.1 MAF.

During Rabi season 2015-16, the water availability remained at 32.9 MAF, which is 0.6 per cent less than Rabi 2014-15 and 9.6 per cent less than the normal availability of 36.4 MAF.

Figure 5.4: Actual Surface Water Availability in Pakistan (Million Acre-Feet)



5.6 Status of drinking water quality

A study on the water quality status of major cities of Pakistan 2015-16 was conducted by Pakistan Council of Research in Water Resources.

During the study, a total of 369 water samples were collected from 25 major cities of Pakistan, i.e., Islamabad, Bahawalpur, Faisalabad, Gujranwala, Gujrat, Kasur, Lahore, Multan, Rawalpindi, Sargodha, Sheikhupura, Sialkot, Mingora, Abbottabad, Mardan, Peshawar, Khuzdar, Loralai, Quetta, Ziarat, Hyderabad, Karachi, Sukkur, Gilgit and Badin.

The samples were collected from 16 types of water supply sources comprising of tube well, water supply scheme, bore well, tap, reservoir, water storage tank, Reverse Osmosis Plant, surface water (river), Karez, spring, tank, hand pump, injection pump, filtration plant, motor pump and donkey pump.

The number and percentage of safe and unsafe water sources (microbiologically or chemically are provided in **Table 5.2.**

Table 5.2: Overall water quality situations of 25 cities and causes of contamination in selected major cities

City	Total No of Sample	Safe Samples		UnSafe Samples		Type and %age of contamination
		No	%age	No	%age	
Islamabad	25	8	32	17	68	Bacterial 17 (68%)
Punjab						
Bahawalpur	25	1	4	24	96	Hardness 6 (24%), Chloride 3 (12%) TDS 7 (28%) Bacterial 23 (92%) Arsenic 12 (48%) Turbidity 4 (16%)
Faisalabad	12	4	33	8	67	Hardness 2 (16%) Chloride 5 (42%) TDS 6 (50%) Fluoride 2 (16%) Bactria 6 (50%) Iron 1 (8%)

City	Total No of Sample	Safe Samples		UnSafe Samples		Type and %age of contamination
		No	%age	No	%age	
Gujranwala	14	3	21	11	79	Bacteria 11 (79%)
Gujrat	9	6	67	3	33	Bacteria 3 (33%)
Kasur	10	6	60	4	40	Bacteria 4 (40%)
Lahore	16	12	75	4	25	Bacteria 4 (25%)
Multan	16	3	19	13	81	Arsenic 10 (62%) Bacteria 12 (75%) Iron 5 (31%)
Rawalpindi	13	5	38	8	62	NO3 (23%) Bacterial 6 (46%)
Sargodha	24	3	13	21	87	Hardness 9 (38%) Chloride 10 (42%) TDS 17(71%) TDS 2 (8%) NO12 (50%) Bacterial 5 (21%)
Sheikhupura	11	6	55	5	45	Fe 1 (9%) Arsenic 1 (9%) NO1 (9%) Bacterial 3 (27%)
Sialkot	9	8	89	1	11	Bacterial 1 (11%)
Sub Total	184	65	35	119	65	
Khyber Pakhtunkhwa						
Abbottabad	7	3	43	4	57	Fe 3 (43%) NO3 (43%) Bacterial 3 (43%)
Mingora	9	5	56	4	44	Bacterial 4 (44%)
Mardan	8	4	50	4	50	Bacterial 4 (50%) Fe 1 (12%)
Peshawar	10	6	60	4	40	Bacterial 4 (40%)
Sub Total	34	18	53	16	47	
Balochistan						
Loralai	7	2	29	5	71	Turbidity 1 (14%) Bacterial 5 (71%)
Quetta	31	5	16	26	84	Turbidity 2 (6%) Bacterial 25 (81%)
Ziarat	9	2	22	7	78	Turbidity 1 (11%) Bacterial 7 (44%) NO 1 (11%)
Sub Total	**47**	**9**	**19**	**38**	**81**	
Sindh						
Hyderabad	15	1	7	14	93	Turbidity 10 (67%) Hardness 3 (20%) Chloride 3 (20%) TDS 3 (20%) Fe 4 (27%) Fluoride 1 (7%) NO_3 Bacterial 14 (93%)
Karachi	28	4	14	24	86	Chloride 2 (7%) TDS 2 (7%) Fluoride 3 (11%) NO_3 1 (3%) Bacterial 24 (86%)
Sukkur	12	0	0	12	100	Turbidity 6 (50%) Hardness 2 (17%) TDS 3 (25%) Fluoride 2 (17%) NO_3 1 (8%) Bacterial 12 (100%)

City	Total No of Sample	Safe Samples		UnSafe Samples		Type and %age of contamination
		No	%age	No	%age	
Badin	29	11	38	18	62	Turbidity 1 (3%) Hardness 1 (3%) PH. 1 (3%) Chloride 2 (7%) TDS 1 (3%) NO1 (3%) Bacterial 16 (55%)
Sub Total	84	16	19	68	81	
AJK						
Muzaffarabad	10	6	60	4	40	Bacterial 4 (40%)
Gilgit Baltistan						
Gilgit	10	0	0	10	100	Turbidity 5 (50%) Bacterial 10 (100%)
Total	**369**	**144**	**31**	**255**	**69**	

Source:

The analytical data showed the prevalence of four water quality tribulations in the country, i.e., Bacterial (69%), Arsenic (24%), Nitrate (14%) and Fluoride (5%).

The analytical findings were compared with the World Health Organisation (WHO) guidelines for respective parameters. The overall water quality results of the country show that out of 369 sources, 114 (31%) sources were found safe whereas 255 (69% sources were unsafe when compared with National Standards for Drinking Water Quality.

PCRWR conducted province wise comparison of water quality of 2002-2006 with the findings of water quality of 2015. As per the sampling plan, the sample collection and subsequent filed and laboratory analysis were carried out for all the four provinces and capital area during 2002-2006. However, in the year 2015, Badin, Gilgit, and Muzaffarabad were also included in the water quality monitoring study.

A province wise analysis of water quality was carried out on the basis of 2,286 samples collected from Balochistan, Punjab, Khyber Pakhtunkhwa, Sindh, AJK and Gilgit Baltistan. The province-wide water quality status from 2002-2006 to 2015 is discussed as under:

Balochistan: In Balochistan, unsafe water samples were in the range of 74-86% in 2002-2006 and 81% in 2015 whereas safe drinking water sources were in the range of 14-26% during the five-year period 2002-2006 and 19% in 2015. Most of the water sources were unsafe for drinking purpose due to bacterial contamination.

Punjab: In Punjab, the percentage of unsafe water sources in five years period (2002-2006) was between 81-91%, whereas this reduced to 65% in 2015. The safe water samples were in the range of 9-19% in 2002-2006 and 35% in 2015 with some improvement.

Khyber Pakhtunkhwa: In Khyber Pakhtunkhwa, the percentage of unsafe water sources during the five years period (2002-2006) was in the range of 52-86%, whereas it was 47% in 2015. Overall unsafe water samples ranged from 47-86% during all the monitoring years of major cities, i.e. 2002-2006 to 2015.

Sindh: In Sindh from 2002 to 2006, 85 to 96% of the water samples were found unsafe for drinking. However, in 2015, 81% of sources were found unsafe. The safe water samples were in the range of 4-15% in 2002-2006 and 19% in 2015.

5.7 Sources of Contamination of Water

Water for drinking purposes mainly comes out from the surface and underground aquifers near the rivers or canals. The surface water quality is dropping rapidly due to the addition of raw municipal and industrial effluents and agricultural runoff into water resources (Chilton, 2001). The surface and groundwater contamination may be physical, biological or chemical.

When the flow of river water is at its peak, it contains high solid suspension. Most of the rivers are extended and diluted and do not endure aquatic life. It is clear that these water bodies are contaminated with faecal matter and need proper processing to free them from contaminants for human use.

About 70% of water for drinking purposes comes from aquifers (Tahir et al., 1998).[16] The decrease in groundwater quality is caused by many direct, indirect, natural and man-made addition, like hazardous waste, landfills, Atmospheric pollutant, chemical and animals waste. The groundwater quality in Pakistan is found saline far away from the main rivers and fresh water near to the main rivers.

The contamination of water due to microbes is the most blistering issue both in urban and rural areas. The drinking water distribution does not meet the WHO Guidelines (WHO, 1996). The main reason for microbial contamination is due to the intermixing of sewer lines with drinking water supply lines. This is due to the leakage of pipe, pollution from sewage lines intrusion into drinking water supplies, and so forth.

Water pollution is the deterioration of water quality due to the addition of wastes coming from industries, domestic and agriculture. Utilization of such water for beneficial use causes contrary effects on the environment and public health. Industrialization and emergence of urban units placed immense stress on water resources and discharge of wastewater into natural water resources that decrease ground and surface water quality (Awan et al., 2002).

The unprocessed and unconventional treatment of human waste is another contamination source including the poor sanitation and monitoring issues in the rural areas (Howell, 2001). The wastewater seeps into the groundwater, contaminating the groundwater or runoff through the surface into surface water bodies. The highest infant mortality rate (12.6%) and fertility rate (7%) reflect the poor health status of Pakistan. This information indicates that most of the treated diseases are due to faecal contamination. About 25% of patients treated at hospitals, private clinics, or healthcare centres are suffering from diarrhoea, including children and adults (Karim et al., 1985; Ahmed & Aslam, 1993).

In most rural areas, no pre-treatment facilities are available for the filtration of water. All this inadequacy is due to microbial contamination and poor water quality. Hand pumps and wells are not safe from surface runoff and flooding (Shuja & Jaffar, 1998).

Chemical contaminants come from industries, soil sediments, and runoff from agriculture, that is, pesticides and fertilizers, and enter into water resources. These chemicals, commonly insecticides, leach into groundwater resources by mixing with irrigated and rainwater.

In Pakistan, another important trouble with groundwater is the highest concentration of salts, which is mainly due to irrigation, soil salts dissolution, sea water encroachment, and chemical industries. Salinity impacts the major areas of Balochistan, Khyber Pakhtunkhwa and Punjab. Effluent from industries and domestics contains a high concentration of arsenic that is becoming a severe problem. The dental fluorosis diseases are commonly found in Sindh, Punjab, and Khyber Pakhtunkhwa.

