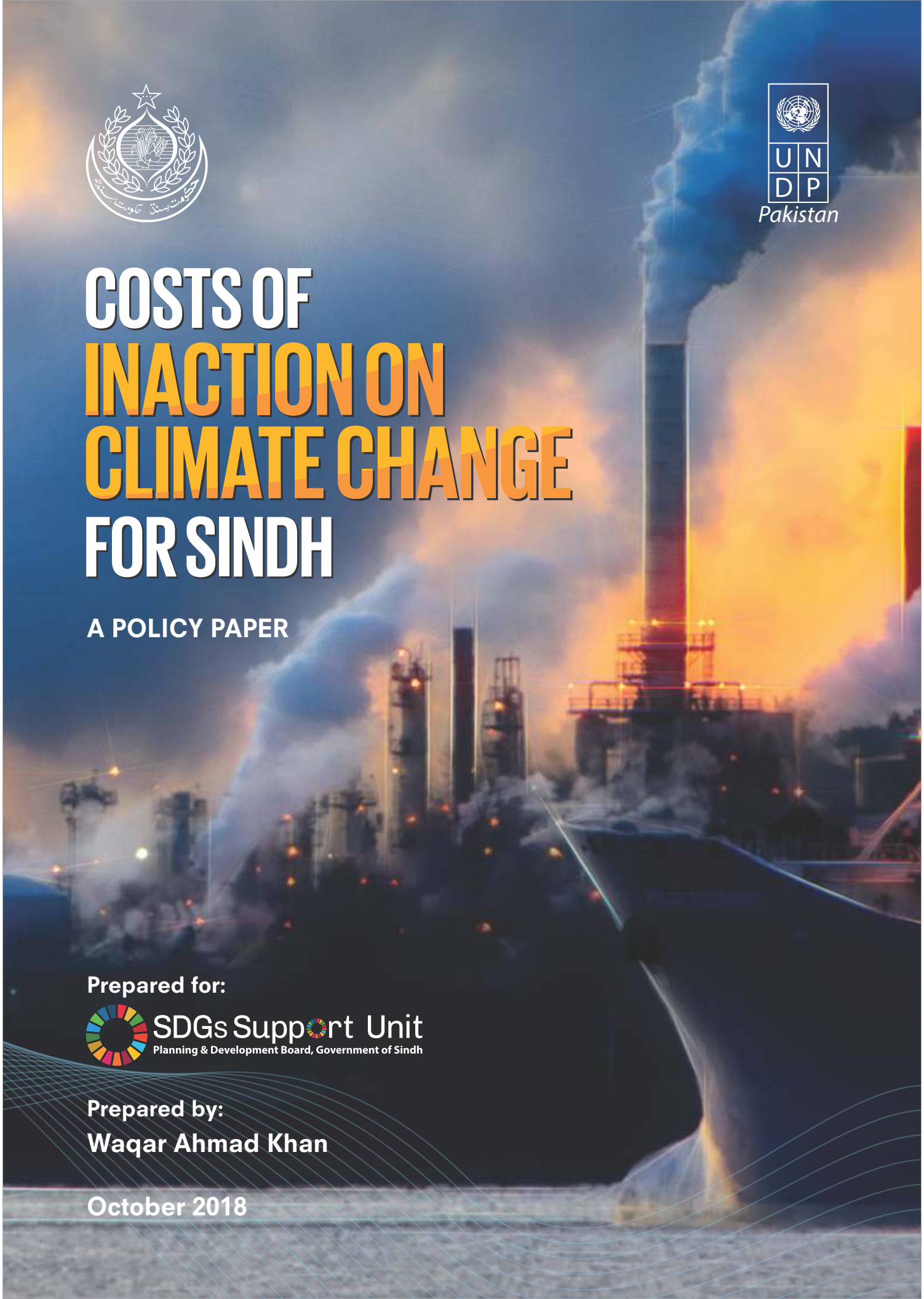


COSTS OF INACTION ON CLIMATE CHANGE FOR SINDH

A POLICY PAPER

Prepared for:

SDGs Support Unit
Planning & Development Board, Government of Sindh

Prepared by:
Waqar Ahmad Khan

October 2018

COSTS OF INACTION ON CLIMATE CHANGE FOR SINDH

A POLICY PAPER

Prepared for:

SDGs Support Unit
Planning & Development Board, Government of Sindh

Prepared by:

Waqar Ahmad Khan

October 2018

UNDP Pakistan

TABLE OF CONTENTS

EXECUTIVE SUMMARY

A recent Germanwatch report for the period 1997 to 2016 ranks Pakistan as the 7th most affected country in the world by climate change. Within Pakistan, Sindh is the worst affected province. Clear signs of the social and economic impacts of climate change can be observed in almost all sectors of the economy of Sindh.

Commissioned by UNDP Pakistan, this policy paper, titled 'Costs of Inaction on Climate Change for Sindh', was prepared for the Planning & Development Board of the Government of Sindh. The intent of the assignment is to inform policy makers of the threats posed by climate change to the province of Sindh, and also about the kind of social or economic costs that would be borne by the province if no mitigation or adaptation actions were taken.

For estimation of the costs of inaction on climate change in Sindh, the European Environment Agency's method, Sir Nicholas Stern's review (2006), UNDP's NEEDS method, and the World Bank's estimates were considered. Sir Nicholas Stern's method was chosen for this assignment for calculating the costs of inaction because of its conservativeness as it presents a higher total cost of inaction (20% of GDP) compared to the World Bank's estimate of 15% of GDP and NEEDS' estimate of 1.8 to 8.8% of GDP. For estimating costs of action, however, instead of the Stern Review's 1% of GDP figure, the IPCC's (2018) number of 2.5% of GDP was used. The European Environment Agency's method for estimating the costs of inaction, on the other hand, is only useful if climate change expenditure data is available in abundance.

Applying Stern's estimates to costs of inaction on climate change in Sindh means related risks could cost at least 20% of the province's GDP every year. On the other hand, using the IPCC (2018) number, the cost to avoid the worst impacts of climate change can be around 2.5% of Sindh's GDP each year. For calculations' purpose, Sindh's GDP which is 30% of Pakistan's GDP (Pasha 2015), i.e. US$ 91.5 billion out of Pakistan's total GDP of US$ 305 billion (2017). Calculations indicate that the cost of inaction on climate change in Sindh would be US$ 18.3 billion every year, which is 20% of the province's GDP. On the other hand, if the worst impacts of climate change are to be avoided then the government of Sindh must be willing to spend at least 2.5% of the GDP, which translates into US$ 2.29 billion every year on climate change mitigation and adaptation. Spending funds of this magnitude on climate change may be a major challenge for the province of Sindh, considering its developing state and other social challenges, including healthcare, water and sanitation, education, transportation etc. for its growing rural and urban population. Consequently, intervention in terms of financial support will be required from the federal government, as well as international donors.

A sector-wise review was also completed to assess the impacts of climate change on the various economic sectors of Sindh and to summarize mitigation and adaptation policy measures from the national and provincial climate change policies. The review also includes costs of inaction and action for the main sectors of the province's economy. A set of recommendations has been included for the Government of Sindh's consideration.

PART I

CLIMATE CHANGE IN SINDH

INTRODUCTION

Sindh is the most vulnerable climate change hotspot in Pakistan. Due to its high vulnerability, changes in average weather will add another dimension to the future growth of Sindh. Climate change has been very hard on this province. The social and economic well being of Sindh has been affected by floods, droughts, extreme heat events, and effects of sea-level rise. People of rural Sindh are the worst affected where reliance on agriculture and livestock is the main economic driver that has been hit by the repeated droughts and floods in recent years. The adverse effects of climate change will potentially impact all sectors of the economy, which in turn can sabotage the achievement of key Sustainable Development Goals (SDGs) by 2030.

To support the Planning and Development Board (P&DB) of the Government of Sindh, through the Sindh SDG Support unit, UNDP commissioned the preparation of this policy paper. The intent behind this assignment is to support P&DB's Sindh Growth Strategy, which will inform the province's development strategies in the long run. This will also complement UNDP's effort of integrating the SDGs into Sindh's planning and budgeting process.

For arriving at the social and economic costs of inaction on climate change for the province of Sindh, which is the ultimate objective of this study, existing information on the subject will be analysed. Since there is no one standard, internationally acceptable way of estimating costs of inaction on climate change available, various proposed methodologies will be considered for this assignment, including the European Environment Agency's (EEA) method, the UNDP National Economy and Environment Development Study (NEEDS) method, the International Panel on Climate Change (IPCC) estimates and the Sir Nicholas Stern's (2006) method.

A global, as well as Sindh focused literature review will be undertaken to understand the extent of climate change related risks for the province. Additionally, a sector-wise review will also be conducted to assess the impacts of climate change on the various economic sectors of Sindh that will consider mitigation and adaptation policy measures from the national and provincial climate change policies. Based on the review, a set of recommendations will be presented at the end of the document as a quick reference for the policy makers of Sindh.

WHAT IS CLIMATE CHANGE?

In simple words, climate change, also sometimes termed as global warming, is the rise in average temperature on Earth. The change in the pattern of weather occurring over longer time scales, i.e. decades or centuries, is called climate change. The term 'climate change' also applies to weather related changes in oceans, land surfaces and ice sheets. It is also the changes, taking place over decades or longer periods of time, in the statistical properties (including averages, variability and extremes) of climate systems.

Climate change can be attributed to two main causes:

a) Natural processes, including changes in the sun's radiation, the Earth's tilt, its orbit around the sun, changing ocean currents, large volcanic eruptions or internal variability in the climate system, and/or
b) Man-made changes in the composition of the atmosphere or land use, e.g. greenhouse gas (GHG) emissions from industrial and agricultural operations, combustion of fossil

fuels and deforestation over a large scale. A vast majority of scientists claim that climate change is due primarily to the human use of fossil fuels, which release carbon dioxide and other greenhouse gases into the air. These gases trap heat within the atmosphere, resulting in a range of adverse effects on ecosystems, including rising sea levels, severe weather events, and droughts.

Weather, on the other hand, is the state of the atmosphere in terms of its temperature, wind, rainfall, humidity and other natural phenomena, over hours, days or weeks, that are caused by changes in oceans, land surfaces and ice sheets.

The Greenhouse Effect

The Sun emits solar energy, which is received by Earth. Some of this solar energy is reflected directly back to space by the atmosphere, water surfaces, land, ice and clouds. The solar energy absorbed by Earth is eventually returned to space in the form of infrared radiation. It interacts with the whole climate system, i.e. atmosphere, oceans, ice sheets and land surfaces, during this process. Certain gases present in the atmosphere absorb infrared radiation going upwards from Earth's surface and re-radiate it in all directions, including back downwards. This phenomenon results in the locking of infrared energy within the Earth's atmosphere as this energy cannot now escape to space. This is referred to as the 'greenhouse effect and the gases that cause this are called greenhouse gases. The most important greenhouse gases are water vapour, CO2 and methane.

The atmospheric concentration of CO2 remained around 300 parts per million between the advent of human civilization roughly 10,000 years ago and 1900. Over the past 100 or so years, this level has gone up to over 400 ppm, resulting in rising average temperatures on Earth.

There is now evidence available that human activities have contributed immensely to the emissions of CO2 and other greenhouse gases over the past 100 to 150 years that may be the primary cause of the rise in temperature and other adverse impacts of climate change globally. Human activities resulting in GHG emissions include:

- **Burning of fossil fuels.** This includes burning of oil, gas and coal that produces CO2 and nitrous oxide.
- **Deforestation.** Trees absorb CO2 and release oxygen to regulate the climate. When deforestation occurs, CO2 that is stored in trees is released back to the atmosphere.
- **Livestock.** During and after digestion livestock produce considerable amounts of methane, hence contributing to GHG emissions.
- **Nitrogen containing fertilizers** result in nitrous oxide emissions.
- **Waste management practices.** Incineration and decomposition (digestion) of waste in landfills and dumps release CO2 and methane.
- **Industry.** Emissions from various industrial activities contribute to GHGs.
- **Chlorofluorocarbons (CFCs).** Also GHGs, these are synthetic compounds that are used as refrigerants, in degreasing solvents and in aerosol sprays etc. They have the potential to destroy the ozone layer.

GLOBAL EFFECTS OF CLIMATE CHANGE

The IPCC Working Group II (2007) reported key findings regarding projected impacts, as well as some findings on vulnerability and adaptation, in each system, sector and region for the range of unmitigated climate changes. The IPCC's key findings for main sectors are presented here.

Freshwater Resources

- By around 2050, annual average river runoff and water availability are projected to decrease by 10-30% over some dry regions at mid-latitudes and in some dry tropics, some of which are presently water-stressed areas.
- Drought-affected areas will likely increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk.
- In the course of the century, water supplies stored in glaciers and snow cover are projected to decline, reducing water availability in regions supplied by meltwater from major mountain ranges, where more than one-sixth of the world population currently lives.

Ecosystems

- The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification), and other global change drivers (e.g., land-use change, pollution, over-exploitation of resources).
- Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change.
- Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increase in global average temperature exceeds 1.5-2.5 degree Celsius.
- The progressive acidification of oceans due to increasing atmospheric carbon dioxide is expected to have negative impacts on marine shell-forming organisms (e.g., corals) and their dependent species.

