Sociological Research and Innovation (SRI)
Volume 2 Issue 2, Fall 2024
ISSN$_{(P)}$: 3007-3251, ISSN$_{(E)}$: 3007-326X
Homepage: https://journals.umt.edu.pk/index.php/SRI

Article QR

Title:	**Climate Change: Impacts on Balochistan and Suggested Contemplative Responses**
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DOI:	https://doi.org/10.32350/sri.22.01
History:	Received: August 21, 2024, Revised: August 21, 2024, Accepted: September 03, 2024, Published: December 10, 2024
Citation:	Rahman, M. U., & Hamza, A. (2024). Climate change: Impacts on Balochistan and suggested contemplative responses. *Sociological Research and Innovation*, *2*(2), 1–22. https://doi.org/10.32350/sri.22.01
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Conflict of Interest:	Author(s) declared no conflict of interest

A publication of
Department of Sociology, School of Social Sciences and Humanities
University of Management and Technology Lahore, Pakistan

Climate Change: Impacts on Balochistan and Suggested Contemplative Responses

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Abstract

Pakistan's contribution to the total Greenhouse Gas (GHG) is one of the lowest in the world and the contribution of the Province of Balochistan is almost none. However, Pakistan, particularly Balochistan province, is among the most vulnerable to climate change. According to studies, there are evidences of a global trend of climate change which can be observed in almost every region of Balochistan. These trends include floods, cyclones, significant increases in the frequency and severity of extreme weather events, and unprecedented monsoon rains. This results in regular siltation of small dams, overflow, and droughts. Similarly, snowfall has also decreased significantly as compared to previous years. The groundwater table is falling day by day and water availability in the province is steadily decreasing. The Balochistan province also lacks necessary infrastructure for water storage. Moreover, it also faces socioeconomic challenges, such as poverty, lack of access to education, limited healthcare services, and disaster management. The combination of all these factors along with the heightened reliance of the people of Balochistan on natural resources, limited technological capabilities, and inadequate financial resources to manage climate extremes, render them vulnerable to poverty. The adaptation and mitigation actions must be prioritized and put into action to tackle the said issues. This can only be achieved by planning and executing suitable adaptation measures, preferably nature-based solutions, at the provisional and local levels. The core of the issue is poor governance and any potential solutions may only be implemented if the government makes competent and workable decisions.

***Keywords*:** climate change, droughts, environment, flood, rains, water scarcity

Introduction

Climate change can be defined as the long-term regional and global shifts in average temperature, humidity, and rainfall patterns. Unlike weather

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which may change just in a few hours, climate change is a significant variation in average weather settings over seasons or several decades. Sometimes, these shifts could be natural, caused by variations in the solar cycle (Kreft & Eckstein, 2013). However, human activities connected with the technological and industrial developments as well as the excessive use of fossil fuels since the 18th century, are the main drivers of this phenomenon. The rapid increase in Greenhouse Gases (GHGs) (carbon dioxide, methane, nitrous oxide, and certain synthetic chemicals) and burning of fossil fuels tend to warm-up the earth and oceans. This increases the sea level and melts snow and ice. Furthermore, it also changes the ocean currents and storm patterns, causes more extreme heat events including fires, changes rainfall patterns, and causes floods and droughts (Mir & Ijaz, 2016). In some other cases, these changes may also impact infrastructure, freshwater supplies, human health, agriculture, forests, coastlines, and marine system.

In contrast to global standards, Pakistan has low per-capita GHG emissions. It emits approximately 0.8 metric tons of CO2 per capita, significantly below the global average of 4.7 metric tons per capita as of 2021 data (The World Bank, 2022). Yet, the country is severely impacted by the effects of climate change. Besides, it is also developing a plan to support international efforts in order to reduce GHG emissions by conserving energy, increasing energy efficiency, and optimizing fuel mix (The Global Economy, 2020).

Balochistan province is among the most vulnerable to climate change as it already faces many problems connected with harsh geography and weather. Alongside all these concerns, climate change is multiplying the challenges to the already strained environmental conditions of the province.