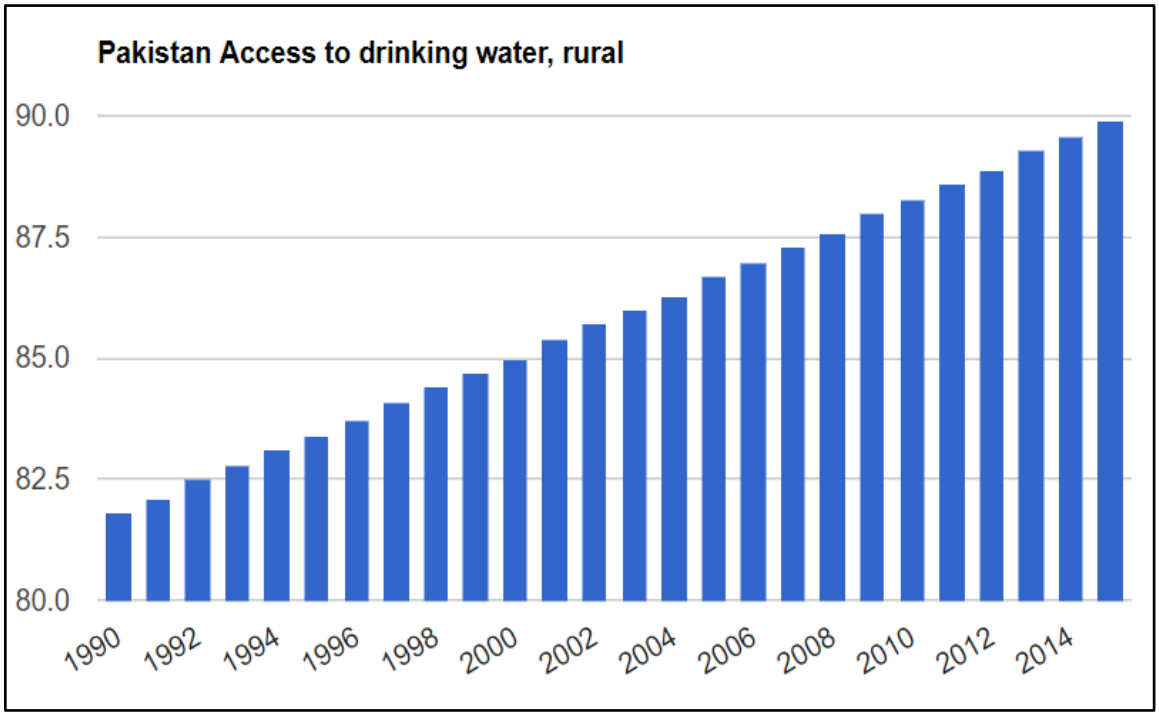
5.8 Access to drinking water Supply

Rural: WHO/UNICEF provides data for Pakistan from 1990 to 2015 about the rural population having access to drinking water is shown in figure 5.5. The average value for Pakistan during that period was 85.85 per cent with a minimum of 81.8 per cent in 1990 and a maximum of 89.9 per cent in 2015.[17]

17

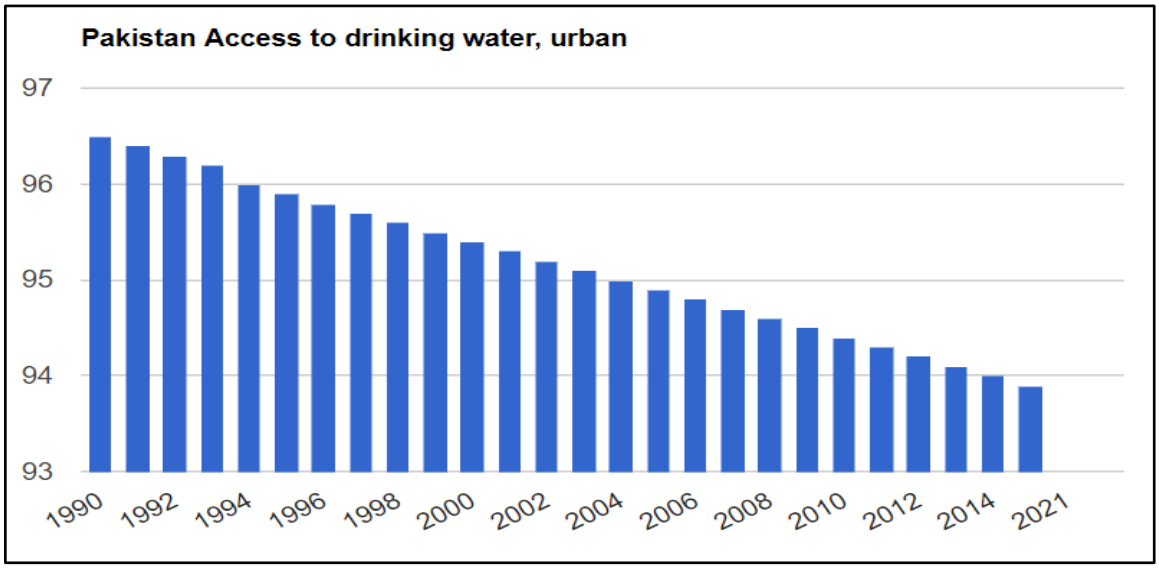
http://www.pbs.gov.pk/sites/default/files/crops_and_climates/compendium_environment/compendium_environment_2015.pdf

Figure 5.5: Pakistan access to drinking water Rural (1990 – 2015)



Urban: WHO/UNICEF provides data for Pakistan about urban population having access to drinking water from 1990 to 2015 is shown in **Figure 5.6**. The average value for Pakistan during that period was 95.17 per cent with a minimum of 93.9 per cent in 2015 and a maximum of 96.5 per cent in 1990.

Figure 5.6: Pakistan access to drinking water, Urban (1990 – 2015)



5.9 Issues and Challenges in Coastal water

There are a number of environmental issues in the coastal zone of Pakistan which have a direct bearing on public health in the coastal areas as follows:

- The coastal development activities involving manmade alterations of the coastal environment have also accelerated the impacts of pollution leading to the deterioration of coastal water quality, depletion of coastal resources, public health risks and loss of biodiversity.

- Karachi has about 8,000 small and large industrial units. The industrial estates of Karachi, namely Sindh Industrial Trading Estate (SITE), Landhi Industrial Trading Estate (LITE), Korangi Industrial Area (KIA), and West Wharf Industrial Area among others, discharge effluents mainly into the Lyari and Malir rivers, which drain into the Arabian Sea.

  The rivers carry calcium, alum, sulphates, magnesium, sodium, potassium, arsenic, halides, and bicarbonates. SITE is responsible for about half of the total industrial discharges of Karachi. Moreover, the LITE and the KIA also discharge their effluents into the mangrove mudflats of Korangi Creek.

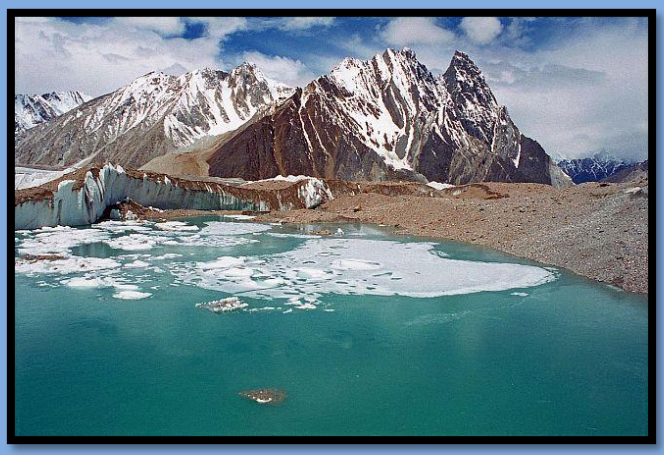
  In addition, three power plants along the Karachi coast that use large quantities of seawater for cooling, and discharge heated effluent and other pollutants into the ocean. This discharge contains chlorine used for the control of biofouling organisms in the plants.

  The impact of these land-based activities including industrial, domestic, and agricultural pollution has resulted in the degradation of the marine ecosystem. One of the impacts of this pollution has been the alteration and sometimes even the destruction of coastal and marine habitats, which play a critical role in various stages of the life cycles of several species of marine fauna.

- One of the major problems of the coastal areas is oil pollution. There is large-scale shipping traffic at Port Qasim. The sources of oil pollution in Manora channel are bilges, outpours from engine rooms of vessels, discharges and leaks from bunkering points, and leaks and small spills during loading and unloading at oil piers.

  Some oil is also brought to the channel through the Lyari River discharge. Among the creeks of the Indus Delta, Gizri Creek and Korangi Creek are most affected by oil pollution from the oil discharges of refineries, industries, and municipal activities of sources located in the Korangi area.

CLIMATE CHANGE



6 Climate Change

6.1 Introduction

Pakistan like many other countries is also facing environmental challenges. It is located in a warm climate region and is more vulnerable to expected climate changes due to its diverse topographic and demographic settings.

The temperature changes under current circumstances are expected to be higher in Pakistan in the long run than global averages. The country is affected by the drastic effects of climate change due to its geographical location and socio-economic situation. In recent years, highly variable monsoon rains and severe climatic events such as floods and droughts have affected the socio-economic structure of the country.

The extreme conditions of the weather in Pakistan like the floods in 2010, 2011, 2013 and 2015 have considerably affected not only the agriculture sector but also damaged infrastructure at a large scale.

Other direct or indirect issues being faced by the country due to climate change include water pollution (caused by floods, avalanches and soil erosion), desertification (caused by water scarcity and rise in temperature), soil erosion, water logging and salinity, solid waste management and deforestation. Pakistan's vulnerability to climate change impacts is well documented and acknowledged (Kreft & Eckstein, 2013).

In the past decade, recurrent spells of extreme weather events such as floods, droughts, glacial lake outbursts, cyclones, and heat waves have taken a heavy toll on both life and property and adversely affected the country's economic growth.

The super flood of 2010 alone, for instance, killed 1,600 people, inundated an area of 38,600 square kilometres (sq. km) and caused damage worth around $10 billion (Ali, 2013). Similarly, the Karachi heat wave (June 2015) led to the death of more than 1,200 people (Chaudhry et al., 2015).

6.2 Geography and Climate of Pakistan

Pakistan extends over an area of 796,095 sq. km with a great diversity in temperature and precipitation. The eastern areas of the southern half mainly receive precipitation through the southwest summer monsoon (from June to September), while the northern and western areas of the southern half of the country get rains mainly through western weather disturbances in winter (from December to March). The summer monsoon accounts for around 60% of the total annual precipitation.