Food, Fibre and Forest Products

- At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1-2 degrees Celsius), which would increase the risk of hunger.
- Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes.
- Regional changes in the distribution and production of particular fish species are expected due to continued warming, with adverse effects projected for aquaculture and fisheries.

Coastal Systems and Low-lying Areas

- Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise. Increasing human-induced pressures on coastal areas will exacerbate the effect.
- Coastal wetlands including salt marshes and mangroves are projected to be negatively affected by sea-level rise especially where they are constrained on their landward side, or starved for sediment.
- Many million more people are projected to be flooded every year due to sea-level rise by 2080s. Those densely populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence, are especially at risk.
- Adaptation for coasts will be more challenging in developing countries than in developed countries due to constraints on adaptive capacity.

Industry, Settlement and Society

- The most vulnerable industries, settlements and societies are generally those in coastal and river flood plains, those whose economics are closely linked with climate-sensitive resources, and those in areas prone to extreme weather events, especially where rapid urbanization is occurring.
- Poor communities can be especially vulnerable,

in particular those concentrated in high-risk areas. They tend to have more limited adaptive capacities, and are more dependent on climate-sensitive resources such as local water and food supplies.
- Where extreme weather events become more intense and/or more frequent, the economic and social costs of those events will increase, and these increases will be substantial in the areas most directly affected. Climate change impacts spread from directly impacted areas and sectors to other areas and sectors through extensive and complex linkages.

Health

- Projected climate change-related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity, through:
  - Increase in malnutrition and consequent disorders, with implications for child growth and development;
  - Increased deaths, disease and injury due to heatwaves, floods, storms, fires and droughts;
  - The increased burden of diarrhoeal disease;
  - The increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change; and,
  - The altered spatial distribution of some infectious disease vectors.

The IPCC Working Group II (2007) has also reported more specific information for several regions of the world concerning the nature of future impacts of climate change. Below are the key projects for the continent of Asia.

- Glacier melt in the Himalayas is projected to increase flooding, and rock avalanches from destabilised slopes, and to affect water resources within the next two to three decades. This will be followed by decreased river flows as the glaciers recede.
- Freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease due to climate change which, along with population growth and increasing demand arising from higher standards of living, could adversely affect more than a billion people by the 2050s.
- Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers.
- Climate change is projected to impinge on the sustainable development of most developing countries of Asia, as it compounds the pressure on natural resources and the environment associated with rapid urbanisation, industrialisation, and economic development.
- Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle associated with global warming. Increases in coastal water temperature would exacerbate the abundance and/or toxicity of cholera in South Asia.

In October 2018, the IPCC released a special report on the impacts of global warming of 1.5°C above pre-industrial levels (IPCC 2018). The report also discuses related global greenhouse gas emissions pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Alongside the report, a Summary for Policy Makers (SPM) was also released that presents the key findings of the special report, based on the assessment of the available scientific, technical and socio-economic literature that is relevant to global warming of 1.5°C and 2°C above pre-industrial levels. Key findings included in the SPM are presented below:

- Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.
- Climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, but lower than at 2°C.
- By 2100, global mean sea level rise is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C. Sea level will continue to rise well beyond 2100, and the magnitude and rate of this rise depends on future emission pathways. A slower rate of sea level rise enables greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas.
- Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater, and coastal ecosystems

and to retain more of their services to humans.

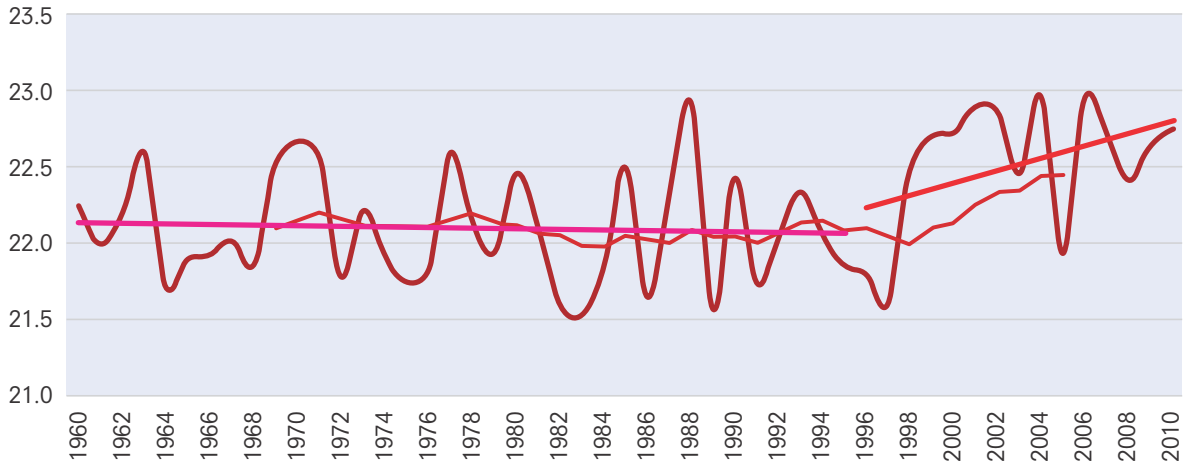
- Limiting global warming to 1.5°C compared to 2°C is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels.
- Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C.
- The avoided climate change impacts on sustainable development, eradication of poverty and reducing inequalities would be greater if global warming were limited to 1.5°C rather than 2°C, if mitigation and adaptation synergies are maximised while trade-offs are minimized.
- Limiting the risks from global warming of 1.5°C in the context of sustainable development and poverty eradication implies system transitions that can be enabled by an increase of adaptation and mitigation investments, policy instruments, the acceleration of technological innovation and behaviour changes.
- Strengthening the capacities for climate action of national and sub-national authorities, civil society, the private sector, indigenous peoples and local communities can support the implementation of ambitious actions implied by limiting global warming to 1.5°C.

PAKISTAN'S CLIMATE OVERVIEW

Pakistan has a varying climate, ranging from tropical to temperate, along with arid and semi-arid conditions, with huge diversity in temperature and precipitation. Typical sources of precipitation include the summer monsoon that occurs during July to September, and other weather disturbances occurring from December to March. 60% of the total annual precipitation in the country comes from the summer monsoon. Average annual rainfall in the arid and semi-arid areas is less than 250 millimeters (mm). On the other hand, the northern mountainous region of the country receives annual rainfall in the range of 760 to 2,000 mm. The Indus Basin in Pakistan covers the entire provinces of Punjab, Khyber Pakhtunkhwa, most of Sindh province, and the eastern part of Balochistan. The Indus Basin is further divided into upper and lower basin plains. The mean summer temperature (March-June) in the lower plains ranges from 42°C-44°C whereas the temperature range for upper plains is 23°C-49°C. The mean winter temperature (December-February) in the lower basin 14°C-20°C compared to the 2°C - 23°C in the upper plains.

Rasul et al. (2012) of Pakistan Meteorological Department analyzed data from 56 meteorological stations for various weather parameters from across Pakistan, representing all its climatic zones with uniform weighing factor allocated according to the surface features of the region. Their analysis revealed alternative cold and hot spells based on inter-annual variability of mean daily temperatures between 1960 and 1997. However, after the occurrence of the severest El~Nino in 1998 and due to failure of summer rains, four-year long drought conditions prevailed in most parts of the country. Unusual heat conditions continued to persist in the country due to loss of vegetation, deforestation, irregular rain cycles and increased

Figure 1: Area Weighted Mean Temperature of Pakistan (1960-2010)



frequency and intensity of heat waves. As presented in the figure below as time series of area weighted mean daily temperatures averaged over each year, the authors witnessed a sharp rise in temperature during the first decade of 21st century, except for the year 2005.

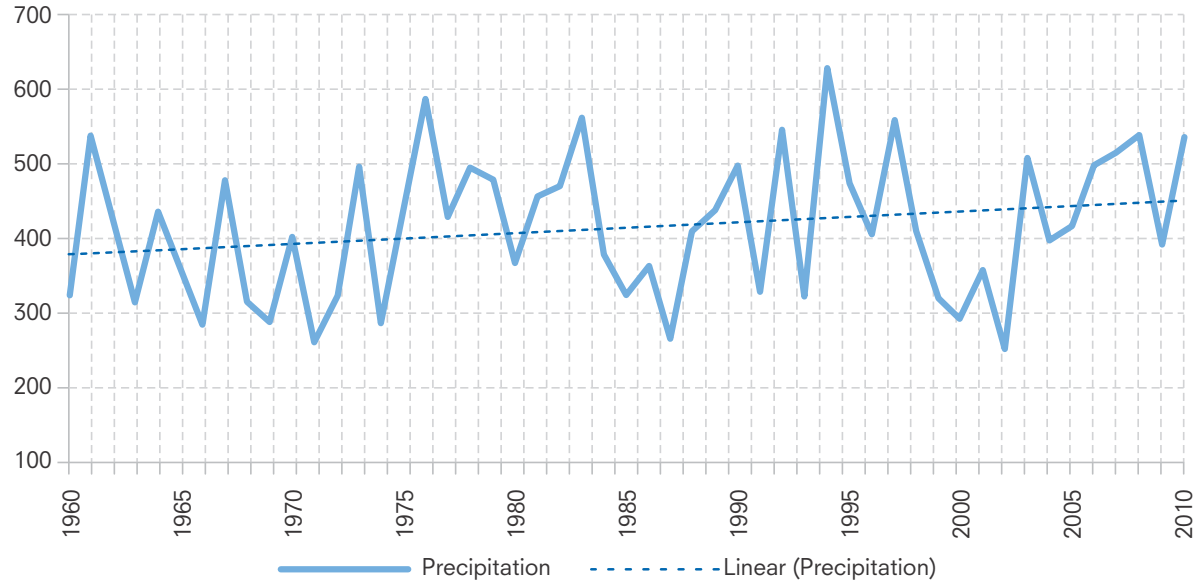
Figure: Rise in mean daily temperatures averaged over each year 1960 to 2010 (Rasul et al. 2012).

Similarly, the analysis of precipitation data from 56 meteorological stations for the period 1960 to 2010 by the authors shows that the number of drought years, falling under the trend line in the figure below, has increased in Pakistan over this time.

Figure: Time series of precipitation over Pakistan for the period 1960 to 2010 (Rasul et al. 2012)

Pakistan's high exposure and vulnerability to the adverse effects of climate change have become established facts, as shown by the several natural disasters in the recent years, especially the giant floods of 2010 and 2011. Over the years, considerable increase in the frequency and intensity of extreme weather events has been recorded. Erratic monsoon activity resulting in frequent and intense floods and droughts has become a normal occurrence.

Figure 2: Time series of precipitation over Pakistan for the period 1960 to 2010 (Rasul et al. 2012)



National Climate Change Policy (2012)

There are imminent climate change induced threats, which may lead to major survival apprehensions for Pakistan. Main areas of concern include water security, food security, and energy security. In recognition of these threats, as reactive measures, as well as to ensure adaptation and sustainability to counter climate change as proactive measures, the National Climate Change Policy (NCCP) was unveiled in 2012, with a focus on adaptation effort for climate change in Pakistan.

As per the National Climate Change Policy (2012), key climate change threats that Pakistan is facing include:

- Recession of the Hindu Kush-Karakoram-Himalayan glaciers;
- More frequent and intense floods resulting in the siltation of major dams;
- Enhanced heat and water-stressed conditions triggered by rising temperatures;
- Decrease is forest cover and migration of affected plant species;
- Increased intrusion of saline water in the Indus delta;
- Projected sea level rise and increased cyclonic activity;
- Increased health risks to humans and climate change induced migration.

The Policy covers measures for addressing issues related to climate change in various sectors, including water, agriculture, forestry, coastal areas, biodiversity and other ecosystems, transportation, and energy. It is important to note that Pakistan's contribution to global GHG

emissions is very small, but due to its high vulnerability to the effects of climate change and its responsibility to the global community in fighting climate change, the current policy framework has been developed which will provide support in the development and implementation of mitigation efforts and action plans for combating climate change.

With the main goal of ensuring that "climate change is mainstreamed in the economically and socially vulnerable sectors of the economy and to steer Pakistan towards climate resilient development", the National Climate Change Policy (2012) presents the following main objectives:

a. To pursue sustained economic growth by appropriately addressing the challenges of climate change;
b. To integrate climate change policy with other inter-related national policies;
c. To focus on pro-poor gender sensitive adaptation while also promoting mitigation to the extent possible in a cost-effective manner;
d. To ensure water security, food security and energy security of the country in the face of the challenges posed by climate change;
e. To minimize the risk arising from the expected increase in frequency and intensity of extreme weather events such as floods, droughts and tropical storms;
f. To strengthen inter-ministerial decision making and coordination mechanisms on climate change;
g. To facilitate effective use of the opportunities, particularly financial, available both nationally and internationally;
h. To foster the development of appropriate economic incentives to encourage public and private sector investment in adaptation measures;
i. To enhance the awareness, skill and institutional capacity of relevant stakeholders;
j. To promote conservation of natural resources and long-term sustainability.

The NCCP (2012) is a guiding document on climate change related mitigation and adaptation for Pakistan. To ensure that climate resilient development continues in Pakistan, as highlighted in the Vision 2025 and other strategy documents, it is essential that relevant input from the NCCP (2012) be integrated within the planning and implementation processes on all fronts.