There has been a significant increase in the frequency and severity of extreme weather events in the province. This results in sea level rise, cyclones, increasing temperature, deteriorating health, low agricultural, livestock production, as well as animal losses and malnutrition (The World Bank, 2010).

On the other hand, severe droughts occur every year due to lower annual rainfall and flash floods in some areas during the monsoon, resulting in regular siltation of small dams (Chaudhry et al., 2009). These flash floods also erode and deplete soils, leading towards loss of livelihoods. Moreover,

these floods also impact infrastructure, cause food shortages, and spread of different diseases. Balochistan has experienced higher than traditional heat waves in recent decades. Snowfall has also considerably decreased as compared with the historic records. The groundwater table is dropping day by day and the water availability in the province is decreasing. Resultantly, this would be disastrous for agriculture and livestock in the province. The issue is further strained by the changing precipitation patterns, cycles, and increased temperatures (Zahid & Rasul, 2012). This may affect health, raise heatwaves, and lead towards an increased demand for artificial cooling as well. The shortage of water, food security, health risks, and increasing demand of energy may result in climate change-induced migration. Migration to the adjacent provinces would create serious sociopolitical issues, leading towards social unrest in large areas. The coastline of Balochistan, which is about 70% of Pakistan's coastline, is vulnerable to the rise in sea level. This may result in cyclonic activities and saltwater intrusion onto groundwater, affecting fisheries, coastal ecosystem, and livelihoods (Khan & Rabbani, 2005).

Furthermore, the province also lacks necessary infrastructure for water storage and disaster management and faces environmental, geographical, and socioeconomic challenges. These challenges include poverty, lack of adequate access to education, and limited healthcare services. The technical and financial capacity of the country at large and the province in particular, is also very low to adapt to the adverse impacts of climate change. Likewise, climate change is also a serious threat to poverty reduction efforts and may undo decades of development efforts (Government of Pakistan, 2012).

Over the next few decades, due to less food and water accessibility than what people currently have in a climate that is far more hostile, would make this province more vulnerable to the consequences of climate change. The population of Balochistan may face serious survival issues due to the aforementioned risks, especially food security, energy, and water supplies (Ahmad et al., 2023).

Topography of Balochistan

Balochistan having an area of 347,190 square kilometers, constitutes almost 44% of Pakistan's total area. Due to inhospitable terrain, harsh climate and scarcity of water, as well as shortage of rivers, it has the lowest population density among all provinces. Geographically, it can be divided

into 4 regions containing lower highlands, upper highlands, deserts, and plains. Its unique geography, featuring mountainous tracts, arid and semi-desert terrain with varying highland plains, add a unique set of challenges to climate change. Balochistan's ecology has distinct ecosystems namely dry lands, mountain ranges, limited woodlands, deserts, inland water bodies, grasslands, and forests. It also has a 770 km long coastline stretching from Jiwani Bay to Sonmiani, near Karachi dotted by limited mangroves and rich marine life.

Climate Profile of Balochistan

Balochistan is one of the driest regions in Pakistan. Its climate is referred to as continental semi-arid Mediterranean and the annual precipitation averages from 200 to 350 mm. While, a variable part of the total precipitation occurs as rain and snow in winter season or as heavy downpours in summers (Iqbal & Zahid, 2014). Generally, the entire province suffers from aridity, however, southern Balochistan is far more arid. In the less arid areas of northern Balochistan, the average annual precipitation does not exceed 350-400 mm, while in other parts of the province, it remains as low as 50 mm per year with a warming trend in mean temperatures. Balochistan has observed the highest rise in mean maximum temperature, with an increase in the frequency of warm days about 4-6 days per decade (Government of Pakistan, 2015). Moreover, in the mountainous areas of the province, an increase in the frequency of cold days was also reported with an average of 30-60 days (Naz et al., 2020). Resultantly, winter and summer cycles are also changing.

Aim and Rationale

Environmental concerns are capturing the attention of everyone including the developed and underdeveloped states and are one of the major concerns of the 21st century (Wexler & Anderson, 2005). The increasing frequency of environmental trends, such as floods, sea level rise, cyclones, rising temperatures, earthquakes, and diminishing water resources are disturbing the environment gravely. Uneven precipitation further worsens the situation in Balochistan, adversely affecting the environmental status and adding to the already existing vulnerabilities in the province with expected repercussions (Zahid & Rasul, 2012).