The climate varies from arid to semi-arid where three-fourths of the country receive rainfall of fewer than 250 millimetres (mm) annually, except in the southern slopes of Himalaya and the sub-mountain region in the northern segment of the country, where annual rainfall ranges from 760 mm to 2,000 mm.

The northern region includes some of the world's highest mountain peaks, such as K-2 (8,611 m high), and the largest glaciers including Siachen (70 km long) and Biafo (63 km) that feed the Indus River and some of its tributaries (Goharnejad et al., 2006).

During winter, the temperatures in this region drop to as low as –50°C and stays around 15°C in the warmest months of May to September (McSweeney et al., 2008).

The western and southern segments of the country represent the Indus River basin plain and Balochistan Plateau. The transboundary Indus basin covers 520,000 sq. km. or 65% of the country's total area, including the whole provinces of Punjab, Khyber Pakhtunkhwa, most of the Sindh territory, and the eastern part of Balochistan.[18]

The average annual rainfall in the Indus plain is around 230 mm. The temperature differences between the upper and lower basin plains are quite noticeable: the mean winter temperature (December–February) in the lower plain is 14°C –20°C, and 2°C –23°C in the upper plain areas, while during summer (March–June), the mean monthly temperature varies from 42°C –44°C in the lower plan, and 23°C –49°C in the upper plain.

The Balochistan Plateau is a vast wilderness of mountain ranges in the southwest of the country with an average altitude of about 600 m. Some seasonal rivers cross this region, but most of its northwestern part is a wide expanse of desert similar to the deserts found in the central part of the country, such as Thar and Cholistan. The rainfall in this region is less than 210 mm annually or 20–30 mm per month.

Pakistan is divided into 5 zones on the basis of climate as follows:

Zone A: The Zone A comprises of cold climate and high mountains, situated in the North of Pakistan located between 34^{o}N to 38^{o}N in the Himalayan Hindukush region covering Chitral, Gilgit, Muzaffarabad, Said-u- Sharif, Skardu, Astor, Dir, Chilas, Parachinar and Kakul.

Zone B: The Zone B comprises of mild cold climate and sub-mountains, located between 31 to 34^{o}N covering Sialkot, D.I. Khan, Islamabad, Peshawar, Cherat and Lahore.

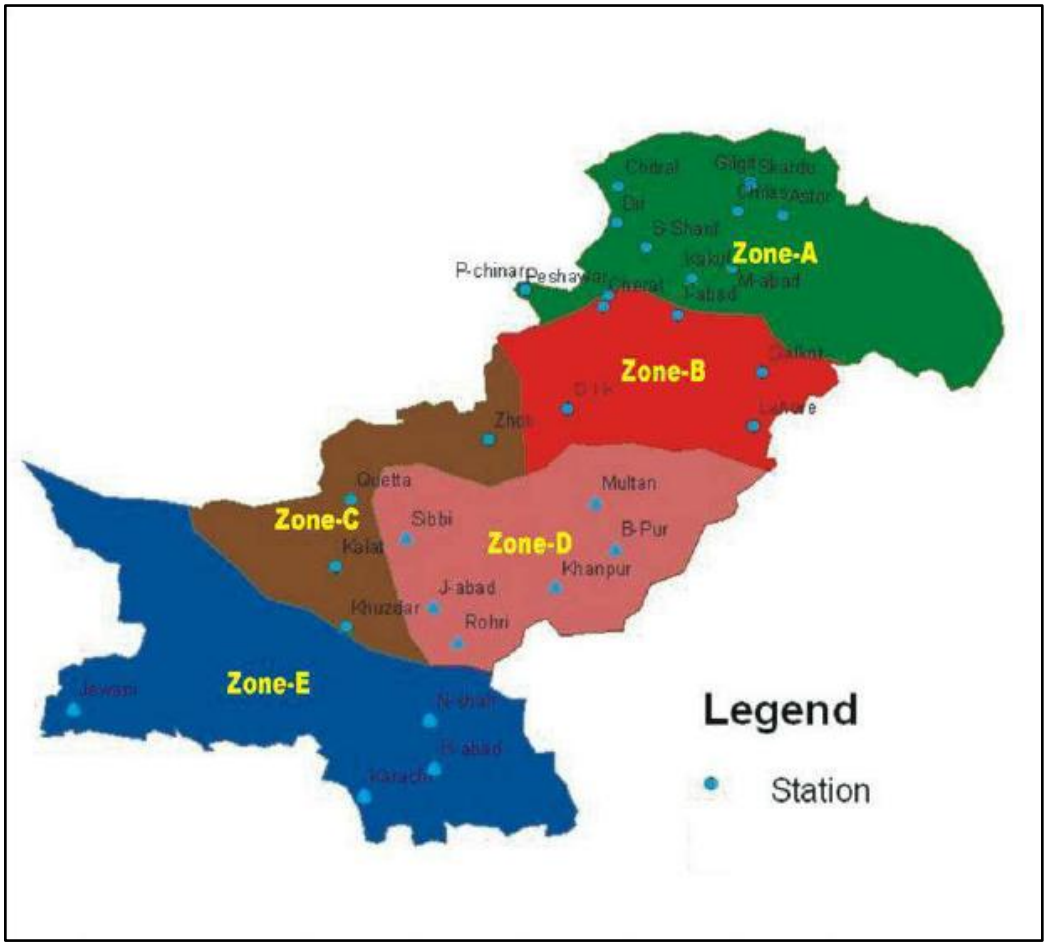
Zone C: The Zone C comprises of cold climate in winters and hot in summers, mostly comprising of a mountainous area with high elevations from mean sea level and laying between 27 to 32^{o}N and 64 to 70^{o}E and comprising of Quetta, Zhob, Kalat and Khuzdar.

Zone D: The Zone D, is the hottest and dry zone of the country with the highest maximum temperatures and comprised of Sibbi, Jacobabad, Bahawalpur, Khanpur, Multan and Rohri.

Zone E: Zone E is a big zone comprising of coastal cities, near to the Arabian Sea. The coastal part comprises only a small part of this region and climate above coastal parts in Balochistan as well as in Sindh province is arid and comprises of Hyderabad, Karachi, Nawabshah, Tharparkar and Jewani (Qasim et al., 2014).

[18] *http://www.fao.org/nr/water/aquastat/basins/indus/index.stm.*

Figure 6.1: Climate zones of Pakistan along with their latitude and longitude



6.3 Climate Threats

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) for the Asia region notes that sensitivity to climate change threats, in agriculture-dependent economies (such as Pakistan), arises from their distinct geography, demographic trends, socio-economic 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 be 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 significantly impact the productivity and efficiency of water-dependent sectors such as agriculture and energy.

6.4 Greenhouse Gas Emissions Profile of Pakistan

According to the National Greenhouse Gas Emissions (GHG) inventory of Pakistan for the year 2011–2012, its total GHG emissions were at 369 million tons of carbon dioxide equivalent (MtCO2e) with 45.9% share of energy, 44.8% share of agriculture and livestock sector, 3.9% share of industrial processes, and 2.6% share of land use change for forestry

sectors. The energy and agriculture livestock sectors alone account for 90.7% of the total emissions pool and have thus far remained the biggest emitters of GHGs since 1994.

Pakistan has prepared four GHG emission inventories to date. Asian Development Bank (ADB) prepared the first one for the years 1989–1990, the Global Environment Facility (GEF) supported the second inventory (the fiscal year 1993–1994), the Pakistan Atomic Energy Commission on the request of the task force on climate change of the Planning Commission of Pakistan prepared the third one for 2007–2008, and the Global Change Impact Studies Centre (GCISC) prepared the inventory for 2011–2012 (Mir & Ijaz. 2015).

Pakistan ranks relatively low among countries on a per capita GHG emissions basis, due to its relatively low level of development and high population. Pakistan's Global Greenhouse Gas Emission's Ranking for total GHG per capita emissions is 135^{th,} and total GHG emissions are 31st.[19]

Thus, the projected total GHG emissions of Pakistan—in line with the government's economic growth strategy—will be more than double by 2020 (compared to the emissions in 2008) and increase by around 14 times by 2050.

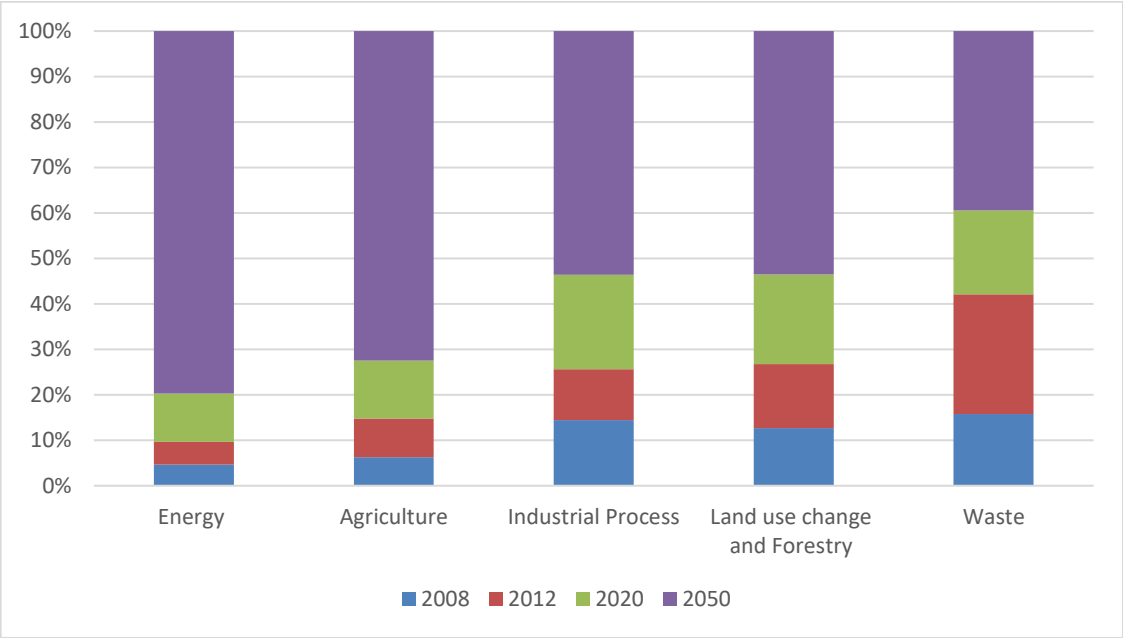
Table 6.1: Projected GHG emissions by sector in 2020 and 2050 under Business as Usual Scenarios (in $MtCO_2e$)

Sector	1994	2008	2012	2020	2050
Energy	86	157	169	358	2,685
Agriculture	72	120	165	245	1,395
Industrial processes	13	18	14	26	67
Land use change and forestry	7	9	10	14	38
Wastes	4	6	10	7	15
Total national emissions	**182**	**309**	**369**	**650**	**4,200**

GHG** = greenhouse gas, MtCO2e = million ton of carbon dioxide equivalent.* ***Source: *Government of Pakistan, Ministry of Planning, Development and Reforms. 2010. Task Force Final Report on Climate Change. Islamabad; K. A. Mir and M. Ijaz. 2015. Greenhouse Gas Emission Inventory of Pakistan for the Year 2011–2012. Islamabad: Global Change Impact Studies Centre (GCISC)*

[19] *http://www.theglobaleconomy.com/rankings/Carbon_dioxide_emissions*

Figure 6.2: Percent sector share of GHG inventory for Pakistan for 2008, 2012, 2020 and 2050



6.5 Past Observed Trends of Climate Change Indicators

During the last century, Pakistan's average annual temperature increased by 0.57°C compared to 0.75°C for South Asia, and average annual precipitation increased by 25%. The warming is mainly due to an increase in winter temperature.