SINDH'S CLIMATE OVERVIEW

The province of Sindh is part of the lower Indus basin, on the Indus River delta, predominantly subtropical, in southeastern Pakistan. Sindh experiences hot summers and cold winters. For summer temperatures (May – August) to go above 46 °C is a normal occurrence, with average temperature staying at around 35 °C. During December and January, the average cold temperature is 2 °C. For precipitation, Sindh receives an average of only 180mm of rainfall. However, water shortages in the province are usually, to an extent, balanced by the spring and summer ice melt in the Himalayas and the monsoon rains in the rest of Pakistan, north of Sindh, that results in the heavy flows in the Indus a few times a year. Considering just the rainfall, which is around 10% of the total evaporation, the entire Sindh could have very easily been a desert like Thar and Kohistan. The province is mostly arid with limited vegetation, except for the Indus River valley, which has an irrigation system in place. Cotton, rice, sugarcane and wheat are the main crops of Sindh. Fruit-bearing trees of Sindh include mango, banana, date palm, guava and orange.

Climate change has been very hard on Sindh. Floods, droughts, extreme heat events, and effects of sea-level rise have all affected the social and economic well-being of Sindh. People of rural Sindh are the worst affected where reliance on agriculture and livestock is the main economic driver that has been hit by the repeated droughts and floods recent years.

According to the World Bank's recently released book "South Asia: The Impact of Temperature and Precipitation Changes on Living Standards", Sindh is the most vulnerable hotspot in Pakistan. Due to its high vulnerability, changes in average weather will add another dimension to the future growth of Sindh. Hyderabad district emerges as the top hotspot in Sindh, followed by the districts of Mirpur Khas and Sukkur. The World Bank also estimates that 15% of the total GDP of Sindh is lost to environmental degradation and climate change. This estimate is much higher than the national figures.

Disturbance in the monsoon (start/end and

number of days) and inter-annual variability, i.e. repeated drought and flood events in Pakistan due to climate change is posing serious challenges for sustainable crop production. The hydrological system of Pakistan upstream and downstream is highly connected. Heavy rainfall or glacier melt in the north immediately runs down to the south and results in flooding of the plains of Sindh, destroying field crops and livelihoods for millions of people. Similarly, shortage of rainfall in the north affects water availability in the south resulting in intense heat and disturbed supply-demand for water.

Sindh Climate Change Policy (Draft 2018)

The Sindh Climate Change Policy (SCCP) is currently in development and was available as a draft during the preparation of this policy paper. The SCCP recognizes that "Sindh is particularly affected with various manifestations of Climate Change such as floods, heat waves, sea water encroachment, air quality deterioration and drought. These risks impacting the health and economic well being of the population and are resulting in social conflicts as well. Climate change repercussions in Sindh merit attention, since it is the country's most urbanized province with an estimated population of nearly 56 million people, 49.5 percent of whom live in urban areas".

The goal of SCCP is to "ensure that climate action is mainstreamed in the development planning, particularly the economically and socially vulnerable sectors of the economy, and to steer Sindh towards economic growth and climate compatible development". The policy presents the following objectives:

a. Formulate a nuanced province specific policy that is in line with the National Climate Change Policy.
b. Enhance awareness of the impacts of climate change among all stakeholders for necessary appropriate measures to combat and minimize these impacts.
c. Embed the concepts of Climate Compatible Development and Sustainable Development Goals in the climate change policy in order to improve the understanding of the policy makers.
d. Link the province's needs to the National Climate Change Policy Framework for implementation.
e. Enhance interdepartmental coordination and cooperation for effective climate action.
f. Ensure water, food, and energy security for Sindh province in the face of a changing climate.
g. Address climate change risks particularly those arising from climate-induced disasters.
h. Ensure interests of vulnerable groups and that gender aspects are adequately addressed in climate development strategies and planning.
i. Develop bases to secure sufficient financial and technological support, and strengthen institutional and human resource capacities to achieve policy objectives; and to be able to tap financial and technological opportunities available internationally.

The SCCP highlights that for Sindh, the phenomenon of shorter winters and longer summers due to increase in maximum and minimum temperature may result in the following implications:

- Late onset and early ending winter will reduce the length of the growing season for crops which will complete their biological life cycle quickly causing reduction in the economic yields as the plants will gain accelerated maturity without reaching proper height and size.
- Early end of winter means that temperatures will start rising in February when wheat crop reaches the grain formation stage. Sharp rise in temperature will cause forced maturity of the grains. Neither the grains will gain proper size and weight nor accumulate optimum starch contents, hence reducing grain yield.
- Banana is another major crop of the Indus Delta in which pollination will be affected due to early end of winter and high spring temperatures. Thermal stress would result in poor fruit set and dwarf yields.
- Such adverse effects are already visible and there is a dire need for adaptation strategies by introduction of crop varieties, which require shorter span and bear the stress conditions.

The SCCP believes that embracing mitigation and adaptation strategies can abridge climate change impacts in accordance with the geographic location, terrain, availability of resources and potential natural disaster threats in that area. Incentivizing reduction and control of emissions through various market based economic forums is another way to prevent the current condition of climate from worsening.

LITERATURE REVIEW

Pakistan-Focused Literature

In the 'Summary for Policy Makers' of the 'Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change' (2007), the IPCC reports that "glacier melt in the Himalayas is projected to increase flooding and rock avalanches from destabilised slopes, and to affect water resources within the next two to three decades. This will be followed by decreased river flows as the glaciers recede".

Asian Development Bank produced a comprehensive report in 2017 titled 'Climate Change Profile of Pakistan', prepared by Qamar Uz Zaman Chaudhry. The report (i) provides a knowledge base of climate changes and impacts in Pakistan, (ii) supports the identification of climate change risks and adaptation options, and (iii) promotes the consideration of new climate technologies.

The report presents key findings of past-observed trends of climate change indicators and future projections for Pakistan. Following are some of the main points:

- During the last century, Pakistan's average temperature increased by 0.57 °C.
- Heat wave days per year increased by 31 days in the period 1980 to 2007.
- Observed sea level rise along the Karachi coast was 1.1 mm per year in the past century.
- The mean temperature rose by 0.6°C to 1.0°C over the hyper arid plains, arid coastal areas, and mountains region of Pakistan between 1960 and 2007.
- Pakistan's projected temperature increase is expected to be higher than the global average.
- The frequency of hot days and hot nights is expected to increase significantly.
- Major crop yields such as of wheat and rice are expected to decrease significantly.
- Water availability per capita is projected to decrease to an alarming level.
- A decreasing trend in rainfall over the Lower Indus Basin.

The author has also extracted information from a Global Change Impact Study Centre (2007) model, according to which the temperature increase in Pakistan will be as high as 4.38 °C by 2080.

The United Nations Framework Convention on Climate Change (UNFCCC) published its report in 2007 titled "Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries". According to the report, glaciers in the Himalayas are melting due to global warming. This presents increased risk of flooding, erosion, and mudslides in Nepal, Bangladesh, Pakistan and northern India during the wet season. This phenomenon intensifies when the melting of snow occurs during the already wet monsoon season, which translates into increased risk of flood related disasters in Himalayan catchments. Global warming could lead to the disappearance of glaciers in the long term. "Throughout Asia one billion people could face water shortage leading to drought and land degradation by the 2050s."

Zahid, M. and G. Rasul published a paper in the Pakistan Journal of Meteorology in 2013, titled "Impact of South Asian High Variability on Monsoon Precipitation in Pakistan". The authors state that the south Asian high variability is known to have significant contribution in the success and failure of summer monsoon of Pakistan situated within South Asia. They conclude that "the strength and oscillation of South Asian high variability and summer monsoon precipitation in Pakistan are strongly inter-reliant upon each other. It is anticipated that climate change can lead the country towards extreme droughts and extreme flooding."

UNESCO and ADB published a paper in the Pakistan Journal of Meteorology in 2012, titled, "Messages for Decision & Policy Makers and Water Managers on Adaptation to Climate Change through Integrated Water Resources Management IWRM at River Basin Level". The paper notes that the type, frequency and intensity of extreme events like tropical cyclones, floods, droughts and heavy precipitation events are expected to rise even with relatively small average temperature increase as a result of global warming. The paper outlines 11 key messages for decision and policy makers and water managers. These include:

1. Adapting to uncertainty is the challenge. There are huge uncertainties associated with changes due to climate. Adapting to these inevitable uncertainties is very important.
2. Climate change impacts on water at the river

basis level. The variability of change has a direct impact on the water cycle at the river basin level. Climate change impacts are compounded by the risks associated with terrestrial and aquatic ecosystems, particularly the availability of agricultural, municipal and fresh water; the quality of drinking water; and flood and drought events.

3. Adaptation must involve the entire river basin and that includes land use and urban planning. Adaptation strategies must be taken into consideration at the earliest stages of land use, irrigation and urban planning.
4. IWRM is a practical tool for adaptive. IWRM 'Integrated water resource management' is an existing global concept to achieve sustainable water and land management. It provides a systematic approach to planning and management covering a wide range of processes and actions, and include stakeholders' participation in its decision making process.
5. Strengthening governance at national and at river basin level is key. Ensuring that coordination mechanisms functions smoothly and correctly requires that organizations at both national and river interface with each other and are linked to an existing institutional management and decision-making roles of local authorities.
6. Strengthen dialogue to encompass scientific findings.
7. Integrated Flood and Drought Management is leading the way.
8. Recognize the difference between developed and developing countries.
9. Operations should work with existing infrastructure. The management of existing infrastructure, and its flexible operation, is an important factor in ensuring the success of adaptation, especially in countries with limited financial resources.
10. Identify hotspots and vulnerable areas. This allows us to focus on appropriate actions under limited resources when dealing with and responding to climate change.
11. Climate change can possibly lead to conflict. Lesser water security may translate into a greater incidence of conflict. Therefore it is imperative to have a deeper understanding of the phenomenon and its associated socio-political linkages.

Sindh-Focused Literature

Pakistan Meteorological Department, Islamabad, prepared a technical report in 2012 titled "Climate Change in Pakistan, Focused on Sindh Province" with Dr. Ghulam Rasul and others as authors. The report attempted to link global changes to the dynamics of Pakistan's climate system including the future climate projections at the finest temporal and spatial resolutions for temperature and precipitation. The report highlights that variability in monsoon rains will result in large floods and extended droughts, creating great threat for Sindh's water, food, and energy security. Climate change presents increased risks to the coastal areas and the Indus deltaic region due to sea-level rise, coastal erosion, saline seawater intrusion and increasing cyclonic activity in the Arabian Sea. The report further highlights that the Indus Delta is located in the intense heat zone and any rise in temperature would impact human health due to heat stokes, diarrhoea, cholera, vector borne diseases; and human settlements due to frequent floods, droughts and cyclones. The report concludes that "in this region, temperature is likely to increase by 4 °C till 2100 and rainfall is going to be highly variable on temporal and spatial scale. The deltaic region would not only be affected by the local weather conditions but also by weather activities in upstream Indus and over the neighbouring sea in the south due to climate change".

In 2018 the World Bank published a book titled "South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards", authored by Muthukumara Mani et al. The book notes that changes in average weather are projected to have overall negative impacts on living standards Bangladesh, India, Pakistan and Sri Lanka. Change in average weather will also reduce growth of GDP per capita in these countries. More than 800 million people, almost half of South Asia's population, currently live in areas that are projected to become moderate to severe hotspots by 2050. In Pakistan, Sindh emerges as the most vulnerable hotspot, followed by Punjab. Hyderabad district emerges as the top hotspot followed by Mirpur Khan and Sukker.

In a study published in the Pakistan Journal of Meteorology "Socio-Economic Impacts of Heat Waves in Sindh" (Hanif, U, 2017) an analysis of mortality and morbidity in Karachi during the heat waves of 2015 has been done in the backdrop of the socio-economic status of the affected citizens. According to the study, majority of the victims were poor who had to earn their living despite the

looming threat of heat strokes and health warnings. Most of the casualties occur due to extended exposure to sun, non-ventilated housing, dehydration due to fasting, prolong power outages and discontinuity of water supplies. The study further notes that during the June 2015 heat wave event, the maximum temperature was recorded as 44.8°C, however, on the peak heat wave day of June 20, the heat index reached as high as 66°C due to reduced wind speed and air pressure along with elevated humidity.

Ahmad, S. A. et al, (2014) report in the paper " Principal Component Analysis to Explore Climatic Variability that Facilitates the Emergence of Dengue Outbreak in Karachi", published in the Pakistan Journal of Meteorology. In the study the authors conclude that "relative humidity and minimum temperature have some impact on the occurrence of dengue fever. If the minimum temperature recorded increase from previous day, the number of dengue cases is expected to increase in next days."