The combination of environmental, geographical, and socioeconomic factors of Balochistan makes it more vulnerable and the most affected. This

state of affairs requires effective climate change and environmental policing along with public awareness campaigns to provide a safe future to the future generation and to make the existing resources sustainable. Balochistan, like the rest of Pakistan, must deal with the problem to mitigate the effects of climate change while maintaining emission reductions and adopting strategies (Government of Pakistan, 2013). Therefore, this study aimed to highlight the impacts of climate change on Balochistan and suggested a comprehensive framework for possible adaptation of strategies.

Methodology and Significance

The current study relied on both primary and secondary data. Data was gathered from reliable sources, such as international organizations, government reports, and academic journals. A descriptive and analytical approach was used to explain the impacts of climate change on Balochistan. The study is an attempt to provide valuable insights to policymakers in order to understand the complex impacts of climate change on Balochistan. Additionally, it provided key initiatives to address climate change adaptation and mitigation, both long and short-run strategies in the context of Balochistan.

Impacts of Climate Change on Balochistan

Climate changes are evident in several important sectors of Balochistan and have extensive consequences. It is anticipated that climate change would make Balochistan, a province with the lowest Human Development Index (HDI) in Pakistan, even more vulnerable. Surface temperatures in Balochistan are rising due to global warming which may result in seasonal shifts (Chaudhry et al., 2009). These seasonal variations would disrupt the parameters of normal weather conditions in the province. For instance, shorter, colder winters, and an increase in the intensity and duration of summers have been predicted to become the norm (Glenn et al., 2014).

Precipitation Changes, Droughts, and Floods

The province's hydrological cycle has changed due to climate change. Rainfall in Balochistan is now irregular and infrequent. Snow used to fall in many parts of northern Balochistan and high plateaus of midlands strip around Kalat-Mastung. However, over time, both the frequency and intensity of snowfall have decreased in some places, rather dramatically. The province's water resources, both in terms of quantity and quality, are suffering, resultantly (Rasheed et al., 2023). Reduction in water availability

for use by people, plants, and animals leads towards droughts. The Intergovernmental Panel on Climate Change (IPCC) has predicted that variations in temperature of two to three degrees Celsius may impact Pakistan and other countries in South Asia (Inrogovernmental Pannel on Climate Change [IPCC], 2014). The average precipitation would decrease due to these changes in temperature which may affect water availability. Consequently, the province would have droughts and drought-like conditions in certain districts . Moreover, Balochistan has also witnessed a protracted drought which began in the late 1990s and lasted for about ten years.

Flood is one of the biggest disasters (Glenn et al., 2014). Some districts of Balochistan are prone to flooding including Naseerabad, Jaffarabad, Lasbela, Jal Magsi, Bolan (Kachhi), Khuzdar, Qila Saifullah, and Qila Abdullah. These areas get floods every year, albeit, the severity varies depending on the region. Each year, severe flooding causes thousands of people to be displaced in addition to millions being affected. People living in the above-mentioned districts have become increasingly vulnerable due to floods, losing nearly everything along with their sources of livelihood . Moreover, torrential rains cause flash floods every year during monsoon (Ali, 2013). The 2022 floods in Naseerabad and the recent flood on 27th February 2024 in Gwadar damaged the civic infrastructure and livelihood of people.

Sea Level Changes and Coastal Region

Sea surface temperatures are rising due to human-induced global warming every year. The changes brought about by rising atmospheric carbon dioxide levels disturb the hydrological cycles and increase ocean acidification. This leads towards more frequent and powerful storm surges, affecting marine plants and life (Siddiqui et al., 1999). Sea level rise, ocean acidification, changes in precipitation, and sea-based natural hazards including storms and cyclones are looming serious threats to coastal areas and communities (Glenn et al., 2014). Furthermore, the mangroves of Balochistan are a valuable resource that is under threat from rising sea levels. variations in temperature and precipitation, and an increase in the frequency and intensity of extreme weather events (Khan & Rabbani, 2005). These factors would also affect the region's biodiversity and soil quality, worsening the environmental challenges further.