The past observed trends of climate change indicators are as follows;

- Heatwave days per year increased by 31 days in the period 1980 to 2007. Cold waves decreased in northeastern and southern parts and increased in western and northwestern parts of the country.
- Observed sea level rise along the Karachi coast was 1.1 millimetres per year in the past century.
- During 1960–2007, the following changes were noted:
  - An increase of 0.6°C to 1.0°C in the mean temperature over the hyper-arid plains, arid coastal areas, and mountains regions of Pakistan;
  - A decrease of 10%–15% in winter and summer rainfall in the arid plains and coastal areas;
  - A rise of 18%–32% in the summer rainfall over the core monsoon region of Pakistan;
  - A decrease of 5% in relative humidity over Balochistan province;
  - An increase of 0.5%-0.7% in solar radiation over the southern half of the country;
  - A decrease of 3%–5% cloud cover over central parts of Pakistan, and a consequent increase of 0.9°C in temperature;

- The northern parts of the country outside the monsoon region have suffered from expanding aridity;
- A decrease of 17% to 64% in rainfall observed during the seven-strong El Niño events in the last 100 years;
- The minimum temperature in summer over central parts of Pakistan has shown a pronounced warming trend while in the extreme north and south have shown a slight cooling trend in some climatic zones; and
- The coastal belt in general and the Indus delta, in particular, have not shown any significant warming or cooling trends (Rasul et al., 2012).

6.6 Projection of Future Climate Trends in Pakistan

6.6.1 Future Trends in Temperature and Precipitation

Using the General Circulation Model for future climate change projection, the Global Change Impact Study Centre (2007) modelled annual temperature and precipitation change for future years 2020, 2050, and 2080 under two emissions scenarios of A2 and A1B.

According to the model, by 2080, the temperature increase in Pakistan will be as high as 4.38°C. Regarding the regional change in annual temperature, the study further noted that (i) the temperature increase in both summer and winter are higher in northern than southern Pakistan, and (ii) the temperature increases in both regions are higher in winter than summer. For the percentage of precipitation change, no significant change is observed. However, there is some precipitation increase in summer and decrease in winter in southern Pakistan (Iqbal & Zahid, 2014).

The climate models show a maximum rise in the northern areas of Pakistan, central and south Punjab, and lower parts of Khyber Pakhtunkhwa. However, mixed trends are projected for precipitation over different regions of Pakistan.[20]

Table 6.2: Regionwide climate projections for Pakistan for alternative scenarios, 2011–2050

Region	Precipitation (mm/decade)			Temperature (°C/decade)		
	A2	A1B	B1	A2	A1B	B1
Pakistan	+1.73	+1.26	-0.89	+0.51	+0.41	+0.24
Northern Areas	+4.6	+2.9	-1.3	0.76	0.63	0.39
Potohar and Upper Khyber Pakhtunkhwa	+6.1	+3.8	-0.5	0.01	-0.34	-0.01
Central/Southern Punjab and Lower Khyber Pakhtunkhwa	-2.98	-1.78	-3.5	+0.63	+0.71	+0.05
High Balochistan	+1.48	+0.92	-0.57	+0.15	+0.26	+0.03
Southeastern Sindh	+5.1	+3.0	-0.1	0.00	-0.1	+0.01

[20] *https://www.adb.org/sites/default/files/publication/357876/climate-change-profile-pakistan.pdf*

Region	Precipitation (mm/decade)			Temperature (°C/decade)		
	A2	A1B	B1	A2	A1B	B1
Sindh and Lower Balochistan	-1.8	-0.98	-0.05	+0.5	+0.27	+0.01

mm = millimeter, KP = Khyber Pakhtunkhwa.

Notes: A2 shows business as usual, A1B shows balanced scenarios, and B1 shows Ideal World (SRES Report IPCC 2001) based on greenhouse gas emissions likely in the 21st century.
***Source:** Q. Z. Chaudhry et al. 2009. Climate Change Indicators of Pakistan. Technical Report. No. 22. Islamabad: Pakistan Meteorological Department.*

In the Indus Basin area, an almost uniform variation in the rainfall distribution over the entire basin region (Rajbhandari et al., 2014). At sub-region levels of the Upper Indus Basin (UIB) and Lower Indus Basin (LIB), models show an increasing trend in the rainfall over the UIB, decreasing in the LIB with a small change in the border zone between the two basin sub-regions.

Winter precipitation is projected to decrease, particularly in the southern part of the basin with greater warming in the winter than in other seasons of the year. Similarly, UIB will become warmer than LIB. The model simulations also suggest a rise in the total number of rainy days over the basin, but a decrease in the number of rainy days, and an increase in rainfall intensity is projected in the border zone between the upper and lower basins, where the volume of rainfall is highest.

The projections of temperature and precipitation for the whole Indus River Basin show a 3°C–5°C temperature rise in mean temperature under the Representative Concentration Pathways (RCP) 4.5 emission scenario.[21]

The mean trend of temperature under RCP 8.5 indicates a 4°C–6°C rise by the end of the century with a sharp increase after 2050. Area average rainfall over Pakistan shows a large inter-annual variability. CMIP5 multi-model mean projections of annual average temperature and precipitation changes for 2046–2065 and 2081–2100 under RCP 4.5 and 8.5 relative to 1986–2005.

Summer rainfall peaks will shift toward August while those of winter will shift toward March. The shifts in the rainfall peaks continue even up to the end of the century. RCP 4.5 shows an increase of 4 mm/day in annual mean precipitation with a shift in maxima toward the northeastern part of the country until 2050. After 2050, the precipitation pattern shifts toward northwest until the end of the 21st century with the same magnitude and wet situation in the southern region. A similar pattern is seen in the RCP8.5 scenario but with less magnitude of up to 2–3 mm/day and more spatial spread.

6.6.2 Projected Sea Levels

In the past century, the average mean sea level rose to 1.1 mm/year for Pakistan. It is difficult to project sea level rise (SLR) by the end of 2100 for Pakistan since data is limited

[21] *https://www.ipcc.ch/report/ar5/syr/*

at the country level. However, the sea level rise projections at the global and regional levels can be helpful in capturing the extent of the risk Pakistan will be exposed to in the future.

IPCC AR5 notes a global mean SLR of 0.2–0.6 m by the end of this century, whereas for South Asia, of which Pakistan's coast is a part of due to the shared Arabian Sea border, 0.7 m (with a range between 0.42 and 1.12 m and a 90% level of confidence) SLR is projected by 2100 on average, relative to the pre-industrial level.

The future sea level rise will most likely affect the low-lying coastal areas south of Karachi toward Keti Bander and Indus River delta.

6.6.3 Future Projections for Climate Change Indicators

- Pakistan's projected temperature increase is expected to be higher than the global average.
- The projected temperature increase in northern parts is expected to be higher than the southern parts of the country.
- The frequency of hot days and hot nights are expected to increase significantly.
- Pakistan's rainfall projections do not indicate any systematic changing trends.
- Major crop yields such as wheat and rice are expected to decrease significantly.
- Water availability per capita is projected to decrease to an alarming level.
- There is an increasing trend in the rainfall over the Upper Indus Basin and the decreasing trend in the Lower Indus Basin (Rabbani et al., 2008; Iqbal et al., 2009).

6.7 Impact of Climate Change on Mountains

The climate change is also taking place in Mountainous areas of Pakistan like another mountainous area of the world, In Gilgit-Baltistan, the climate stations in Gilgit, Skardu, Gupis and Bunji showed an increase in the total temperature in last two decades from 1980 to 2006 and increased by 0.440 C per decades observed.

There is more rainfall than snow. Through a detailed analysis of past records of different meteorological stations of the Gilgit-Baltistan, it was observed that the night temperatures are increasing in the Northern Areas of Pakistan.

According to research conducted by Hussain et al., the maximum temperatures have increased all around the year, especially in high mountainous regions in Pakistan during the period from 1971 to 2000.

Climate change is taking place in Gilgit-Baltistan. Information taken from different climate stations like Gilgit, Skardu, Gupis and Bunji shows an increase in mean temperature between the years 1980 to 2006 by 0.19^{o} C per decade.

Increasing population and changing lifestyle under economic transformation raised the level of anthropogenic contribution to climate change many folds as compared to always existing natural ones. It was discovered that change in climate caused flash floods and river bank erosion in Skardu district of Gilgit-Baltistan. The flash floods are emanating from glacial melting, leading to river bank which causes erosion and flooding of fields.

There are more than 5,000 glaciers feeding the Indus from 10 sub-basins through different tributaries ranging from few tens of meters to more than 70 km long.

According to glacier inventory developed by ICIMOD in 2005 with the help of RS/GIS techniques, over this glaciated domain, there are about 2,500 glacial lakes formed due to glacier meltwaters and 52 of them were declared potentially dangerous for Glacial Lake Outburst Flood GLOF (Rasul et al., 2019).

Pakistan has followed the similar warming trend as the global average during the past 100 years rather northern mountains housing the Himalayan-Karakoram-Hindukush glaciers have retained more heat that the low elevation plains.

Last decade was the warmest one in Pakistan with 0.93˚C rise in temperature as compared to the 1971-2000 long-term average. High mountain climate was even warmer than the national average by an additional 0.4˚C. This rise was 75% more than that was projected for Pakistan during the decade 2001-2010.