Another paper, published in the Pakistan Journal of Meteorology in 2012 titled "Vulnerability of the Indus Delta to Climate Change in Pakistan", with Rasul, G. as the lead author, describes the current and future impact of climate change in the Indus Delta. The paper notes that "the Indus Delta is a vast track of fertile land feeding a large proportion of population with food and fibre. Although it is composed of low laying areas of the Indus irrigated plain but the changes occurring in the climatic conditions of the extreme north also directly affect through water deficit or surplus. The Himalaya-Karakoram-Hindukush region, which hosts the world's third largest ice mass after the poles, has warmed up more than 1.5°C, almost double than the remaining parts of Pakistan (0.76°C), during the last three decades. Increased frequency of torrential rains, prolonged heat waves, frequent tropical cyclones, recurring flooding and persistent drought are the phenomenal changes experienced by this deltaic region. Rapid melting of glaciers in the north is not only contributing to floods downstream rather it results into sea level rise. Resultantly, intrusion of saline water into the fertile land has been destroying fertile agricultural land." "Erratic behaviour of monsoon precipitation has resulted in degradation of rangeland and further deterioration of the already degraded cultivated land areas such as those suffering from water erosion, wind erosion, water logging, salinity etc. Future climate projections indicate that at least 5°C rise in temperature over the Indus Delta is expected by the end of the 21st Century. Due to this increase in temperature, domestic animal and crop water requirement will rise 1.5 times over the present levels." "Water availability will further decrease reducing the per capita share. Precipitation pattern is going to be highly variable. Poverty, lack of resources and low adaptive capacity of the local population of the Indus Delta to climate change has been exaggerating the vulnerabilities and posing challenges to sustainable food production."

PART II

COSTS OF INACTION ON CLIMATE CHANGE

COSTS OF INACTION ON CLIMATE CHANGE: THE CONCEPT

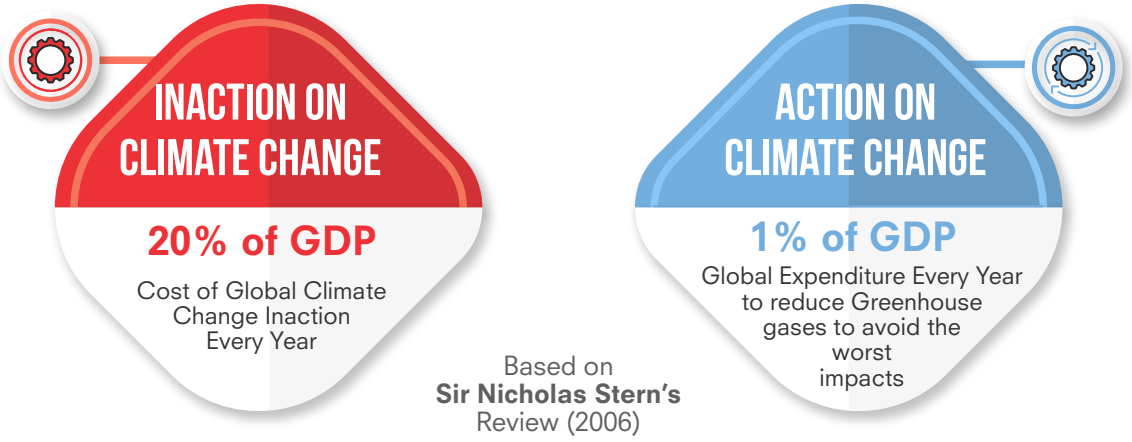
To better describe the concept of the costs of inaction on climate change, it is important to understand that social and economic costs due to climate change are unavoidable. There may be two possible cost scenarios, i.e. (1) costs of taking action to battle climate change, or (2) to continue to do business as usual without investing in climate change adaptation and/or mitigation and bear the costs of inaction in the form of deterioration of the well-being of the people and the planet. There might be a choice of picking one option based on the analysis. Which one will be more cost effective, taking action now or continue to do business as usual? While the world's understanding about the science of climate has matured over the years, debate about the economics of climate change is still wide open.

Major impacts caused by climate change are already visible in most parts of the world and are expected to become more noticeable in the future. Changes due to climate will lead to wide ranging impacts on the natural and man-made environments across different sectors and regions. This in turn will lead to economic costs of climate change, also termed as 'costs of inaction'. Understanding costs of inaction on climate change is increasingly becoming a useful tool for policy makers worldwide for designing timely policy interventions, and mitigation and adaptation measures development to deter the harmful impacts of climate change.

The Stern Review and IPCC (2018)

Sir Nicholas Stern, Head of the UK Government Economic Service and former Chief Economist at the World Bank conducted a review on the topic of costs of inaction on climate change in 2006. The review considers recent scientific evidence, the economic effects on human life and the

Figure 3: Global Cost of Inaction versus Cost of Action on Climate Change



environment, and the approaches to modelling. It concludes that it is still not too late to avoid the worst impacts of climate change, if we act now and act internationally. It finds that climate change will affect all countries, however the poorest countries will suffer earliest and most. Unaddressed climate change might raise average temperatures by over 5 °C from pre-industrial levels, which would change the physical and human geography of planet Earth. The review estimates that climate change related risks could cost at least 20% of GDP. On the other hand, reducing greenhouse gas emissions to avoid the worst impacts of climate change can be around 1% of global GDP each year. The review concludes that atmospheric levels of greenhouse gases should be limited to 450 – 550 parts per million. Stern's review also examines UK's national and international policy challenges of moving to a low-carbon global economy, including,

1. Carbon pricing, through taxation, emissions trading or regulation,
2. Technology policy, to drive the development and deployment of low-carbon and high efficiency products, and
3. Removing barriers to energy efficiency, and to inform, educate and persuade individuals about what that can do to respond to climate change.

The review suggests certain key elements that future international framework should include, such as emissions trading; technology cooperation; action to reduce deforestation; and adaptation.

IPCC Costs Of Action (2018)

The IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels (IPCC 2018) also mentions estimates of investments in the energy system. According to IPCC, "Global model pathways limiting global warming to 15°C are projected to involve the annual average investment needs in the energy system of around 2.4 trillion USD (2010) between 2016 and 2035 representing 2.5% of the world GDP".

Investment of 2.5% of global GDP (IPCC 2018) as cost of action on climate change is much higher than the already discussed Stern estimate of 1% (Stern 2006). However, considering the fact that the Stern review was conducted in 2006, whereas the IPCC's proposed estimates are very recent and includes several new and updated findings on the impacts of climate change, it is proposed that the Stern review's costs of inaction, i.e. 20% of GDP every year and the IPCC estimate for costs of action, i.e. 2.5% of GDP be combined in order to arrive at more rational numbers for costs of action and inaction on climate change for the province of Sindh.

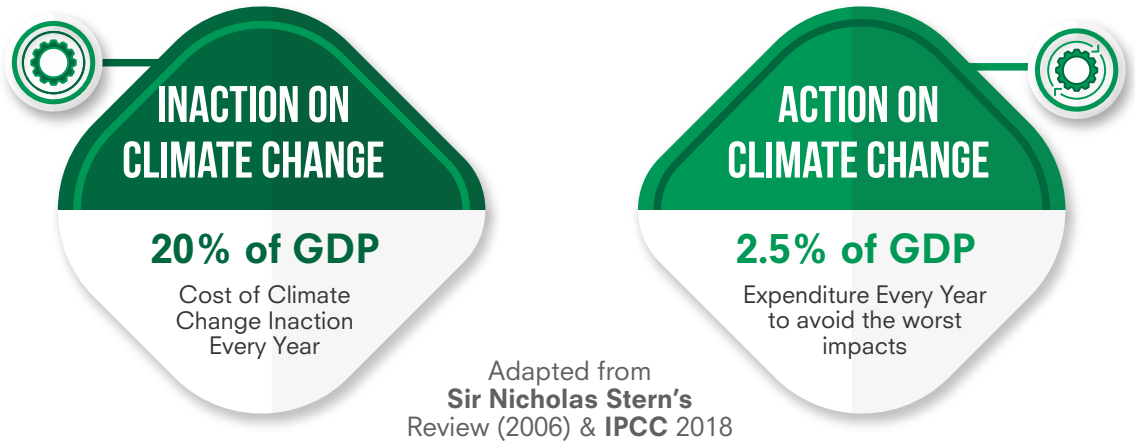
COSTS OF INACTION: THE SINDH PERSPECTIVE

In Part I of this paper, key information about Sindh's climate and the impacts of climate change such as droughts, extreme heat events, and effects of sea-level rise have been presented which have all affected the social and economic well being of the people of Sindh. In Part II, an attempt will be made to link these and other adverse impacts of climate change with key sectors of Sindh's economy and to analyse the costs of inaction within these sectors.

Sindh has the second largest economy in Pakistan after that of Punjab. As mentioned earlier in this document, according to the World Bank, 15% of the total GDP of Sindh is lost to environmental degradation and climate change every year. This number is 5% lower than the Stern Review (2006) that has estimated the loss due to climate change at 20% of GDP. Considering the high vulnerability of the province of Sindh and adopting a more conservative approach, it is proposed that the costs of inaction on climate change for Sindh be analysed using the Stern number, i.e. 20% of GDP. Additionally, for the costs of action on climate change in Sindh, instead of the Stern Review's 1%, the recently released IPCC estimate of 2.5% of GDP shall be used.

Applying a combination of the Stern Review (2006) estimates of 20% of GDP for costs of inaction and IPCC's estimates of 2.5% of GDP for costs of action on climate change in Sindh means related risks could cost at least 20% of the province's GDP every year, however the cost to avoid the worst impacts of climate change can be around 2.5% of the province's GDP each year. The ultimate goal of this policy paper is to sensitise policy makers and other stakeholders to start the conversation regarding policy interventions and allocation of appropriate budgets to initiate steps for battling climate change. This is right in-line with SDG 13 (Climate Action).

Figure 4: Sindh's Cost of Inaction versus Cost of Action on Climate Change



Adapted from **Sir Nicholas Stern's** Review (2006) & **IPCC** 2018

COST OF RESPONDING TO CLIMATE CHANGE

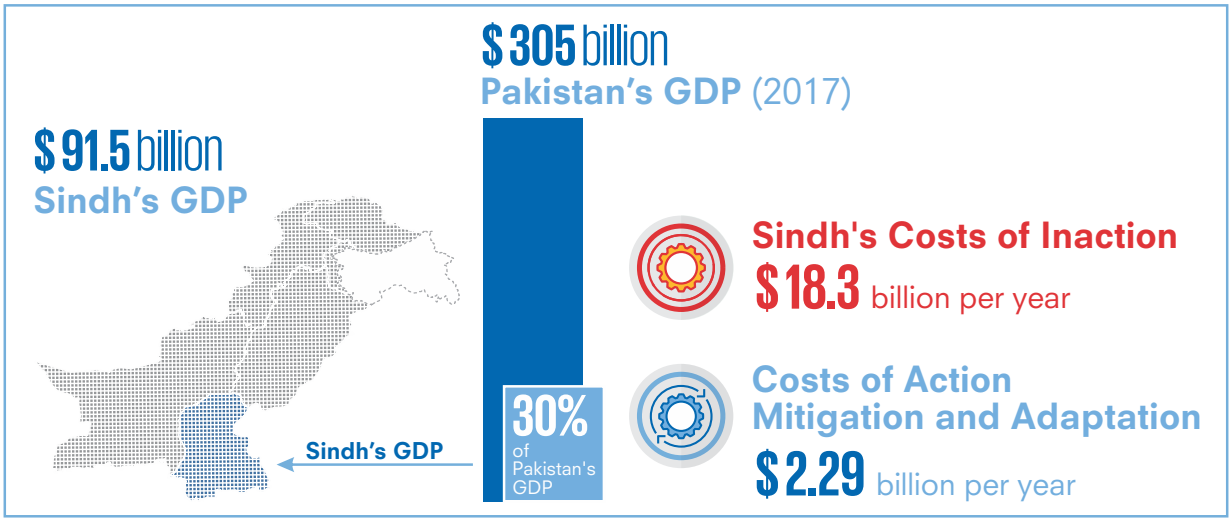
Climate change is a reality for Pakistan. According to the Climate Change Vulnerability Index, Pakistan is amongst the countries that are severely affected by climate change. An ADB study from 2014 on the economics of climate change in South Asia (ADB 2014) indicates that the total cost of climate change will increase over time, and may even become 'prohibitively high' in the long term. The study further states that "…even under optimistic climate change scenarios, huge impacts are likely on vulnerable sectors across South Asia, resulting in significant losses in gross domestic product (GDP) and, hence, in economic growth and poverty reduction". Key sectors identified by the study include water, agriculture, energy, health, transport and coastal and marine resources.

In 2015, the Ministry of Climate Change, with support from UNDP, prepared the 'Pakistan – Climate Public Expenditure and Institutional Review (CPEIR). The document is an excellent review, which is focused on Pakistan as a country and does not provide information specific to the province of Sindh. The review recognizes that presently there is no standard, internationally well-accepted methodology to estimate climate change adaptation and mitigation costs. In order to overcome this limitation, the UNDP National Economy and Environment Development Study (NEEDS) used different methods to calculate these costs.

For estimating costs of climate change for the province of Sindh, a combination of the Stern Review (2006) and IPCC (2018) is being used. This means that climate change related risks in Sindh could cost at least 20% of the province's GDP every year but mitigation and adaptation cost can be only 2.5% of the GDP. The rationale behind using the Stern and IPCC estimates in combination is the conservativeness of the two reviews as they present a higher total cost of inaction compared to the World Bank's estimate of 15% of GDP and NEEDS estimate of 1.8 to 8.8% of GDP. Similarly, the European Environment Agency's method for estimating the costs of inaction is only useful if climate expenditure data is available in abundance.