Around 70% of Pakistan's coastline lies in Balochistan which is expected to be affected by climate change (Saadullah, 2012). Coastal erosion and sea intrusion, particularly on Pasni, Sur Bander, Pishukan, and Jiwani, endanger the 770 km of shoreline and intrude on the small farming lands. A greater frequency of above-average strong cyclones, such as *Gonu* (2006), *Yemyin* (2007), and *Phet* (2010), is also a problem for the coastal belt (Nasir et al., 2012). Additionally, overfishing by illegal trawlers, environmental deterioration, and variations in sea surface temperatures have all affected the marine ecosystem of the region (Wexler & Anderson, 2005).

Impacts on Water Resources

The deficiency of water has increased and the quality of water has declined which has now become distinctive in both rural and urban settings of Balochistan. Quetta experiences a 50% shortfall in water supply. Groundwater levels in the province have dropped by 5-10 meters in the last decade, severely affecting both urban and rural communities. The average rainfall has decreased in comparison with the previous 20 years due to which the water table does not get recharged and has dropped as a result of the changing climate (Rasheed et al., 2023). The water resources are further depleted by water-mining tube wells with no clear policy for the extraction of water. Groundwater has significantly decreased over the past five to six years. In spite of that, breaking through "hard rock," groundwater extraction has proved pointless in many places. The province's Karez system has almost dried up due to inadequate groundwater made worse by the effects of climate change (Ahmad et al., 2023).

Impacts on Agriculture and Livestock

Small-scale farming and agriculture are the primary means of income of majority of people living in Balochistan. A total of 67% of Balochistan's population is associated with agriculture and livestock, generating more than half the Gross Domestic Product (GDP) of the province (Integrated Food Security Phase Classification [IPC], 2022). More than 53% of Balochistan's cultivated land is used by *Sailaba* (Flood water) and *Khushkhaba* (rainfall and runoff) farming techniques. Regardless of this, 1.09% of the land is irrigated and the poorest sections of society depend on non-irrigated farming practices for their livelihoods. Furthermore, even small changes in the hydrology and weather may have disastrous effects on

their lives (Thornton et al., 2015). An increase in temperature hastens the drying out of the soil, reducing its water content and fertility. This poses a serious threat to food security in the province by negatively affecting crops and horticultural production (Iqbal et al., 2009).

Balochistan already receives very little rainfall (Ahmad et al., 2012) and agriculture and livestock sectors are particularly vulnerable to further climate change impacts including harsh weather, droughts, and epidemics. The water level in some areas of the province has reached the dead zone. Since most places cannot draw water to irrigate crops, this shortage has significantly affected agriculture. Crop production has become a challenging task due to seasonal swings since inexperienced farmers find it difficult to keep up. The majority of agricultural methods in Balochistan are rain-fed and irregular precipitation makes crop cultivation a challenging task, jeopardizing crop quality and yield. The Northern region in the province was well-known for its abundant fruit and dense tree cover which provided a variety of fruits and the Quetta city used to be called the fruit basket of the country. However, the previous five to six years have seen a significant decrease in the amount of tree cover due to changes in temperature, unpredictable rainfall, and a decrease in the amount of water available (Rasul et al., 2012). In Balochistan, the 17% reduction in forest cover from 2000 to 2020 highlights a significant environmental challenge. This amounts to a loss of approximately 29,000 hectares which has severe implications for the province's fragile ecosystem and socioeconomic stability. Additionally, frequent dry spells, a lack of rainfall, and sometimes irregular heavy rainfalls impact people, specifically farmers and shepherds. Most of the farmers have given up on farming, whereas shepherds keep a few livestock (Franz, 2011).

Rangelands constitute an estimated 80% of Balochistan's land area on which most of the province's animal production relies. It also offers ecosystem services, such as carbon sequestration, firewood for home energy, nutrient recycling, biodiversity, wildlife habitat, and ecotourism (Iqbal et al., 2009). The degradation of these rangelands is posing serious threats on floral and faunal biodiversity and ecosystem instability.