Snowline has been shifting rapidly uphill causing the biodiversity to migrate and precipitation in the form of rainfall instead of snowfall. Such up-rise of the thermal regime has started melting the low elevation glaciers at a faster rate. As a result, the formation of new glacial lakes and the expansion of existing lakes to the danger of outburst flood has increased.

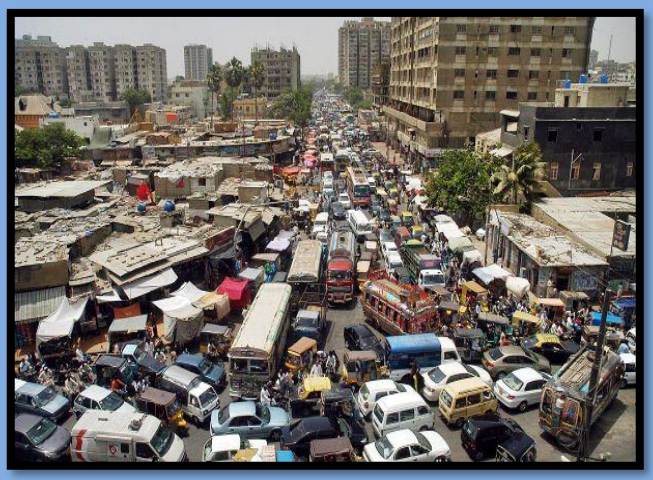
Supra- and sub-glacial lakes have been showing the greater potential of outburst due to the addition of glacier meltwater and rainfall. Their monitoring is a serious concern as they continue discharging and accumulating water in an irregular and invisible manner. The monitoring of terminal lakes is comparatively easy.

In general, low elevation glaciers up to 4,500 m have been losing their ice mass at a much faster rate. Above 4,500 m the melt rate is slow or glaciers or stable. There are a few examples of advancing glaciers, but only satellite imageries will not prove it until mass balance shows positive signs.

Most of the Pakistani glaciers are debris covered, and thickness of debris layer is inversely related to the ice melt rate. Lower elevation glaciers have a large coverage of debris than higher ones.

Signs of black carbon have been traced on the lower terminus of the valley glaciers adding the acceleration to the melting process. Source of that carbon may be wood burning in the nearby villages for cooking and heating. Valley temperature inversion, which commonly prevails, helps smoke to deposit on terminal ice.

URBANIZATION



7 Urbanization

7.1 Introduction

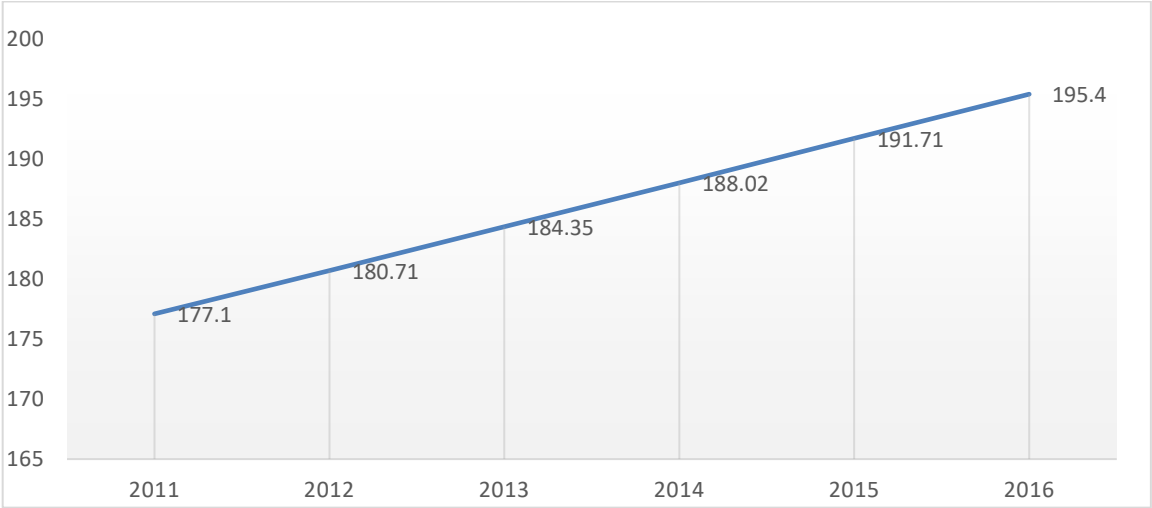
Urbanization is a global phenomenon and describes the growth and expansion of cities and suburbs and the transformation of surrounding rural areas.

Urbanization is necessary to sustain growth in developing countries and is an important part of nurturing growth. Urbanization occurs as a result of more work opportunities and better living standards in cities as compared to rural areas. However; the process of urbanization is accompanied by social, health and environmental issues and, therefore planning to make the urbanization helpful in the economic development of the country.

7.2 Population of Pakistan

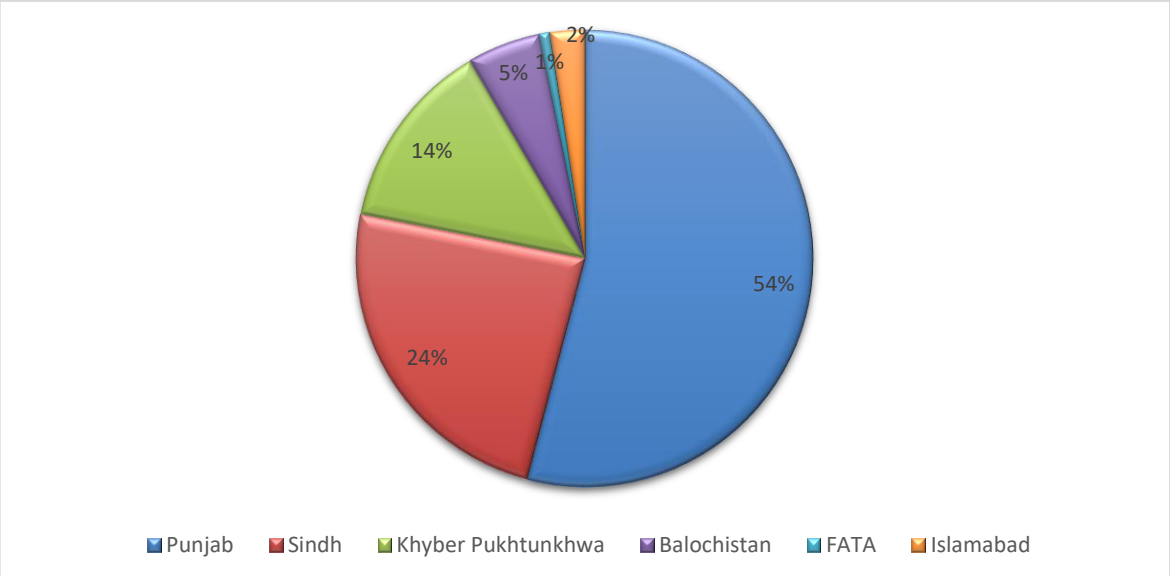
Pakistan population was 195.4 million in 2016. Pakistan has been able to witness a decline in population growth rate to 1.89 in 2016 as compared to 1.92 in 2015 and 1.95 in 2014. Pakistan's population increased by 10.3 % during the last 5 years.

Figure 7.1: Population of Pakistan increase from 2011 to 2016



Presently, 54 % of the population of Pakistan lives in Punjab, 24% in Sindh, 14 % in Khyber Pakhtunkhwa, 5% in Baluchistan and 3% in FATA and Islamabad.

Figure 7.2: Population of Pakistan with respect to the province

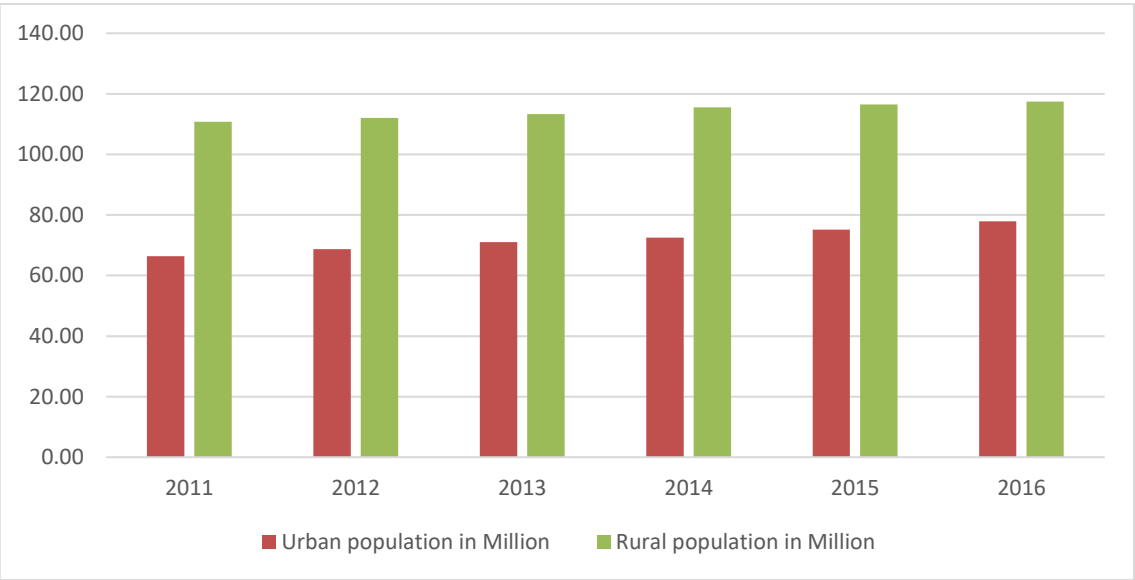


7.1 Urbanisation in Pakistan

Pakistan is one of those developing countries where urbanization is taking place rapidly, and as a result, the share of urban population is increasing significantly. The population in rural areas decreased from 61.4 per cent in 2014 to 60.1 per cent in 2016, whereas, the population in urban areas increased from 38.5 per cent in 2014 to 40.0 per cent in 2016.

Cities are important drivers of development and poverty reduction and the hub of major economic activities. In Pakistan, migration generally takes place for economic reasons, and movement from rural to urban areas is causing a higher population growth rate in the latter. Poor living conditions and a high rate of population growth coupled with unemployment and low wages in rural areas is leading to large-scale migration to the urban area.