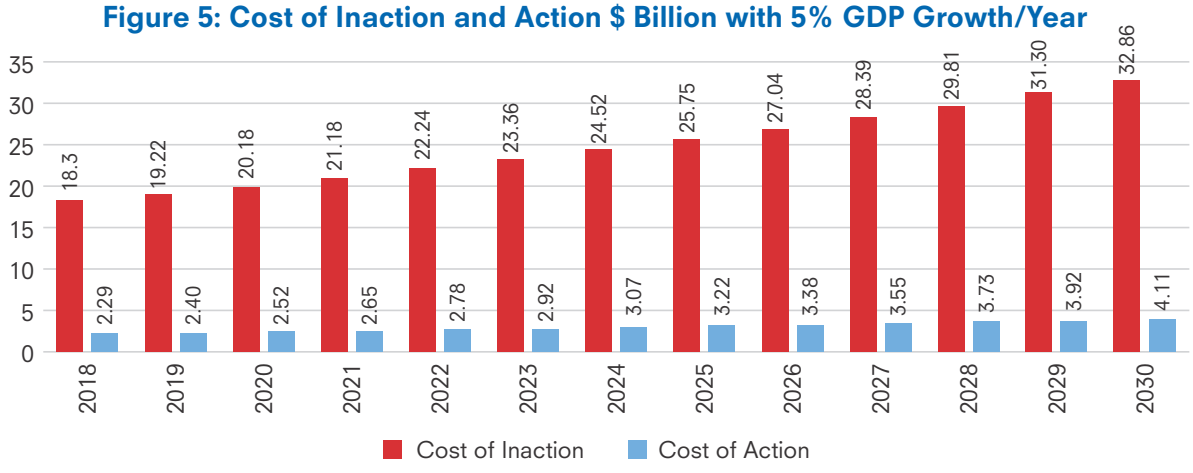
Provincial GDP numbers are usually not made public in Pakistan. In order to arrive at a defendable GDP figure for Sindh, the author had to rely on Dr. Hafiz A. Pasha's paper titled "Growth of the Provincial Economies", which was published by the Institute of Policy Reforms in 2015 (Pasha 2015). Dr. Pasha has estimated the provincial GDP of Sindh at 29.6% of that of Pakistan's for the period 1999-2000 and 30% for the period 2014-15. It would be safe to assume that Sindh's GDP was around 30% in 2017 as well, hence this number will be applied to the Stern Review and IPCC (2018) estimates for calculating the costs of action and inaction on climate change in Sindh.

Pakistan's GDP was US$ 305 billion in 2017, which is the highest ever in the history of the country. Sindh's share in the national GDP, at the rate of 30%, translates into US$ 91.5 billion. Applying the Stern review, the cost of inaction on climate change in Sindh would be US$18.3 billion every year, which is 20% of the province's GDP. On the other hand, if the worst impacts of climate change are to be avoided through climate change mitigation and adaptation, then government of Sindh must be willing to spend at least 2.5% of the GDP (IPCC), which translates into US$ 2.29 billion every year. As mentioned earlier, according to the ADB (2014) study, the cost of climate change will increase with time so estimates in this case cannot be absolute.



Timely action in Sindh becomes extremely important when the province's vulnerability to the adverse impacts of climate change is taken into account. Also, the fact that a 5% GDP growth for Sindh (Pasha 2015) over the next several years will make it costlier for both inaction and action on climate change will make the matter even more urgent and should trigger policy interventions on urgent basis. The following figure 5 presents the trend of the growing cost of action and inaction for climate change in Sindh.

Figure 5: Cost of Inaction and Action $ Billion with 5% GDP Growth/Year



GAP ANALYSIS

In order to better execute any solutions for mitigation and adaptation for the impacts of climate change in Sindh, it is important that fundamental gaps be identified and discussed. For this purpose, discussion on key gaps is presented here.

Financial Gaps

As discussed above, for Sindh the proposed price tag for mitigating or adapting to climate change is 2.5% of the GDP or US$ 2.29 per year that will continue to increase with the 5% increase in the province's GDP every year. Spending funds of this magnitude on climate change may be a major challenge for the province of Sindh, considering its developing state and other social challenges, including healthcare, water and sanitation, education, transportation etc. for its growing rural and urban population. Consequently, intervention in terms of financial support will be required from the federal government, as well as international donors. Now might be the right time for the Sindh government to initiate advocacy and lobbying at national, as well as international level for seizing green funding opportunities. Public Private Partnership (PPP) may be one way of raising funds for addressing the impacts of climate change.

Technological Gaps

In many parts the world, various technologies have been assessed at field scale and put in to action to combat climate change. Examples include:

- Carbon Capture and Storage (CCS): In CCS, carbon dioxide form industrial operations is captured and permanently stored in deep geological formations. Industrial scale CCS is in successful operation in several parts of the world, including USA, Canada, Australia, Algeria, Saudi Arabia, UAE, India, China and others.
- Renewable Energy: Large-scale investments will be required for the development of renewable energy projects in Sindh, including wind, solar, and tidal energy.
- Energy efficiency improvement: Investments in R&D and adaptation will be required for the improvement of energy efficiency in the province.

Knowledge & Information Gaps

It has been established that climate change is impacting Sindh in many ways. Researching for information on climate change specific to the province of Sindh is a major challenge for researcher and practitioners. Information may be available but in bits and pieces and scattered all over the place. There is a need for a central portal for knowledge and information on climate change in the province. Additionally, academic institutions should be encouraged to engage in Sindh-focused advanced research, technology, and new knowledge development.

Capacity Gaps

The capacity gaps might require a separate gap analysis to understand the current state of capacity of Sindh for dealing with climate change. Certain tools, modelling softwares, and trained professionals in the field of climate change are essential to be able to work on mitigation and adaptation to climate change.

CLIMATE CHANGE PROJECTS IN SINDH BY OTHER STAKEHOLDERS

An internet review was undertaken to research for climate change related projects that have been initiated by other stakeholders for the benefit of the province of Sindh. Some of key projects are presented here.

- Red Crescent Pakistan's Sindh branch is actively working on projects in Sindh, including Livelihood, Installation of Solar Water Pumps in Thar, Integrated Community Based Risk Reduction, and Climate Change Adaptation projects.
- Social Policy and Development Centre prepared a study titled 'Gender and social vulnerability to climate change: a study of disaster prone areas in Sindh'. The study investigates the gender dimensions of socio-economic vulnerability to climate change among rural communities of disaster prone areas in four districts of Sindh, including Badin, Dadu, Thatta and Tharparkar.
- USAID and Rural Support Programmes Networks (RSPN) launched their Sindh Agriculture Recovery Project (SARP) in response to the 2010 floods in Sindh. The project's target areas were Jacobabad, Qambar Shahdadkot, Shikarpur, Kashmore, Larkana, Thatta and Dadu.
- The World Bank committed to US$ 140 million for the Sindh Barrages Improvement Project. The financing will help improve the reliability and safety of the Guddu and Sukkur Barrages and strengthen the Sindh Irrigation Departments' ability to operate and manage them.
- In 2014, ADPC and Oxfam Novib carried out a study titled 'Climate Change Risks and Vulnerabilities of Badin Distric in Sindh Province, Pakistan' in three union councils (Kadhan, Ahmed Rajo and Bhugra Memon). The project was focused on implementing a set of structural and non-structural measures with an underlying objective of enhancing the resilience of coastal communities to climate change and other environmental hazards.
- In 2015, the World Bank approved the 'Sindh Irrigated Agriculture Productivity Enhancement Project' with objective to improve irrigation water management at tertiary and field levels in Sindh, supporting efficient management of scarce water resources at the tertiary and field level where losses are the highest.
- WWF carried out a European Commission funded project (2011-2015) titled 'Building Capacity on Climate Change Adaptation in Coastal Areas of Pakistan' that intended to mitigate the climate change risks faced by vulnerable communities in coastal areas in Sindh (Keti Bunder and Kharo Chan, Thatta District) and Balochistan (Jiwani, Gwadar District) through the implementation of interventions related to adaptation and capacity building.

COSTS OF INACTION IN VARIOUS SECTORS AND RELATION WITH SDGs

This section presents a sector-wise analysis to highlight the costs and risks of the adverse impacts of climate change on Sindh for three sectors, i.e. 1) **Agriculture, Forestry and Fishery, 2) Industry, Manufacturing and Energy**, and 3) Services, that includes transport, storage, construction, trade, hotels, finance, housing and others. Selection and grouping of these sectors for analyses of the costs of action and inaction on climate change for Sindh is based on the grouping of sectors and sub-sectors as given in the Pakistan Economic Survey 2016-17 'Growth and Investment' document. Each of these sectors has been discussed in detail under separate headings in this section. Additionally, an attempt has been made to link climate change impacts with the relevant SDGs to highlight challenges in the achievement of the SDGs by 2030. All of these sectors are integral pillars of the economy of Sindh. Allocating resources to any of these sectors on priority basis to combat climate change should be the decision of the government of Sindh.

Agriculture, Forestry and Fishery

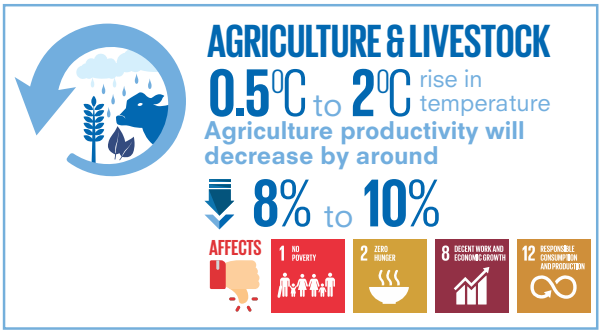
Uncontrolled adverse impacts of climate change on the agriculture sector (i.e. reduced productivity) of Sindh will directly affect the achievement of SDG 1 (No Poverty) and SDG 2 (Zero Hunger), and will indirectly affect SDG 8 (Decent Work and Economic Growth) and SDG 12 (Responsible Consumption and Production).

The agriculture and livestock sector accounts for the country's 19.53% GDP. Sindh's share in the national agricultural GDP is 23.1%. Pakistan's 60% population rely directly or indirectly on agriculture. The 2011 floods heavily impacted the agriculture sector, causing damage to crops, livestock, fisheries, poultry and on-farm water distribution infrastructure. According to the Pakistan Economic Survey 2011-2012, the total estimated loss is US$1,840.3 million. The province of Sindh suffered the most with 94% of the total damage.

Rise in temperature due to climate change will have direct impacts on the agriculture sector. The ADB (2017) estimates that with the rise of temperature (0.5°C to 2°C), agricultural productivity will decrease by around 8% to 10% by 2040. Various models estimate a decrease in yield of major corps, especially for wheat and rice, and the length of growing season in four agroclimatic zones of the country.

The draft SCCP (2018) proposes the following policy measures for adaptation to combat climate change for the agriculture sector in Sindh:

- Take measures to reduce crop failures, and improve crop health by reducing disease outbreak and impact of extreme events.
- Promote use of climate resilient, organic (fertilizers and pesticide), and high yielding inputs and practices.
- Commission relevant institutions and departments to undertake scientific studies on plant-pathogen relationship and patterns of pest and disease spread to Sindh and specific to projected changes in temperature.
- Develop appropriate digital simulation models for assessment of climate change impacts on physical, chemical, biological and financial aspects of agricultural production systems in various agro-ecological zones.
- Reduce migration to urban areas by providing farmers and communities localized livelihood diversification options.
- Improve demand forecast, access to farm produce, market structure & supply chains, ensure value addition of produce.
- Through viable legislation and land-use planning ensure that fertile land is prioritized for agricultural use and discourage conversion of this and for town planning, non-agricultural purposes, and deforestation.



- Encourage and incentivize the use of renewable energy and low carbon emitting technologies on farms and agricultural land especially for tube wells and biogas.
- Establish climate change units or centers at the agriculture research organizations in the province to; categorize areas according to their vulnerability to extreme climate change events, climate resilient crop varieties, and modern farming techniques.
- Promote water efficient farming techniques, especially in low rainfall areas, such as precision farming, laser levelling, and nutrient management etc.
- Increase reliance on crops and agricultural inputs, and improve food security.
- Reduce the soil degradation caused by water logging, and salinity through crop rotation techniques, water efficiency, and rainwater harvesting.

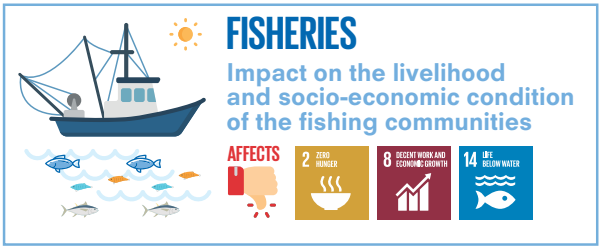
The fisheries sector is an important one for Pakistan's economy. On one hand, it ensures food security for the local population, and on the other hand exports of fish products to international markets brings in valuable foreign exchange. Adverse impacts of climate change on this sector will directly affect the achievement of SDG 2 (No Hunger), SDG 8 (Decent Work and Economic Growth), and SDG 14 (Life Below Water).

Pakistan annually produces 1 million tons of fish products. Approximately two thirds of the total fish products (mostly shrimp and demersal species) come from marine sources in which Sindh has a 70% share. The 2011 floods caused major damage to inland fisheries in the central and southern districts of Badin, Dadu, Hyderabad, Kamber Shahdadkot, Khairpur, Larkana, Matiari, Mirpurkhas, Neushero Feroze, Sangar, Shaheed Benazirabad, Tando Allahyar, Tando Mohammad Khan, Thatta, Tharparkar, and Umerkot in Sindh (Pakistan Economic Survey 2011-2012).