Out-of-Season Rainfall and Rise in Temperature

Balochistan used to witness three or four rain spells throughout the monsoon season, however, the rains are out of sync lately, either there is an

unexpected, intense downpour that causes a deluge, or there has been no rain for months (Rafiq et al., 2022). During the 2022 monsoon season, the province recorded 500-700% above-normal rainfall in districts, such as Lasbela and Jhal Magsi, leading to devastating floods. While, rain in some areas in the province decreased to only 1-2 irregular spells, annually. Moreover, drought conditions between 2018 and 2021 affected over 60% of the province, with precipitation levels falling from 30-50% below the historical average.

Due to climate change, temperature is increasing and extreme weather events, such as heat waves have started taking place in the province (Kreft & Eckstein, 2013). For instance, the Quetta region recorded an increase of 1.1°C in mean annual temperature from 1961-2020, higher than the national average of 0.8°C. The past average temperature in the province was around 21°C, while recent data indicates that temperatures are now average around 22.1°C. Historically, 15-20 days per year were considered "very hot" (above 40°C), however now, due to climate change, this number has increased to 40-50 days per year.

Quetta City has not witnessed snowfall in the recent years. Although, the surrounding mountains do receive some snowfall each winter. In past decades, the city used to experience a fair amount of snowfall in the winter and due to its scenic beauty and snow, it was known as ‘Little London’ which is not the case any longer (Khan et al., 2021).

Impacts on Health

Balochistan is Pakistan's least populated province with the lowest HDI score. Inadequate health services, resulting from a variety of factors, such as a shortage of basic facilities and qualified medical personnel, communities living in remote or nomadic areas, as well as other sociocultural barriers, limit basic health services.

Heatwaves, combined with prolonged dry spells, have further worsened waterborne diseases. Resultantly, 30-40% of the population is suffering from diseases, such as diarrhea and typhoid due to contamination of water sources. Furthermore, rising temperatures and increased flooding due to intense rains have contributed to the spread of vector-borne diseases, such as malaria and dengue, with malaria cases increasing by 30-40% in recent years. The decreasing availability of water has also led to food insecurity and malnutrition, especially in rural areas, where 30-40% of

children suffer from stunted growth due to poor nutrition. The province also has one of the highest infant mortality rates of 79 per 1000 live births. Lack of access and availability of all basic health necessities and services with the combined effects of climate change have placed immense pressure on Balochistan's already fragile healthcare system. This may have a detrimental effect on the already vulnerable population of Balochistan (Government of Pakistan, 2011).

Impacts on Energy

According to data, Balochistan's overall electricity demand is estimated to be between 1,400 and 1,600 MW annually, however, the supply is closer to 700 MW. The province's electricity grid networks lack the capacity to transmit energy in order to meet demand in full. Increased investments in the province are anticipated due to CPEC. Two examples of these projects are the 1,320 MW coal-based power plant in Hub, Balochistan, and the 300 MW imported coal-based power project in Gwadar. Balochistan is a significant player in Pakistan's power sector and has made significant energy-related investments in recent decades. Therefore, it is crucial to carefully consider its choices for energy demand. Due to climate change impacts, the rising temperatures have also led to an increase in energy needs, since households depend more on electrical appliances to stay cool during the long, hot summers.

In the broader context of global energy demands and climate change mitigation, nuclear power offers a significant advantage as a clean energy source. Unlike fossil fuel-based energy generation, nuclear energy produces virtually no greenhouse gas emissions during operation, making it a critical component of the energy mix for addressing climate change. As countries and regions strive to meet growing energy demands while reducing their carbon footprints, nuclear power provides a reliable, low-carbon alternative that can support both energy security and climate objectives. Its capacity for large-scale, stable energy generation, combined with advancements in technology, positions nuclear power as an essential part of the global transition towards sustainable and clean energy systems.