Figure 7.3: Urban and Rural Population of Pakistan from 2011 to 2016



Pakistan is one of South Asia's most urbanized countries. It proceeds in two ways, i.e. the multiplication of points of concentration and the increase in the size of individual concentrations. The average urban population of South Asian countries is 22.4 %, and rural is 77.6 % as whereas the urban population of Pakistan is 40 % which is the highest of all South Asian countries.

The exponential growth of urbanization has resulted in a rapid increase in the size of urban areas as well as an increase in the development of slums in the suburbs because of large-scale migration from rural to urban cities. In the case of Lahore, for example, there is a reallocation of extensive productive agricultural areas to residential areas, leading to losses in agricultural productivity, biodiversity, and overall sustainability.

The United Nations Population Fund estimates that, by 2025, nearly half the country's population will live in cities. Other projections – which use density-based rather than administrative definitions of urbanisation, and take into account "peri-urban" areas that lie just outside formal urban boundaries – conclude that the urban population has already reached 50%. By 2025, Pakistan's rural population is expected to exceed that of the urban population in absolute terms – through the gap will have been narrowed significantly.

7.3 Urban Sprawl

Urban sprawl, a consequence of socioeconomic development under certain circumstances, has increasingly become a major issue facing many metropolitan areas. Urban sprawl or suburban sprawl describes the expansion of human populations away from central urban areas into low-density, non-functional and usually car-dependent communities, in a process called suburbanization.

In Pakistan urban sprawl is occurring in cities: Islamabad/ Rawalpindi, Multan, Karachi, Hyderabad, Quetta, Skardu, Mingora, Gilgit, Gwadar, Gujranwala, Lahore, Sukkur, Peshawar, Faisalabad, Swat, Muzaffarabad and Mirpur. It is critically important to properly characterize urban sprawl in order to develop a comprehensive understanding of the causes and effects of urbanization processes. The consequent of urbanisation are slums, unhygienic conditions, communicable diseases, illiteracy, unemployment, overcrowding and stretching of an overburdened system.

7.4 Shortage of Houses

The State Bank of Pakistan's Quarterly Housing Finance Review of 2015 stated that there was a shortage of around 8 million housing units in 2009, which has been accumulating by 0.34 million units every year.

The property development industry suffers from low public confidence. Financial weaknesses and the absence of clear and fair business practices have affected its credibility, contributing to the reluctance of financial institutions in providing development and construction finance. There is a need to strengthen the property titling and land administrative procedures including improvements to the legal provisions, standardization of processes, and computerization of all relevant revenue records said the report.

Although the regulatory framework for land registration and transfer regime exists in Pakistan, the process by which land is acquired and registered is cumbersome at times,

because of a number of institutions and registration procedures required to execute property transactions.

In addition to this, national and local master plans for town planning and housing facilities are either inadequate or poorly enforced, which leads to inefficient allocation of land and uncontrolled urban development. Over-restrictive building codes and laws on subdivision limit the efficient use of urban land and increase the price to consumers, especially in zones having relatively higher prices of lands.

The housing shortage in cities is creating slums in major urban cities of Pakistan. United Nations World Cities Report 2016 has named Karachi's Orangi town as the largest among the world's five largest slums.

7.5 Consequences of Urbanization on Environment

Urbanization leads to overpopulation and is a major cause of most environmental problems in the rapidly growing human population. Major consequences of urbanization on the environment are:

- Urbanization brings technology and innovation. Urban centres are equipped with complex road networks. These roads then link up with smaller, older, narrower roads in urban centres in Pakistan. This causes severe traffic congestion and insufficient traffic management leading to the number of traffic accidents.

- Pakistani urban centres have poor water management facilities. About 40% of water is wasted through water leakages in pipes. Less than 1% of wastewater is treated in Pakistan. Sewage is collected through open drains, and discharge into rivers, streams, lakes and canals without treatment.

- The poorly developed urban centres in Pakistan experience poor sanitation conditions. In urban centres, less than 50% of solid waste is collected by the government while the rest is left to root on the streets. There are heaps of garbage, in poorly developed urban centres in Pakistan increases the disease prevalence rate.

- In urban centres, open burning of waste causes air pollution problems. In addition to this, untreated air from industrial areas directly release into the air, causes respiratory illness in urban settlers. Factories emit untreated effluents into freshwater bodies causing a water pollution problem.

- Stress on drinking water resources due to urbanization has led to water purchasing practices through water tankers. The drinking water quality is compromised, exposing the population to various water-borne diseases. This has led to another challenge that is the provision of adequate water supply and sanitation facilities in cities.

RENEWABLE ENERGY

8 Renewable Energy

8.1 Introduction

Ever Since the increased content of Carbon Dioxide in the atmosphere causing "Global Warming Effect" economies are shifting toward alternative energy sources that have no undesired consequences.

Pakistan is endowed with plenty of natural resources of renewable energy in solar, wind and water resources. The water resources are also to produce electricity. Pakistan has abundant hydropower resources, and the Government is keenly facilitating private investors to promote hydropower generation in the country.

The government of Pakistan is taking all possible measures to ensure energy security and sustainable development in the country. Efforts are underway to improve the power sector fuel mix in the country to reduce the price of power basket and improve financial viability.

Under the reforms, large capacity addition is planned from wind, solar, nuclear, hydel and coal power projects in the medium term. The emphasis is towards achieving a less oil-dependent power generation mix through the development of indigenous energy resources particularly hydel, coal and renewable energy resources for sustainable and affordable energy supply in the country.

Alternative Energy Development Board (AEDB) has been established by the Government with the main objective to facilitate, promote and encourage the development of Renewable Energy in Pakistan.

The government is taking all possible measures to ensure energy security and sustainable development in the country. In its bid to diversify its energy mix, due attention is being given to fast-track development of the Alternative / Renewable Energy resources in the country. The AEDB has been pursuing the development of Alternative and Renewable Energy based power projects through private investors.

8.2 Progress on Renewable Energy

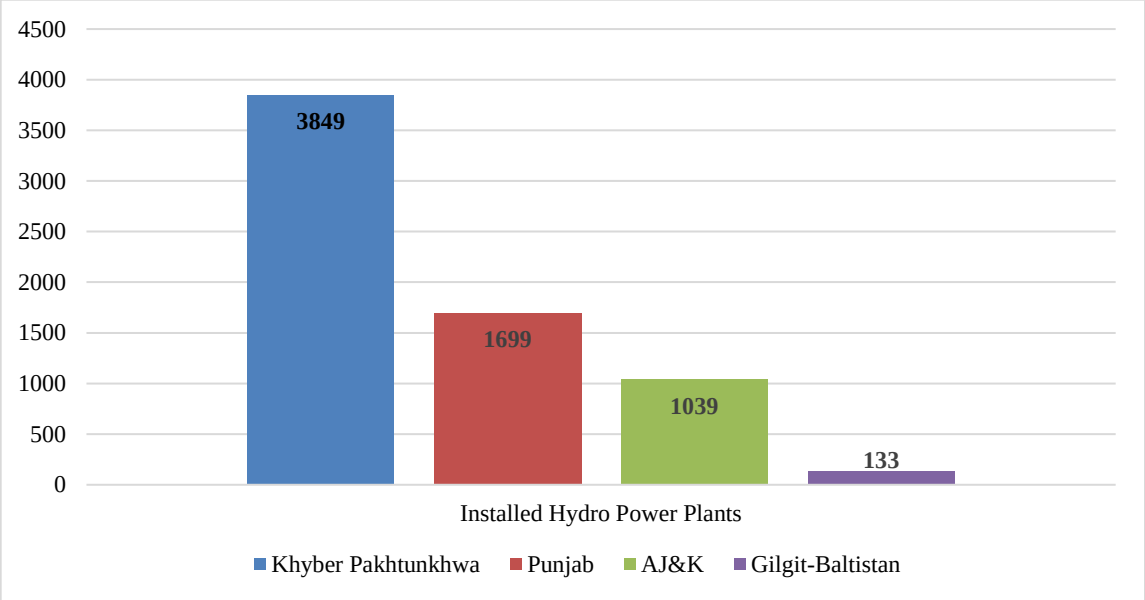
8.2.1 Hydro Power

Pakistan is endowed with hydropower resources of about 59,796 MW, out of which 24,736 MW are in Khyber Pakhtunkhwa, 21,725 MW in Gilgit-Baltistan, 6,450 MW in Azad Jammu & Kashmir and 7,291 MW in Punjab. About 89% of this hydropower potential is still untapped and yet to be harnessed.

The total installed capacity of the hydropower projects in the country is 6,720 MW, out of which 3,849 MW is in Khyber Pakhtunkhwa, 1,699 MW in Punjab, 1,039 MW in AJ&K and 133 MW in Gilgit-Baltistan region[22].

[22] *Hydro Power Resources of Pakistan, Private Power Infrastructure Board, 2011*

Figure 8.1: Hydropower resources in various regions of Pakistan in MW



***Source**: Hydropower Resources of Pakistan, PPIB, 2011*

During July-March Financial year 2016, the installed capacity in the Pakistan Electricity Power Company system remained 23,101 MW. The share of hydel power was 7,027 MW which is 29% of the total electricity generated in Pakistan.[23]

Small hydropower is considered one of the lucrative options for the generation of electricity. The sector has been mainly handled by the provincial governments.