Fish population and distribution will be directly affected by rising sea temperatures, which will translate into low fish production, hence compromising domestic food security as well as export of fish products. The draft SCCP (2018) reports that a decline in Palla fish has already been observed. All climate change threats, related to the fisheries industry, will have impact the livelihood and socio-economic condition of the fishing communities. The SCCP proposes the following policy measures for the fisheries industry in Sindh:

- Adopt integrated ecosystem approach with three main pillars: managing fisheries and aquaculture; adapting to climate change; and reducing risk from natural disasters.
- Promote and develop climate change resilient, fast growing, indigenous, and high yielding fish varieties.
- Training programs and skill development on sustainable fishing techniques, mending and maintaining fishing equipment, and marketing of fish to be delivered for small scale farmers. There should be specific attention paid to women in these programs.
- Formalize fish farms and aquaculture as an industry.
- Improve regulatory and administrative regime for fish farmers and fishermen to ensure that illegal fishing techniques are not used.
- Promote use of low energy intensive technologies, which increase heat recovery in refrigeration and encourage the use of solar water heating on fish farms.
- Protect the habitat of fish by reducing release of harmful chemicals from industrial practices, which release toxins into the rivers and lakes.
- Fill critical gaps in knowledge to assess the vulnerability of fisheries and aquaculture to climate change, especially on small-scale farmers.
- Improve lives and livelihoods of fisherman through efficient use of fish and its by-products to increase food security.
- Protection of freshwater (inland) fish and biodiversity in Sindh.

To support the achievement of SDG 15 (Life on Land) specifically and SDG 13 (Climate Action) in general terms by 2030, it is essential that steps be taken in Sindh to enhance forestation and to protect the existing forest cover. Sindh's total forest area is 2.78 million acres, which is about 8% of the total 34.84 million acres land area of the province. The forested area is inclusive of riverine forests, irrigated plantations, mangrove forests, coastal forests and rangelands (SCCP 2018). Pakistan's National Forest Policy was launched in 2015 with the goal of "expansion of national coverage of forests, protected areas, natural habitats and green areas for restoration of ecological functions and maximizing economic benefits while meeting Pakistan's obligations to international agreements related to forests".



Forests play a very important role in the livelihood of rural populations. They are a source of fuel wood, food, timber, habitat for wildlife, and various important ecosystem services, such as carbon dioxide sequestration deterring cyclones and storms in coastal areas. The Indus Delta is home to 97% of the total mangrove forests and supports over one million people, out of which 135,000 depend on mangroves for their livelihood. Change in temperature and precipitation and increased and more intense extreme weather events will affect forest cover severely, which may deteriorate biodiversity and soil quality in the province (ADB 2017).

The SCCP (2018) outlines the following policy measures to discourage deforestation:

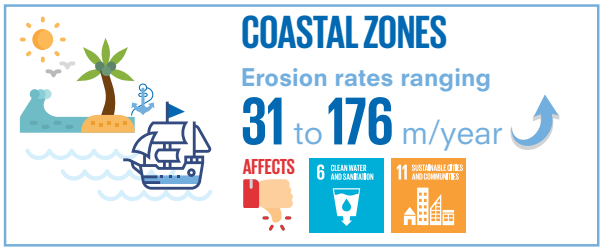
- Limit deforestation and reduce GHG emissions associated with forestry operations.
- Create more forest through afforestation, re-forestation and establish new forests on abandoned land of other non-forested areas using indigenous species and avoiding foreign and invasive species.
- Regulate, monitor and control timber mafia activities that result in illegal clearing of forests.
- Promote urban plantation of trees and indigenous species to adapt to heat waves and increase carbon sinks.
- Discourage use of forests as fuel and firewood for domestic uses in urban and rural areas.
- Develop forest cover assessment at district level through GIS/RS in decision make and forest carbon accounting system to assess changes in carbon stocks in forest areas.
- Develop a provincial GHG inventory and strive to reach zero net emissions through forests as carbon sinks.
- Training of forest department officials to understand the value of ecosystem, protection of biodiversity, and the carbon sequestration functions of the forests.
- Protect the socio-economic well-being of the communities that depend on forest wood for survival and sustainable practices should be promoted among them.

Relevant SDGs whose achievement may be impacted by not investing in the coastal zones and intrusion of salt water into river delta related issues includes SDG 6 (Clean Water and Sanitation) and SDG 11 (Sustainable Cities and Communities).

Pakistan's coastline along the Arabian Sea is 1,046 km long, falling within the administrative boundaries of the provinces of Sindh and Balochistan. Induced by rise in temperature and sea level, increase in stormy conditions in the Arabian Sea has resulted in increased tidal activity. These tidal motions and waves continue to encroach the shoreline, resulting in threats to agricultural land, infrastructure and development activities.

Various studies indicate that rise in sea level will have significant negative impacts on the coastal areas and their resources. Some of these impacts can already be noticed in the form of inundation of low-lying areas, degradation of mangrove forests, declining drinking water quality, and decrease in fish and shrimp production. Because of its tidal flat topography and higher population concentration along the coastal areas, such as Karachi, the Sindh coastal areas' vulnerability to climate change is considered higher than that of the coastal areas of Balochistan.

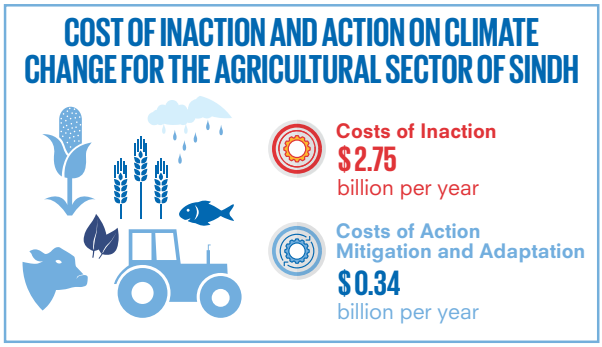
The rate of erosion along the coastal belt is also expected to increase with the rise in sea level. Hajamaro, Ghoro, Kaanhir, and Kahhar, the creeks in the delta regions, have erosion rates ranging from 31 m/year to 176 m/year. The highest erosion rate, i.e. 176 m/year, with a retreat rate of 425 m from 2006 to 2009, in Sindh is at the south side of the mouth of Ghoro Creek. The delta region is both shrinking and sinking due to the lack of sedimentation and subsidence. By 2050, after sea water intrusion into the delta, 0.79% of the Indus Delta population will be at risk while 2.73% of the delta area will potentially be lost (ADB 2017).



Cost of Inaction and Action on Climate Change for the Agricultural Sector of Sindh

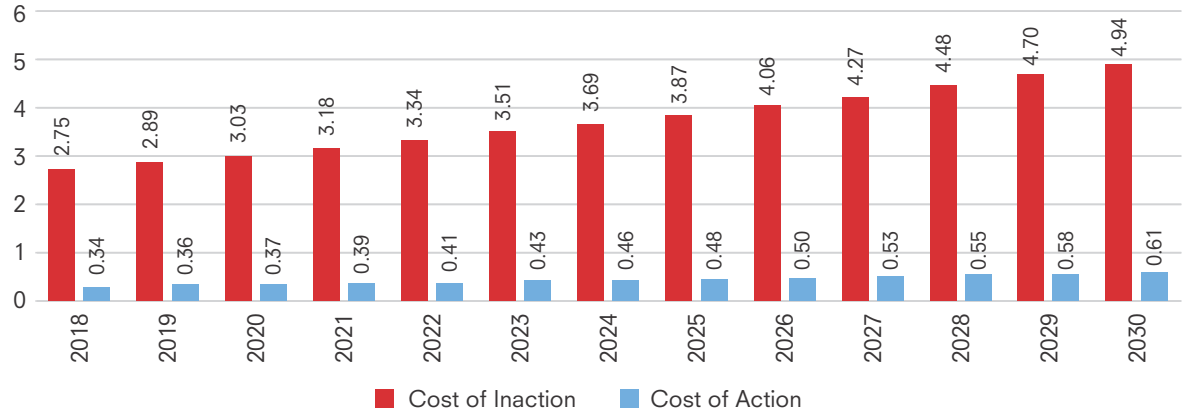
According to the Economic Survey of Pakistan, the agricultural sector contributes 19.53% to Pakistan's GDP. The share of the agricultural sector in Sindh's GDP is 23.1% as estimated by Dr. Hafiz Pasha. Calculations based on these numbers yield an estimated size of Sindh's agricultural sector at US$ 13.75 billion.

Applying the Stern model for cost of inaction, i.e. 20% of the GDP and the IPCC estimate for cost of action, i.e. 2.5% of the GDP to the share of the agricultural sector of the province of Sindh, the cost of inaction is estimated at US$ 2.75 billion and the cost of action on climate change would be US$ 0.34 billion.



The following two tables and charts present the trend of the growing cost of action and inaction for climate change in Sindh.

Figure 6: Cost of Inaction and Action $ Billion with 5% GDP Growth/Year (Agriculture)



Industry, Manufacturing and Energy

The industrial sector holds a very important role in the economy of Sindh. With its multi-dimensional linkages, both direct and indirect, it has spillover effects on the province's economy. This sector creates demand for raw material that is produced by the agricultural sector in the province. It also provides supplies of various machines and tools that contribute to the growth of other sectors of the economy. Additionally, the industrial sector of Sindh is a major source of tax revenues and also contributes creating job opportunities for its growing urban and rural population. Sindh's main industries include textiles, tanning, pharmaceuticals, minerals, cement, salt, sugar, cotton, coal, china clay, oil and gas, automobiles, steel, fertilizers, and industrial chemicals.

Pakistan's Vision 2025, the steadily growing population and other ambitious goals for economic development over the next several years will increase the country's demand for more energy. Keeping on pace with achieving SDG 7 (Affordable and Clean Energy), substantial investment will be required for new power generation, transmission and distribution of conventional electric, gas and renewable energy.

The country's energy sector's share of GHG emissions in 2012 was 46%, the highest among the sectors. At the same time the energy sector is highly sensitive to the impacts of climate change. Changes in precipitation patterns, temperatures rising, and the extreme weather events are the key likely impacts of climate change on the energy sector. The demand for energy in Pakistan far exceeds supply, has resulted in severe energy

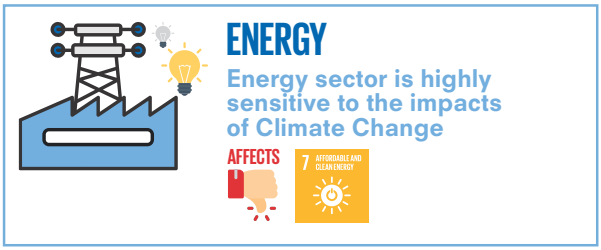
crises. This crisis accounted for 7% GDP losses in 2013 alone. Sindh's population currently stands at 55.24 million, with half of the population living in cities. Rapid urbanization and industrialization has resulted in increased energy demand (SCCP 2018).

Presented below are the ADB's (2017) summarised key finding on projected climate change implications for energy sector in Pakistan, which is equally application to Sindh:

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

The SCCP (2018) proposes the following measures to tackle impacts of climate change in the energy sector:

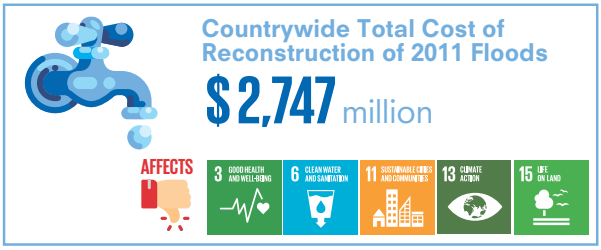
- Development of provincial energy policy that aims to reduce reliance on imported sources of energy and promotes indigenous renewable energy such as micro-hydel, solar, wind, geo-thermal, waste-to-energy, bioenergy and nuclear.
- Promoting local and foreign investment in the renewable energy market through financial support mechanisms, and provide further incentives such as carbon taxes, subsidies and tax reforms.
- Identify regulatory gaps or bottlenecks, address them through amendments in existing regulatory framework for renewable energy, particularly supply off-grid rural populations.
- Develop a GHG inventory of energy consumption and production in Sindh to provide the energy and environment department with key information on which they should base their annual planning.



- Conduct applied research to increase the insight and knowledge about possible carbon reduction by the introduction of low carbon energy and renewable technologies, as well as on the feasibility and cost-effectiveness of these measures from a carbon mitigation perspective.
- Promote decentralized renewable energy generation in industrial, commercial and residential areas by introducing smart metering, and smart grids to increase electricity supplies.
- Creation of R&D cell at the EPA to study the possible options for carbon reduction through employing various low carbon and renewable energy technologies.
- Identify regulatory framework gaps in renewable energy generation and effectively address them.
- Establish a Research and Development cell at EPA office to study options for carbon emissions' reduction.

Water security is of paramount importance for Pakistan, particularly for the province of Sindh. Relationship between the lack of water and the various life functions that it supports is quite complex. Stress on Sindh's water resources due to climate change or any other cause will directly affect the achievement of key SGDs in the province, such as SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 15 (Life on Land).