Disaster Risk Reduction

One of the main factors and climate-related obstacles to Balochistan's development is the frequent drought which has considerably harmed Gwadar and Lasbela in recent years (Balochistan University of Information

Technology, Engineering and Management Sciences, & Quetta and Global Change Impact Studies Centre, 2019). The consequences of this phenomenon are particularly noticeable in the province. This is because it reduces crop yields, lowers water levels, and raises the death rates of livestock and wildlife (Iqbal, 2020). Simultaneously, the province is vulnerable to flooding during the monsoon season, especially the communities residing in villages near the three main watershed areas/basins, that is, the Hub River Basin, the Porlai River Basin, and the Gwadar Ormara Basin (Food and Agriculture Organization of the United Nations, 2011). In Lasbela, intense rainfall in 2007 destroyed about 40% of health facilities. Previously, due to heavy water flows in 2005, the Makran Coastal Highway got washed away, resulting the loss of millions of dollars. The province also faces challenges in providing relief and rescue after disasters since the majority of its population lives in remote communities and has inadequate physical infrastructure. This underscores the importance of early warning systems and preemptive adaptation measures (The World Bank, 2010).

Proposed Contemplative Responses

The ability of a system to modify and react to the consequences of a drought or other pressures, or to anticipate such events and prepare itself beforehand, is known as 'adaptive capacity or adaptability' (Smit & Skinner, 2002). In other words, it is the ability of a system to adapt to climate change by mitigating possible damages, seizing opportunities, or dealing with the fallout and consequences. To put it another way, adaptive capacity is the system's ability to create and carry out efficient adaptation plans or to respond to changing stresses and hazards in order to lessen the likelihood that these hazards would arise as a result of climate change (Government of Pakistan, 2013).

Pakistan, particularly Balochistan's exposure and vulnerability to the consequences of climate change demand that adaptation and mitigation actions must be prioritized and put into action. Water, food, and energy security for the people of the province as well as minimizing the effects of natural disasters on the economy, human life, health, and property can only be achieved by planning and executing suitable adaptation measures, preferably nature-based solutions, at the national and local levels (Government of Pakistan, 2011). Nevertheless, the core of the issue is bad governance and any potential solutions may only be implemented if

government makes competent, workable decisions. The following section provides key initiatives to address climate change adaptation and mitigation, both long and short-run strategies in the context of Balochistan.

Water

- Water situation in the province demands to ensure the use and exploitation of groundwater by avoiding excessive pumping.
- Regulate and resolve the demand for water storage and distribution in the province.
- Create infrastructure required to fully use hill torrent potential.
- Conserve water where possible including cutting down on irrigation system losses and offering incentives to use more efficient irrigation methods.
- Adopt and implement the laws and rules necessary to establish a groundwater regulatory framework and to manage water resources, effectively.
- Encourage and support farmers in Balochistan to maintain and enhance the traditional *Sailaba* farming irrigation system which has a lot of room for improvement if built and operated correctly.
- Establish a seasonal hydro-meteorological forecast, particularly for monsoon rainfall storage and usage.

Forests

A very small land area of the province is covered by forests including the Juniper, around Ziarat and Chilghoza forests near Zhob. These forests offer a variety of advantages whichinclude controlling soil erosion, regulating water flow, medicinal plants, a key source of carbon sequestration, and supporting local livelihoods. The minimal amount of public funds allocated to restoration is not promising. In order to reduce the threats and vulnerability of forests and biological diversity from the effects of climate change, Balochistan needs to adopt the following policies in coordination with the federal government:

- Promote forest pathology research at provincial level to reduce damage to forests caused by insects and diseases. This is because the world's second-largest Juniper forest in Ziarat Valley, grown over thousands of

years, is facing serious threats both from climate change and a disease called Dieback.