8.2.2 Solar Power

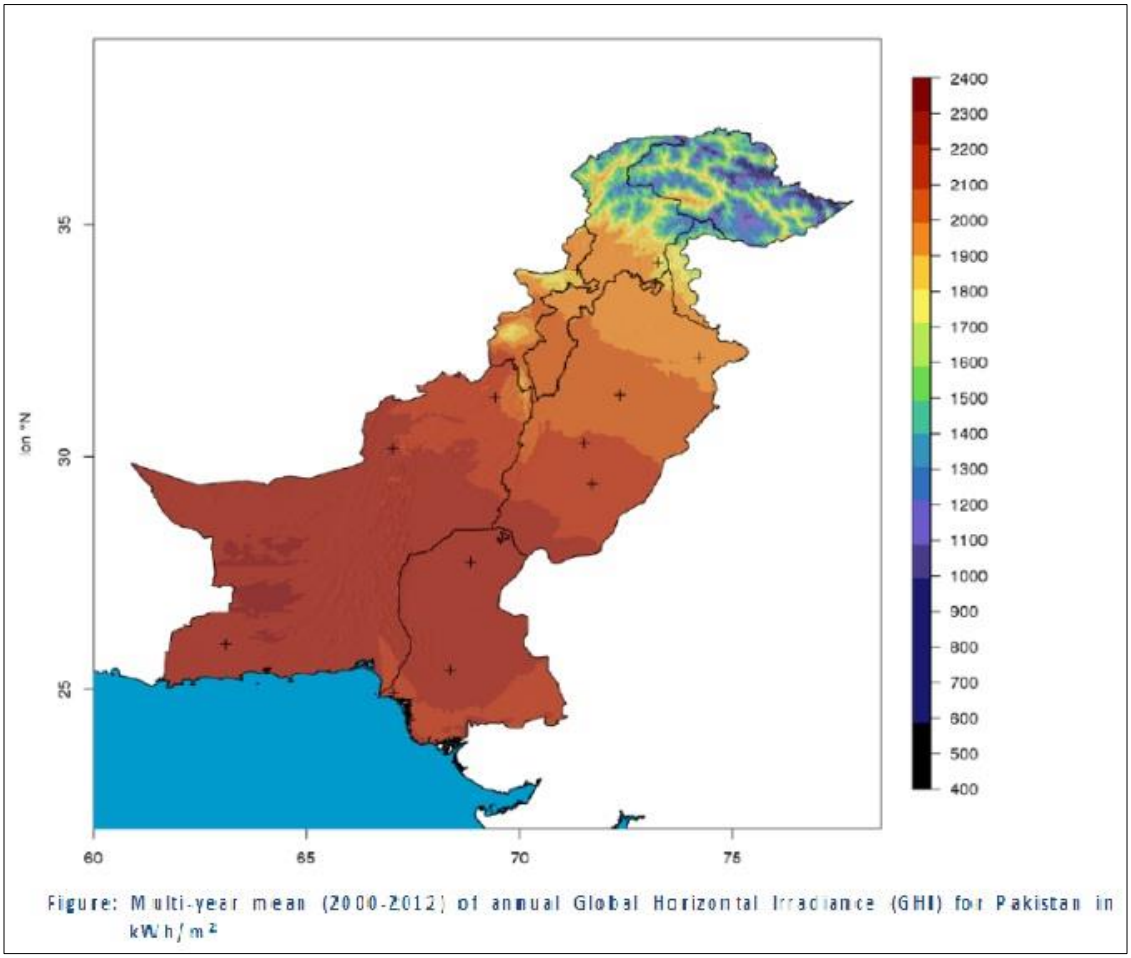
The average amount of daily sunlight in Pakistan is nine and a half hours; there are a few cloudy days even in the wettest regions. The Government of Pakistan has tasked the AEDB to ensure 5% of total national power generation capacity to be generated through renewable energy technologies by the year 2030.

The World Bank and AEDB, Government of Pakistan, implemented a Renewable Energy Resource Mapping activity covering all of Pakistan.

The project is funded by World Bank's Energy Sector Management Assistance Program and focuses on the assessment of wind, solar and biomass resources, including ground-based data collection, GIS analysis, and geospatial planning.

[23] *Energy, Table 2, Electricity Generation for July -March since 2008-09, Pakistan Economic Survey 2015-16*

Figure 8.2: Solar map of Pakistan



During 2015, Quaid-e-Azam Solar Power Plant with an installed capacity of 100 MW generated electricity of 25 Gwh.[24]

8.2.3 Wind Power

Pakistan is blessed with tremendous wind resource. Pakistan is developing wind power plants in Jhimpir, Gharo, Keti Bandar and Bin Qasim in Sindh. The government of Pakistan is developing wind power energy sources due to problems supplying energy to the southern coastal regions of Sindh and Balochistan. Another area with potential is Swat which shows good wind conditions.

The Chagai District in Balochistan has good potential for wind power in the Nukundi area near the Afghan/Iran Border, with wind speeds often 12.5% higher than the average required for energy generation.

Based on analysis of satellite data for the period 2000-2010 and existing ground data, initial results indicate good wind regime in the country as shown in **Figure 8.3**.

[24] *Energy, Table 3: Electricity Generation through renewable resources, Pakistan Economic Survey 2015-16*

Figure 8.3: Wind map of Pakistan

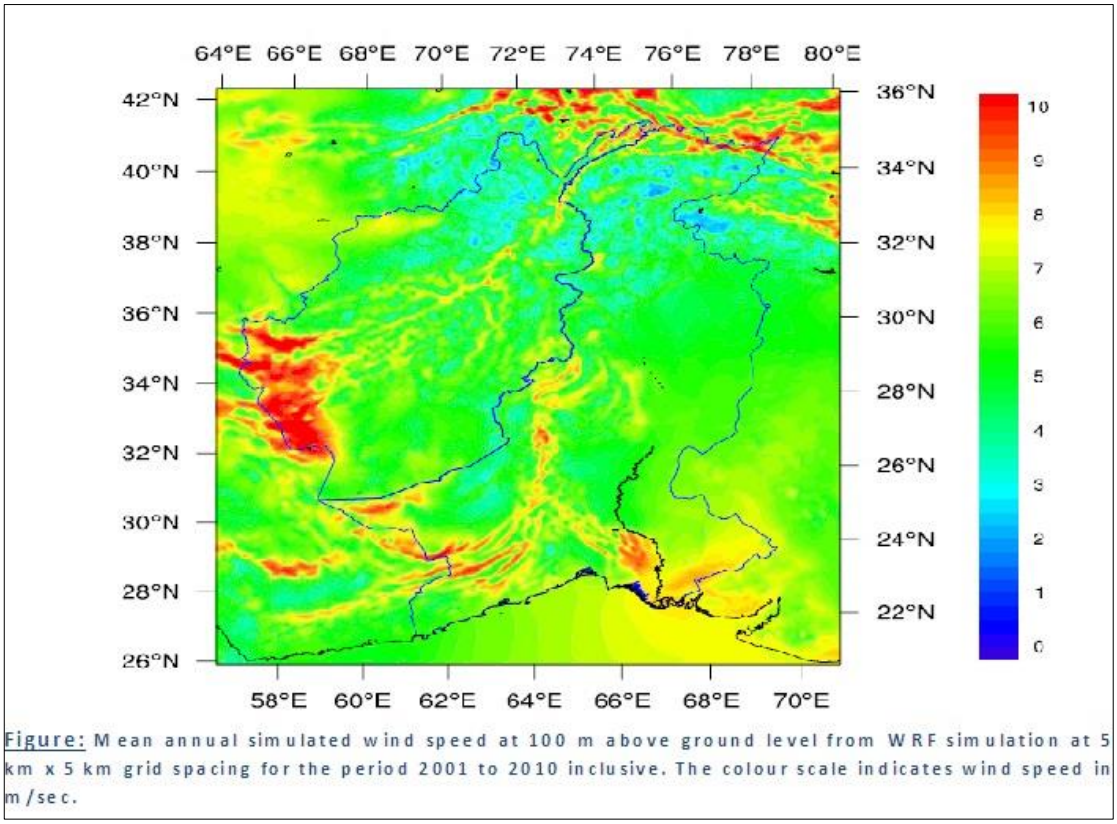


Figure: Mean annual simulated wind speed at 100 m above ground level from WRF simulation at 5 km x 5 km grid spacing for the period 2001 to 2010 inclusive. The colour scale indicates wind speed in m/sec.

During 2015, five wind power projects having a total installed capacity of 256 MW generated electricity of 457 Gwh.

Table 8.1: Electricity generation through Wind Power Plant

S. No	Name of Project	Capacity (MW)	Generation (Gwh)
1	Fauji Fertilizer Company (FFC) Energy Ltd (TGF)	50	139
2	Zorlu Energy	56	156
3	Three Gorges First Wind Energy - I	50	80
4	Foundation Wind Energy - I	50	56
5	Foundation Wind Energy - II	50	26
	Total	**256**	**457**

Source: *Energy, Table 3: Electricity through Renewable Resources, Pakistan Economic Survey 2015-16*

8.2.4 Bio Engineering

During 2015, three bagasse co-generation plants having a total installed capacity of 82 MW generated electricity of 319 Gwh.

Table 8.2: Electricity generated through Bagasse Co-generation

Sr. #	Name of Project	Capacity (MW	Generation (Gwh)
1	M/s JDW Sugar Mills (Unit-II) Rahim Yar Khan	26	163
2	M/s JDW Sugar Mills (Unit-III) Ghotiki	26	124
3	M/s RYK Mills Ltd. Rahim Yar Khan	30	32
	Total	**82**	**319**

***Source**: Alternative Energy Development Board (AEDB)*

8.2.5 Tidal Power

Tidal power has not yet been operational in Pakistan compared to other renewable energy sources, but in the near future, it may play a key role. The coastline of Pakistan, which is about 1,045 km-long with dominant features, is the best resource for harnessing tidal energy.

In Sindh, two sites, creek system of Indus delta of 170 km and two to five meters tidal heights at the Korangi Creek, are available to exploit the tidal energy. Sonmiani Beach and Kalamat are also good prospects of tidal energy in Balochistan

Environmental legislation &Institutional Framework

9 Environmental legislation &Institutional Framework

The enactment of comprehensive legislation on the environment, covering multiple areas of concern, is an ongoing phenomenon in Pakistan.

After the enactment of Pakistan Environmental Protection Act, 1997, the authorities or agencies responsible for catering environmental problems were not only empowered but also were given the regulatory framework both encompassing their power and functions at provincial as well as at federal levels. The basic legislative and institutional framework for the protection of the environment in the country is now in place.