Sindh's climate is predominantly arid or semi-arid with principally desert like features. Water sector is already highly stressed in the province. The Indus Basin Irrigation System, which is the world's largest system, is dependent mainly on precipitation; glaciers and snowmelt, and ground water extraction (ADB 2017).



Key findings on the water challenges for Pakistan due to climate change have been highlighted by Q. Chaudhry in the "Climate Change Profile of Pakistan" (ADB 2017). Most of these findings can be directly associated with the climate change challenges of the province of Sindh. Below are some of the main findings:

a) Increased variability in the monsoon and winter rains resulting in increased variability of river flows;
b) Uncertainty about future river flow and glaciers melting;
c) Increased demand for irrigation water because of higher evaporation rates at elevated temperature in the wake of reducing per capita availability of water resources and increasing overall water demand;
d) Conventional irrigation system with high water losses and low crop water productivity (wheat at 24% and rice at 55% less than the world averages);
e) Influence of groundwater recharge due to high level of abstraction and changes in precipitation and evapotranspiration; and
f) Lack of transboundary river inflows and glaciers monitoring infrastructure.

Climate change induced droughts are another noticeable impact that has been hitting Sindh since 1968. The districts of Tharparkar, Dadu and Sukkur are expecially prone to droughts (NDMA 2007). Other regions of Sindh affected by droughts include Achhro, Thar, Nara, Kohistan, Kachho and the coastal belt (SCCP 2018).

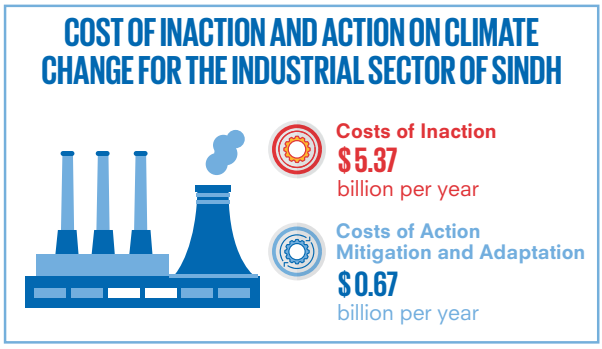
Climate change induced flooding is a major risk for Sindh. Despite below average rainfall in Sindh in 2011, heavy rainfalls in mid-August caused major flooding in all 23 districts of Sindh. The peak rainfall was received in Mithi, Sindh. Estimates produced by the World Bank and Asian Development back indicate that the 2011 floods killed 520 people in Sindh and Balochistan and 1,180 people were injured. According to the Ministry of Finance's Pakistan Economic Survey 2011-2012, the countrywide minimum cost of reconstruction amounts to US$2747 million, with agriculture sector hit hardest, followed by housing, education, financial, and industrial sectors.

The draft SCCP (2018) proposes the following policy measures for adaptation to combat climate change for the water resources sector in Sindh:

- Promote water-efficient irrigation strategies in order to conserve water in the highest water-consuming sector.
- Promote rainwater harvesting in villages as localized solution for improving availability of water.
- Development and implementation of integrated water resource management.
- Regulate, monitor and protect groundwater usage especially in the coastal areas to curb seawater intrusion in coastal areas.
- Legislation of laws pertaining to private sector usage (domestic and industrial) of water and enforcement of existing laws to protect the water resources of the province.
- Preparation of an up-to-date inventory of water resources for the province including surface and groundwater.
- Address the needs for additional water storage and distribution infrastructure in the province and improve municipal water resources and infrastructure.
- Increase expenditure on research in the water sector to minimize water losses and encourage conservation practices.
- Strengthen the capacities of relevant stakeholders and government officials for monitoring, protection and conservation of water resources including municipal water authorities.
- Ensure access to water in arid areas of the province and invest in building early-warning systems in the face of natural hazards such as floods and droughts.
- Reverse Osmosis Plants to be employed in areas that lack water fit for human consumption.

Cost of Inaction and Action on Climate Change for the Industrial Sector of Sindh

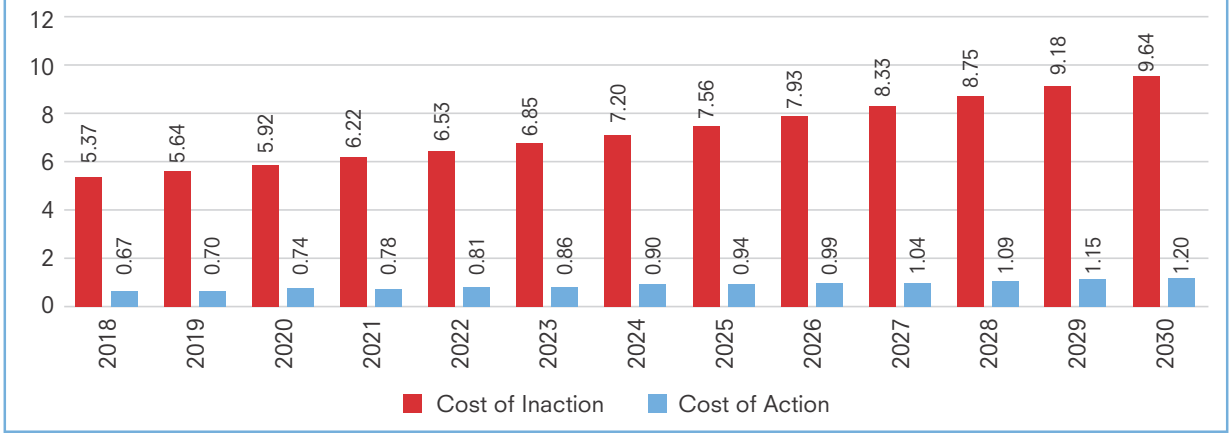
In order to arrive at reasonable estimates of costs of inaction and action on climate change and related yearly projections for the industrial sector of Sindh, numbers from the Economic Survey of Pakistan (2016-17) and from Dr. Hafiz Pasha's research have been used. According to the Economic Survey of Pakistan, the industrial sector's contribution to the country's GDP was 20.88%, with a growth rate of 5.02%. Dr. Hafiz Pasha estimated Sindh's industrial sector's share in the province's GDP at 42.2%. Based on Pakistan's 2017 GDP and Sindh' contribution to the national GDP, Sindh's industrial sector's share in the province's GDP translates to US$ 26.87 billion.



Applying the Stern model for cost of inaction, i.e. 20% of the GDP and the IPCC estimate for cost of action, i.e. 2.5% of the GDP to the share of the industrial sector of the province of Sindh, the cost of inaction is estimated at US$ 5.37 billion and the cost of action on climate change would be US$ 0.67 billion.

The following two tables and charts present the trend of the growing cost of action and inaction for climate change in Sindh.

Figure 7: Cost of Inaction and Action $ Billion with 5% GDP Growth/Year (Industry)



Services

The services sector of Sindh consists of several sub-sectors including transport, storage, communication, wholesale and retail trade, hotels and restaurants, finance and insurance, ownership of dwellings, public administration, and community, social and personal services.

Approximately 50% of Sindh's population lives in cities. Climate change can impact urban infrastructure and transport, hence adversely affecting the livelihood of the people in many ways. If not addressed in time, it will affect the achievement of SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities).

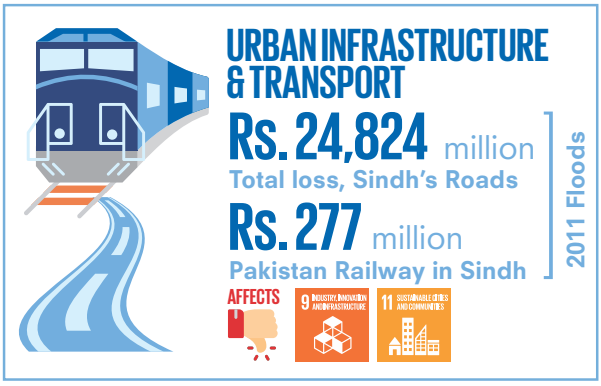
The national highway system is 1,975 km long in the province of Sindh, in addition to the 13,700 km of provincial highways and 31,900 km of district roads. The length of railway line within Sindh is 1,899 km. The 2011 floods damaged the transport and communication system in 18 districts of Sindh. It affected national and provincial highways, and district and municipal roads. Reasons of damage to road infrastructure were submergence, high surface runoffs and ingress of water in roadway formation. There were also damages to railway tracks, bridges, stations and residential buildings in Sindh under the administration of Pakistan Railway. The Pakistan Economic Survey (2011-2012) reports a total loss of Rs. 24,824 million to Sindh's roads and Rs. 277 million to Pakistan Railways assets located within Sindh.

Urban infrastructure and transportation systems in Pakistan are under heavy stress due to old infrastructure of airports, ports, railway system, and highways, in addition to overpopulation, and economic and environmental pressures. In Sindh's coastal areas, the risk of storm surge during extreme weather events is even higher due to sea-level rise, which can adversely affect the urban services and transport systems. Due to the interdependence of urban infrastructure services, the failure of services in one area is very likely to affect other services. The ADB (2017) has summarized key findings on projected climate change implications on urban infrastructure and transport in Pakistan, given below. These implications are equally applicable to the province of Sindh.

- Increased stress on urban drainage systems due to high rainfall and flash floods;
- Hydrological extreme impacts on urban potable water by inundating water supply systems and consequently worsening the quality of supplied water;
- Impacts on coastal towns through projected sea level rise and storm surges. The possible impact on coastal towns, particularly in Karachi, are: damage to sensitive government installations, residential and commercial properties; livelihood losses to fishing communities; and damage to ecosystems and biodiversity; and
- Increased rate of mortality due to extreme heat waves or the urban heat island effect.

The transport sector is one of the major GHG emitters and contributes to poor air quality for urban citizens, which, in addition to other implications of climate change, also adversely affects human health. The SCCP (2018) proposes the following policy measures to address climate change impacts in Sindh due to the transport sector.

- Integrate climate risk planning in transport strategies and develop climate resilient plans for road transport, aviation, and rail. Develop sustainable transport policy for Sindh aiming at climate resilience in the transport sector of the built environment.
- Rationalize competing priorities of livelihood creation and mass transit (GHG reduction).
- Improve traffic management and sustainable transport through education, public awareness, and regulatory monitoring.
- Set aside annual budget for technical capacity development required for implementation of sustainable transport related projects.
- Reduce passenger travel demand and time through land-use planning.
- Promote non-motorized modes of transport.
- Encourage private sector investment in increasing access to low GHG emission, clean, affordable, and sustainable transport.
- Increase energy efficiency standards for both new and used vehicles, establish vehicular emissions testing stations (VETS) all over Sindh and phase out old/out-dated/high emissions



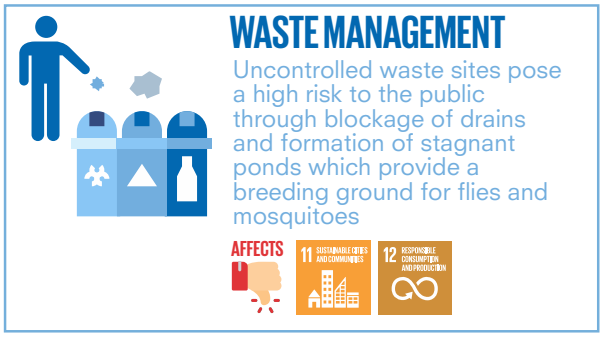
producing vehicles and promote low sulphur fuel for the transport sector and adoption of Euro VI standards.
- Investments in efficient transport, transit systems and infrastructure.

Waste Management Practices

Sustainable waste management is essential for any civilized society. If not properly handled, solid waste can give birth to monstrous problems that will affect several sectors of the economy. Improper waste management will directly affect the achievement of SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production).

The provincial assembly of Sindh passed the 'Sindh Solid Waste Management Board Bill' in 2014 for the collection and disposal of solid and other waste in the province. However, Karachi in particular and many other cities of Sindh in general present the picture of large uncontrolled garbage dumps at times, facing severe garbage outbreaks. Communities such as Lyari and Malir in Karachi are located right next to garbage dumps, which are completely exposed. Sindh's 2nd largest city, Hyderabad is no exception. It has been reported in the Mehran University Research Journal of Engineering and Technology (Khoso et al, 2018) that the solid waste management system is not proper, right from collection to disposal. Uncontrolled waste sites pose a high risk to the public through blockage of drains and formation of stagnant ponds, which provide a breeding ground for flies and mosquitoes, increasing risk of diseases in the nearby communities. Additionally, research that was done for this paper did not reveal a single scientifically designed and operated sanitary landfill in the province of Sindh. In February 2018, work was initiated on the redesigning of the landfill at Jam Chakro, Sindh on scientific grounds but an update was not available at the time of the writing of this paper.

Policy measures proposed in the SCCP (2018) are presented here:
- Create jobs in waste management and recovery through research and creating partnerships between different stakeholders.
- Rationalize environmental quality standards in view of assimilation capacities of receiving environment.
- Promote the concept of 3Rs (Reduce, Reuse, Recycle) to increase sustainable waste management
- Promote energy-from-waste projects
- Improve municipal waste management



- Develop provincial solid waste standards for waste storage, collection, transport, treatment and disposal, in line with air and water quality standards
- Promote decentralization of the disposal system to the local environment and organizing public awareness on sustainable waste management through electronic and print media and street campaign, through community organizations such as schools, institutions, and households, suing a public address system, distributing leaflets, and by using the divisions public awareness team
- Existing waste treatment schemes to be made more effective and functional and new schemes to be installed on need basis.
- Ensure proper labelling, handling and prevent illegal dumping and hazardous industrial waste
- Encourage treatment, and reuse of wastewater from manufacturing, commercial, and industrial processes
- Promote waste management technologies, which provide co-benefits (e.g. anaerobic digestion).