- The axing of Juniper trees continues in and around Ziarat. Villagers cut the trees for shelter besides firewood in extremely cold weather, when the temperature is sub-zero in the entire valley. Moreover, the gas pressure in pipes drops drastically, leaving the locals without gas for weeks and months. Ziarat has not received the facility of gas for over two years now. These trees are also cut down for many other purposes, such as agriculture extension, construction, medicinal, and furniture purposes. The government should also provide means of burning to the local populace, such as gas and electricity regularly without any load shedding. Besides energy provision, there is a need to take effective measures in order to protect the interests of communities depending on forests. These interests include the creation of employment opportunities and development of specific forest prevention policies. This may help preserve these forests for the betterment of both the present and future generations.
- Encourage and pursue regeneration and afforestation initiatives using plantations. These include climate change-adaptable and promoting the use of substitute fuels to stop deforestation of Pine forests in the Sulaiman range and small Mangrove forests in the coastal belt and in other parts of the province.
- Establish forest protection and fire prediction services as well as strengthen forest departments' ability to curtail wildfires and involve local communities in the identification and extinguishment of wildfires as well. This is because these types of incidents have started occurring more frequently and there is a lack of required equipment to contain them. For instance, on 10th May 2022, a blaze erupted in the Pine Nut and Olive Forest of Sherani District in Zhob Division. The combustion soon turned into a large-scale wildfire. Firefighters from the provincial and national disaster management authorities tried to quench the flames, using rescue vehicles and firefighting equipment, with little success. Finally, the fire was extinguished with the support of Iran's "biggest firefighter aircraft" Ilyushin Il-76. Pakistan may also consider developing such aircrafts.

- Ensure community involvement in the preservation of the biodiversity of mountains. Moreover, introduce high-altitude, cereal crops, resistant to drought for the mountains of Balochistan by encouraging research into drought- and pest-resistant crops, as well as "low delta crops". Furthermore, encourage the use of hydraulic ram pumps and gravity drip irrigation in hilly regions of the province and discourage high water-demanding plants unless they are in locations that are flooded.

Agriculture and Livestock

- Introduce a new variety of crops with high yield capacity which may resist heat stress and drought as well as which are less prone to severe rainstorms.
- Introduce and improve livestock breeds that are more productive in terms of milk and meat, as well as which are also less vulnerable to heat stress and are more drought-tolerant.
- Improve irrigation methods by applying contemporary strategies including trickle irrigation and the usage of sprinklers.
- Ensure the availability of high-quality feed and fodder for livestock to enhance their grazing on rangelands.
- To lower the risk of crop failure, encourage farmers, especially in rain-fed areas, to cultivate a mix of heat- and drought-resistant low delta crops rather than monoculture.

Coastal

- It is important to build natural barriers, such as plantation and regeneration of mangroves, coastal palms, and other appropriate trees, especially in the vicinity of low-lying coastal human clusters. This may reduce soil and sand erosion and lessen the destructive effects of cyclones and tsunamis.
- Determine vulnerable coastal areas that need to be protected from commercial activities and infrastructure construction, and decide about the level of activities allowed in those areas.
- There is also a need to decrease and manage garbage disposal as well as solid and liquid pollution in bay areas.

Health

It is now a widely acknowledged fact that climate change has major negative effects on human health due to an increase in the frequency and intensity of extreme weather events, such as heat and cold waves, excessive or insufficient precipitation, strong winds, and cyclones. For instance, floods and storms not only raise the chance of death and injury, however, they also have other health effects. These effects include diarrheal illnesses brought on by a lack of clean water for drinking, cooking, and personal hygiene. Besides, the impacted population may also experience serious psychological issues, resultantly. Similar to this, the risk factor of numerous vector-borne illnesses that are sensitive to rainfall and temperature, such as dengue fever and malaria, rises with anticipated climatic changes. Therefore, there is a need to improve and expand disease outbreak monitoring and forecasting systems. These systems may prevent potential health impacts of climate change and enable early planning for effective interventions. Besides, there is also a need to adopt water and sanitation safety strategies for rural and urban areas.

Local Strategies for Floods

When a flood disaster is likely to occur, the residents of the area must employ specific regional coping mechanisms in order to protect their homes from the damage. The following strategies may be adopted at local levels to seek protection from floods:

- Repairing the roofs and walls of houses
- Raising the house, off the ground
- Making taller plinths for rooms
- Planting trees and grass next to house to reduce soil erosion
- Dry and steady food reserves

Moreover, water reservoirs should be built in the upper catchments of Naseerabad and Jaffarabad to lessen the flood damage and control the flow of water over the division. Most of all, flood irrigation must be avoided and modern efficient irrigation methods should be adopted, such as the use of sprinklers, drip, and trickle irrigation systems.