Table 9.1: Timeline of institutionalization of Climate Change in Pakistan

Brief History of Institutionalization of Climate Change in Pakistan		
Year	**Accomplishment**	**Purpose and/or Function**
1974	Environment and Urban Affairs Division establishment at the Federal Level	Follow up to Stockholm Declaration June 1972
1983	Pakistan Environmental Protection Ordinance enacted	First comprehensive environment-specific legislation
1989	Environment and Urban Affairs Division upgraded to Federal Ministry of Environment, Forestry and Wildlife	
1991-1993	National Conservation Strategy Prepared	It improved the broad framework for addressing environmental Challenges
	National Environmental Quality Standards adopted in 1993	
1995	Cabinet Committee on Climate Change established	Acted as policy coordination forum for climate change
1997	Pakistan Environmental Protection Act enacted	The first environmental act of the country
2002	Global Centre for Impact Studies on Climate Change established	This research centre on climate change functioned for 10 years as a development project
2004-2005	Prime Minister Committee on Climate Change Convenes National Environment Policy	The Committee comprises of Prime Minister, Minister of Water and Power, Food and Agriculture, Science and Technology, Environment, Planning Commission, Special Advisor to the Prime Minister
2006	National Energy Conservation Policy, National Renewable Energy Policy, Clean Development Mechanism, National Operational Strategy	
2010	18th Amendment to the 1973 Constitution	Devolution of power to provinces
2011	Ministry of Environment ceases to exist	Functions transferred to the Planning Commission
	New Federal Ministry of Disaster Management	

Brief History of Institutionalization of Climate Change in Pakistan		
Year	**Accomplishment**	**Purpose and/or Function**
2012	Ministry of Disaster Management renamed to Ministry of Climate Change	Elevate climate change issue to a cabinet-level portfolio
	National Climate Change Policy approved by Federal Cabinet	A dedicated policy on climate change
	Punjab and Baluchistan Environmental Protection Act prepared and enacted	Deals with the environmental cases; 2013 decision prioritizes environmental cases in the high court
	"Green Benches" established in all High Courts and Supreme Court of Pakistan by the Chief Justice of Pakistan	
	National Disaster Management Plan approved	
	National Sustainable Development Strategy	
2013	Ministry of Climate Change down-graded to Division of Climate Change	
	Global Centre for Impact Studies on Climate Change granted autonomous status	National Disaster Risk Reduction Policy approved
	National Disaster Risk Reduction Policy approved	Serves as the secretariat for the Prime Minister Committee through "GCICC Act 2013."
2014	Framework for Implementation of Climate Change Policy adopted	
2015	Division of Climate Change upgraded to the Ministry of Climate Change	Federal Focal Ministry on all climate change related issues

***Source**: ADB-Climate Change Profile of Pakistan*

During 2010, the Ministry of Environment was devolved to the provinces under the 18th Amendment to the Constitution. Subsequently, in 2011, a new Ministry of Disaster Management was set up, which was later renamed to become Ministry of Climate Change in 2012. This ministry saw demotion to a division with a budget slashed, and then up-gradation again in subsequent years. Today, the environment is under provincial governments, while climate change remains a federal subject.

Unfortunately, actions and implementations by the government institutions were not as swift as the changes in status had been. Lack of political will or eagerness and fickle policy focus inflicted the progress. Though climate change and the environment has been institutionalized, the evolution of acceptance of the issue has taken too long. Like many other departments, the government's approach has been patchy, resting mostly on ad hoc reaction. In short, there has been little long-term strategizing.

At present, climate change is largely represented by the government's disaster risk management arrangements. National Disaster Management Authority deals with environment and climate-related issues whereas the Provincial Disaster Management Authority and District Disaster Management Authority are the provincial and district level bodies with interrelated objectives. Even though the National Disaster Management Authority has had strong political support, it too suffers from a lack of funds, capacity and research.

As for the policies, the National Climate Change Policy (2012) is the main policy framework for climate change in Pakistan, which was eventually launched in 2013. This is the first comprehensive policy that addressed the challenges the country faces now and in future due to climate change. The focus of the policy is on both adaptive and mitigation strategies to combat the adverse effects of climate change but prioritize adaptation measures.

9.1 Legislation and Institutional Responses to Environmental Concerns

The 18th Constitutional Amendment has empowered provincial EPAs to take care of most of the environmental issues in the provinces, while the resource-constrained Pak-EPA's main responsibilities have been limited to assisting provincial governments in the formulation of rules and regulations under PEPA 1997.

Provincial EPAs have been created in Punjab, Sindh, Khyber Pakhtunkhwa, Baluchistan, Gilgit Baltistan, and Azad Jammu and Kashmir. Similarly, Provincial Environmental Tribunals has been established.

9.2 Environmental Policies

9.2.1 National Environmental Policy 2005

The National Environment Policy provides an overarching framework for addressing the environmental issues facing Pakistan, particular pollution of freshwater bodies and coastal waters, air pollution, lack of proper waste management, deforestation, loss of biodiversity, desertification, natural disasters and climate change. It also gives directions for addressing the cross-sectoral issues as well as the underlying causes of environmental degradation and meeting international obligations.

It is mentioned in the National Environment Policy aims to protect, conserve and restore Pakistan's environment in order to improve the quality of life of citizens through sustainable development.

9.2.2 National Drinking Water Policy 2009

The Policy aims to improve the quality of life of the people of Pakistan by reducing the incidence of death and illness caused by water-borne diseases. Toward this end, the Policy provides specific guidelines[68] for increasing access to safe drinking water, protection and conservation of surface and groundwater resources, water treatment and safety, appropriate technologies and standardization, community participation, public awareness, capacity development, public-private partnership, research and development, emergency preparedness and response and coordinated planning and implementation.

The policy places special emphasis on the establishment of new drinking water systems, rehabilitation and up-gradation of existing water supply systems, sustainability of water supply infrastructure, water conservation, water quality improvement, water treatment and drinking water sector management information system.

The policy also suggests various legislative measures to ensure its effective implementation, including enforcement of the National Drinking Water Quality

Standards[69]. It stipulates that the respective tiers of the government will devise strategies and action plans in pursuit of the policy.

9.2.3 National Climate Change Policy 2012

The National Climate Change Policy has been translated into a Climate Change Policy (CCP) implementation framework for each one related to adaptation and mitigation separately.

The Policy provides a framework for addressing the issues that Pakistan faces or will face in future due to the changing climate. In view of Pakistan's high vulnerability to the adverse impacts of climate change, in particular, extreme events, adaptation effort is the focus of this policy document. The vulnerabilities of various sectors to climate change have been highlighted and appropriate adaptation measures spelt out.

Notwithstanding the fact that Pakistan's contribution to global greenhouse gas (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, forestry, agriculture and livestock. Furthermore, appropriate measures relating to disaster preparedness, capacity building, institutional strengthening; technology transfer; introduction of the climate change issue in higher education curricula. The policy thus provides a comprehensive framework for the development of Action Plans for national efforts on adaptation and mitigation.

9.3 Environmental Legislation

9.3.1 Legislation

Prior to the promulgation of the Pakistan Environmental Protection Act (PEP -Act) 1997, Pakistan had some laws containing provisions for environmental protection. These laws dealt with land use, water quality, air quality, noise, toxic and hazardous substances, solid waste and effluents, marine and fisheries, forest conservation, mineral development, energy, public health, etc. They were not effective, as punishment for violations was mild and easy to circumvent. The laws included:

- The Pakistan Penal Code, 1860
- The Canal Drainage Act, 1873
- The Punjab Local Government Ordinance, 1979
- The Motor Vehicles Ordinance, 1965; and The Motor Vehicles Rules, 1969
- The Factories Act, 1934
- The West Pakistan Fisheries Ordinance, 1961
- The Forests Act, 1927
- The Boilers Act, 1923
- The Pakistan Petroleum (Exploration and Production) Rules 1986
- The Antiquities Act, 1975
- The West Pakistan Epidemic Diseases Act, 1959, etc.

9.3.2 Provincial Laws

After the 18th Amendment to the constitution of Pakistan, all the Provincial EPAs have promulgated their own Environmental Protection Acts as follows:

- AJK EPA Environmental Protection Act, 2000
- AJK EPA (Review of IEE/EIA) Regulation, 2009
- Baluchistan Environmental Protection Act,2012
- Punjab Environmental Protection Act, 1997, (amended 2012)
- Khyber Pakhtunkhwa Environmental Protection Act, 2014
- Sindh EPA Environmental Protection Act, 2014
- Sindh Environmental Protection Agency (Review of IEE/EIA) Regulations, 2014
- Gilgit-Baltistan Environmental Protection Act, 2015

10 Conclusion

The state of the environment normally relates to an analysis of trends in the environment of a particular place. This analysis encompasses aspects such as quality of drinking and surface water, air pollution, land degradation, land use which keeps on changing with time. The rapid urbanization and motorization make these changes even more severe.

Aspirations for social mobility and search for better opportunities have already turned Pakistan into the second-most rapidly urbanizing country of South Asia with city dwellers accounting for 36 per cent of the total population. In coming years this trend is set to grow further, resulting in a sizeable vibrant urban middle class despite innumerable economic, social and environmental pressures in the already dense urban areas.

The Ministry of Climate Change undertakes serious effort to ensure implementation of multilateral environment agreements of which Pakistan is a signatory.

The land use analysis shows that there is very small and insignificant variation in land use data for the last 16 years. There is no significant improvement in land use with respect to agriculture and forest cover.

The current forest cover of Pakistan is extremely inadequate when considering exposure of the country to future climatic threats. Considerable efforts are in hand for the revival of forestry, aiming to expand the forest cover through mega tree plantation programmes and strengthening the regulatory and forest protection policy mechanism. The Khyber Pakhtunkhwa Province's afforestation programme and the Green Pakistan Programme are other noteworthy examples of the country's commitment.

Based on available information (which represents a partial inventory of possible emission sources), the road transport sector is responsible for 85% of the particulate matter of fewer than 2.5 microns ($PM_{2.5}$) total emissions and 72% of the particulate matter of fewer than 10 microns (PM_{10}) emissions.

Transboundary air pollutants also affect the cities in Pakistan, particularly due to secondary aerosols during winter. Such events also cause marked reductions in visibility, disrupted transportation, smog formation and increased injury and death.

The main factor behind worsening water availability and food security situation in the country is exponential population growth. In addition, climate change is causing recurrence of extreme events, by which frequent flooding and droughts are confronted.

The per capita water availability in Pakistan from 1955 to vision 2025 is from 2,490 to 837 cubic metre. Pakistan is moving from a water-stressed region to a water-scarce region and is continuously approaching the low-level limits of its water resources.

A study on the water quality status of major cities of Pakistan 2015-16 was conducted by Pakistan Council of Research in Water Resources. The overall water quality results of the country show that out of 369 sources, 114 (31%) sources were found safe whereas 255 (69% sources were unsafe when compared with National Standards for Drinking Water Quality.

The report has highlighted the difficulty in obtaining reliable data on the environment. The limited air quality data available for Pakistani cities makes it quite difficult to provide a conclusive remark on the major pollutants of concern in the country.

The Annual National Report on Environment has highlighted a wide range of Pakistan's environmental challenges and focuses on the set of issues of particular concern in the context of climate change and sustainable development.

The report helps policymakers to make informed decisions. The report has highlighted legislators to undertake necessary legislation to protect public health and to save natural resources from pollution.

Pak EPA hopes that the report may be of use to policymakers, researchers, consultants, academia, students, print and electronic media as well as general public interested to know about the state of the environment in Pakistan.

Pak EPA is committed to producing the next edition of the Annual National Report on Environment of Pakistan which will be based on primary as well as secondary data on the environment.

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