Human Health

SDG 3 is all about 'Good Health and Well-Being'. Rise in temperatures and precipitation due to climate change will increase the risk of several diseases and loss of lives because of the frequency and intensity of heat waves in Sindh. Timely intervention in terms of policy and investment in adaptation and mitigation can ensure the achievement of SDG 3 by 2030.

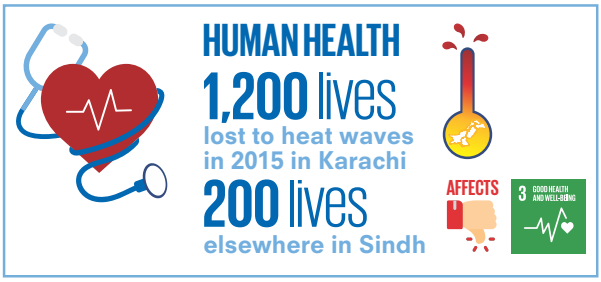
The floods of 2011 resulted in substantial damage to the public health infrastructure in Sindh. The Pakistan Economic Survey 2011-2012 reports that in Sindh, out of the total 708 health facilities in 11 districts, 113 were damaged at varying level during the floods. The direct losses to health facilities were calculated at US$4.6 million.

Climate change can affect human health through various determinants, such as safe drinking water, clean air, sufficient food, and secured shelter. Heat

waves are projected to increase both in frequency and intensity (ADB 2017). 1,200 lives were lost to heat waves in June 2015 in Karachi alone, in addition to 200 lives elsewhere in Sindh. Karachi saw the maximum temperature of 44.8°C which is the second highest after 1979. Other diseases spread of which may be enhanced by climate change include various infectious diseases, mental diseases like depression, distress, aggression, etc., and malaria and dengue (ADB 2017).

The draft SCCP (2018) proposes the following policy measures for adaptation to combat climate change for the human health sector in Sindh:

- Draft, prioritize and implement district-wise health, heat and disaster management plans, which help reduce risks to human health from climate-induced disasters and diseases.
- Conduct Needs Assessment of the health sector, identifying infrastructure, human resource and financial resources required by sub-urban and rural health facilities to equip them to handle climate induced diseases and disasters.
- Ensure just and equitable access to health insurance.

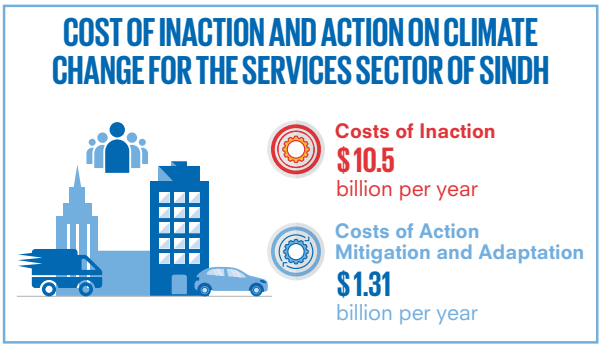


- Counter the prevalence of malnutrition and stunted growth by ensuring access to food and clean water.
- Ensure availability and access to sufficient, safe and nutritious food to meet the dietary needs.
- Take measures to reduce water-borne diseases and ensure access to safe, clean drinking water.
- Improve geographical spread of health facilities between urban and rural areas.
- Promote low carbon and climate resilient building designs which improve insulation, provide adequate ventilation, and green space.
- Promote research on the nexus of climate change and health (spread, prevalence and incidence of disease; food security; water security; indoor air etc.).

Cost of Inaction and Action on Climate Change for the Services Sector of Sindh

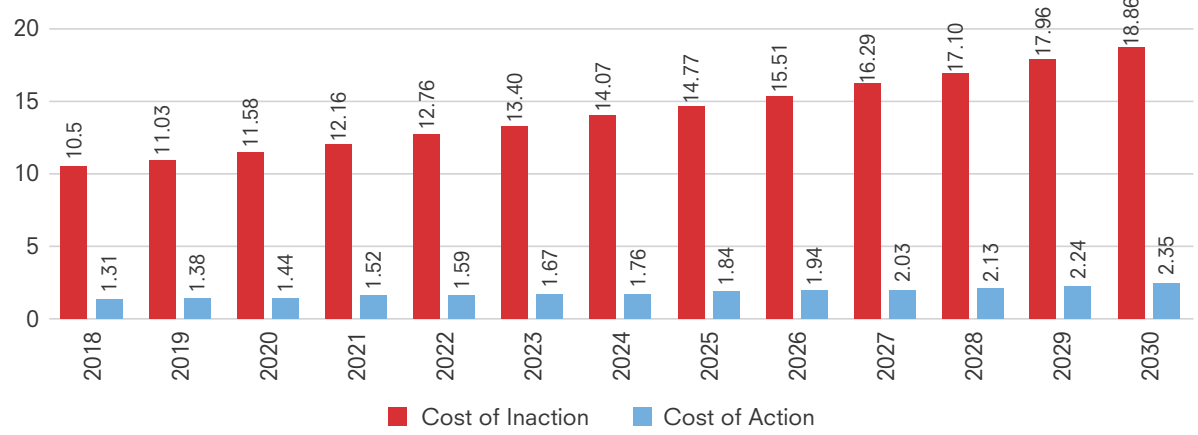
On national level, the services sector contributes 59.59% to the GDP and has seen a growth rate of 5.98% (ESP 2016-17). According to Dr. Hafiz Pasha's estimates, on the other hand, the services sector of Sindh contributes 28.9% to the provincial GDP. Calculations result in the total size of the services sector in the provincial economy as US$ 52.52 billion.

Applying the Stern model for cost of inaction, i.e. 20% of the GDP and the IPCC estimate for cost of action, i.e. 2.5% of the GDP to the share of the services sector of the province of Sindh, the cost of inaction is estimated at US$ 10.5 billion and the cost of action on climate change would be US$ 1.31 billion.



The following table and chart present the trend of the growing cost of action and inaction for climate change in Sindh.

Figure 8: Cost of Inaction and Action $ Billion with 5% GDP Growth/Year (Services)



CONCLUSION AND RECOMMENDATIONS

According to a recent Germanwatch report, for the period 1997 to 2016, Pakistan is the 7th most affected country in the world by climate change. Within Pakistan, Sindh is the worst affected province. Manifestations of climate change can be seen in all sectors of the economy within the province. The time for action is now as the costs of inaction may be too high to bear within a few decades. The following recommendations have been compiled for the benefit of policy makers in the province of Sindh:

1. A detailed baseline needs to be developed for all factors relevant to climate change for the province of Sindh, covering key sectors of the economy. Presence of a baseline will help understand and gauge the amount of change that will take place due to interventions for countering climate change.
2. Introduce climate change awareness and sensitization campaigns for policy makers in Sindh on local, district and provincial level.
3. A detailed gap analysis exercise should be undertaken to understand the financial, technological, knowledge, and capacity gaps that are hindrances in action on climate change in Sindh.
4. Implementation of existing policies should be ensured in the province on local, district and provincial level.
5. There is room for improvement in coordination and integration of efforts of relevant stakeholders in the province. This can be achieved by setting up a central office for coordination for climate change in the province.
6. There is an opportunity for establishing a Community of Practice (CoP) on climate change for Sindh. Key stakeholders, experts, academics and donors, can meet as members of the CoP on regular basis to discuss climate related prevailing issues, to identify gaps in efforts, and to provide a roadmap to the government of Sindh on climate change mitigation and adaptation.
7. If the worst impacts of climate change are to be avoided through climate change mitigation and adaptation, then government of Sindh must be willing to spend at least 2.5% of the GDP, which translates into US$ 2.29 billion every year. Breakdown of this number for the three key sectors of the economy is: Agriculture, forestry and fishery US$ 0.34 billion, Industry, manufacturing and energy US$ 0.67 billion and Services US$ 1.31 billion.
8. Communication and understanding issue on climate change should be addressed on priority basis to eliminate mind gaps on the subject of climate change in the province.
9. Develop a climate change index for Sindh that is linked to human development index of the province.
10. A central portal for knowledge and information on climate change should be established in the province.
11. Academic institutions should be encouraged to engage in Sindh focused advanced research, technology, and new knowledge development.
12. Sindh government should initiate advocacy and lobbying at national, as well as international level for seizing green funding opportunities for its climate change initiatives.
13. Public Private Partnership (PPP) may be one way of raising funds for addressing the impacts of climate change.
14. Large-scale investments should be made in the development of renewable energy projects in Sindh, including wind, solar, and tidal energy.
15. Investments in R&D and adaptation should be made for the improvement of energy efficiency in the province.
16. Promote local and foreign investment in the renewable energy market through financial support mechanisms, and provide further incentives such as carbon taxes, subsidies and tax reforms.
17. Identify regulatory gaps or bottlenecks, address them through amendments in existing regulatory framework for renewable energy, particularly supply off-grid rural populations.
18. Create jobs in the environment and climate change sector through research and creating partnerships between different stakeholders.
19. Develop provincial environmental standards for air, water, wastewater, and green cover, and for solid waste's storage, collection, transport, treatment and disposal, in line with air and water quality standards
20. Develop sanitary landfills in the province on scientific basis.
21. Integrate climate risk planning in transport strategies and develop climate resilient plans for road transport, aviation, and rail. Develop sustainable transport policy for Sindh aiming at climate resilience in the transport sector of the built environment.

REFERENCES

ADB 2017, "Climate Change Profile of Pakistan", Qamar Uz Zaman Chaudhry, Asian Development Bank 2017.

Rasul et al 2012, "Climate Change in Pakistan – Focused on Sindh Province". Pakistan Meteorological Department, Technical Report No. PMD-25/2012.

SCCP 2018, Sindh Climate Change Policy (draft) 2018. Environment Protection Agency, Government of Sindh.

NCCP 2012, National Climate Change Policy 2012, Ministry of Climate Change, Government of Pakistan.

IPCC 2007, Summary for Policymakers, in Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, p. 17.

IPCC, 2013, Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC 2018, Summary for Policymakers. "Special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways". First Joint Session of Working Groups I, II, and III of the IPCC. Incheon, Republic of Korea, 6 October 2018.

Mani, Muthukumara; Bandyopadhyay, Sushenjit; Chonabayashi, Shun; Markandya, Anil; Mosier, Thomas. 2018. South Asia's Hotspots : Impacts of Temperature and Precipitation Changes on Living Standards. South Asia Development Matters;. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/28723 License: CC BY 3.0 IGO."

M. H. Panhwar "Climate of Sindh and Irrigation". https://panhwar.com/Article138.htm. Accessed on August 28, 2018.

Encyclopedia Britannica. https://www.britannica.com/place/Sindh-province-Pakistan. Accessed on August 28, 2018.

Hanif, U 2017, "Socio-Economic Impacts of Heat Waves in Sindh". Pakistan Journal of Meteorology, Vol. 13, Issue26: Jan 2017.

Ahmad, S. A. et al, 2014, " Principal Component Analysis to Explore Climatic Variability that Facilitates the Emergence of Dengue Outbreak in Karachi", Pakistan Journal of Meteorology. Vol. 11, Issue 21: July 2014.

Zahid, M. and G. Rasul 2013, "Impact of South Asian High Variability on Monsoon Precipitation in Pakisatn". Pakistan Journal of Meteorology. Vol. 10, Issue 19: July 2013.

UNESCO and ADB 2012, "Messages for Decision & Policy Makers and Water Managers on Adaptation to Climate Change through Integrated Water Resources Management IWRM at River Basin Level". Pakistan Journal of Meterology. Vol. 9, Issue 17: July 2012.

Rasul, G. et al. 2012. "Vulnerability of the Indus Delta to Climate Change in Pakistan". Pakistan Journal of Meteorology. Vol. 8, Issue 16: Jan 2012.

EEA 2007, "Climate Change: the cost of inaction and the cost of adaptation". EEA Technical Repot. No 13/2007.

Stern, N. 2006. "Stern review: the economics of climate change". United Kingdom: N. p., 2006. Web.

Pakistan: Flood Impact Assessment, Pakistan Economic Survey 2011-2012. Government of Pakisatn, Ministry of Finance.

Pakistan: Climate Public Expenditure and Institutional Review (CPEIR). UNDP 2015.

Khoso et al, 2018. 'Solid Waste Mangement Issues in Hyderabad City', Mehran University Research Journal of Engineering and Technology, Vol. 37, No 3, 653-662 July 2018.

National Forest Policy 2015, Ministry of Climate Change, Government of Pakistan.

ADB 2014 Mahfuz Ahmad and Suphachol Suphchalasai, "Assessing the Costs of Climate Change and Adaptation in South Asia". (Manila, Asian Development Bank).

Pasha 2015. "Growth of the Provincial Economies", Dr. Hafiz A. Pasha, The Institute of Policy Reforms 2015.

Pakistan Economic Survey 2016-17, "Growth and Investment" Government of Pakistan.