Disaster Preparedness

With the anticipated rise in the frequency and intensity of extreme weather events, in addition to floods, landslides caused by heavy rains, droughts, and cyclones, climate change is expected to further increase the frequency and intensity of climate-related natural catastrophes. Although, climate change projections are scenario-based, thus its estimates involve a specific amount of uncertainty. There are compelling signs that the aforementioned risks are getting worse throughout South Asia, especially in Pakistan, as a result of climate change. Pakistan is already witnessing the effects of climate change which are too obvious to ignore. Consequently, there is a need to make arrangements in order to reduce its effects by taking preparedness and adaptability measures. In order to comprehensively tackle disaster management within the framework of climate change, the Governments of Balochistan and Pakistan should take the following measures:

- Advance and strengthen the disaster management institutions, procedures, and capacities that can handle a variety of risks and improve the institution's overall resilience, effectiveness, and efficiency.
- Clear protocols need to be established for mechanism and coordination that specify the responsibilities of every department involved in natural disasters. Moreover, interministerial coordination should be enhanced at both the provincial and federal levels related to climate change through interdepartmental decision-making and coordination mechanisms. Local capacities must be enhanced for disaster preparedness and mitigation at district levels.
- There is a need to upgrade and redesign the storm drainage capacity of the provisional capital and other vulnerable monsoon areas as well as cities of the province in light of the anticipated rise in short-duration, severe rainfall events linked to climate change.
- Flood and cyclone shelters should be built in areas vulnerable to floods, cyclones, and heavy rains. In this regard, redesigning and constructing multipurpose disaster resilience structures including schools and other government building may serve as a safe shelter and withstand natural disasters.

- A curriculum on environmental planning and climate change needs to be introduced and developed with a focus on disaster risk reduction (DRR). This should be inc;uded in the formal education system at all levels, especially the higher education system.

Conclusion

Despite contributing minimally to GHG emissions, Balochistan remains disproportionately susceptible to the adverse effects of climate change due to its unique socio-economic and environmental vulnerabilities. With GHG emissions totaling 490 million tons of carbon dioxide equivalents in 2017–2018, the province faces multifaceted challenges including water scarcity, recurrent droughts, flooding, and increased frequency of extreme weather events. These challenges are exacerbated by insufficient infrastructure, limited technological capabilities, and socio-economic constraints, such as pervasive poverty, inadequate educational opportunities, and limited access to healthcare services.

This study revealed that Balochistan must contend with a dual imperative: addressing the immediate impacts of climate change while simultaneously tackling deep-seated structural deficiencies. Emerging threats, such as escalating food insecurity and water shortages further accentuate the province's vulnerability. Projections indicate that, in the absence of effective intervention, climate change would severely impact agricultural productivity, livestock, public health, and energy accessibility over the coming decades. This necessitates the implementation of urgent, holistic, and contextually tailored adaptive strategies.

One critical avenue for mitigation lies in diversifying energy resources, particularly through the adoption of nuclear power as a clean and sustainable alternative. Nuclear energy, characterized by its minimal carbon emissions, holds significant potential to bolster Pakistan’s energy security, reduce reliance on fossil fuels, and facilitate sustainable development in Balochistan. Integrating nuclear power within a comprehensive strategy for climate adaptation and mitigation could address energy-related challenges while fostering long-term industrial and economic growth.

Enhancing Balochistan’s climate resilience requires the mainstreaming of adaptation measures into provincial development frameworks, the strengthening of institutional capacities, and the adoption of inclusive, community-centered resource management practices. Investing in clean

energy solutions, particularly nuclear power, represents a pivotal opportunity to mitigate the multifaceted impacts of climate change while advancing sustainable development and improving the socio-economic conditions of the region's population.

Conflict of Interest

The authors of the manuscript have no financial or non-financial conflict of interest in the subject matter or materials discussed in this manuscript.

Data Availability Statement

The data associated with this study will be provided by the corresponding author upon request.

Funding Details

No funding has been received for this research.

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