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Climate Change in Pakistan: Impacts, Strategies, and the Way Forward

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ABSTRACT

The purpose of this study is to evaluate the social implications of climate change in Pakistan and to identify the most crucial government responses to the issue. Pakistan is particularly vulnerable to climate change; there are frequently significant floods and times of intense rain there, which have a detrimental effect on the country's infrastructure, agriculture, and human life. These climate-related effects have a significant impact on many facets of society, including social justice, health, food security, and displacement. The study involves a thorough investigation of past extreme weather events, scientific studies, and reports to determine the effects of climate change in Pakistan. Additionally, it examined government programs and activities for reducing and preparing for climate change. Pakistan has enormous difficulties from climate change, which exacerbates existing vulnerabilities and has an impact on many facets of society. Encouragement of renewable energy, reforestation, energy efficiency, climate-resilient agriculture, public awareness campaigns, and international collaboration are a few examples of government activities to combat climate change and reduce greenhouse gas emissions. It is advised that Pakistan maintain the specified strategies while guaranteeing the active participation of all stakeholders in order to effectively address climate change. Building a more resilient and sustainable future will also depend on boosting investments in climate change adaption strategies and encouraging international cooperation

Introduction

Pakistan has 230 million citizens, making it the sixth most populous country in the world. It features a large variety of biological zones, from the Karakoram Himalayas in the north to the coastal zone in the south, and a plethora of natural resources. In the east are the Indus and its tributary flood plains, and in the west are the Himalayan and Hindu Kush mountain ranges. Each of these ecosystems has received resources that have helped the country's economic development. The country's robust livestock industry has been supported by the rangelands, which make up the majority of the country's steep topography.(Guanabara et al., n.d.).

The grave global catastrophe of climate change requires immediate attention from governments, organizations, and individuals on a global scale, as well as prompt action. The

majority of experts concur that the observed changes in Earth's climate over the past century are largely attributable to human activity, and that minimizing these consequences will involve reducing greenhouse gas emissions.

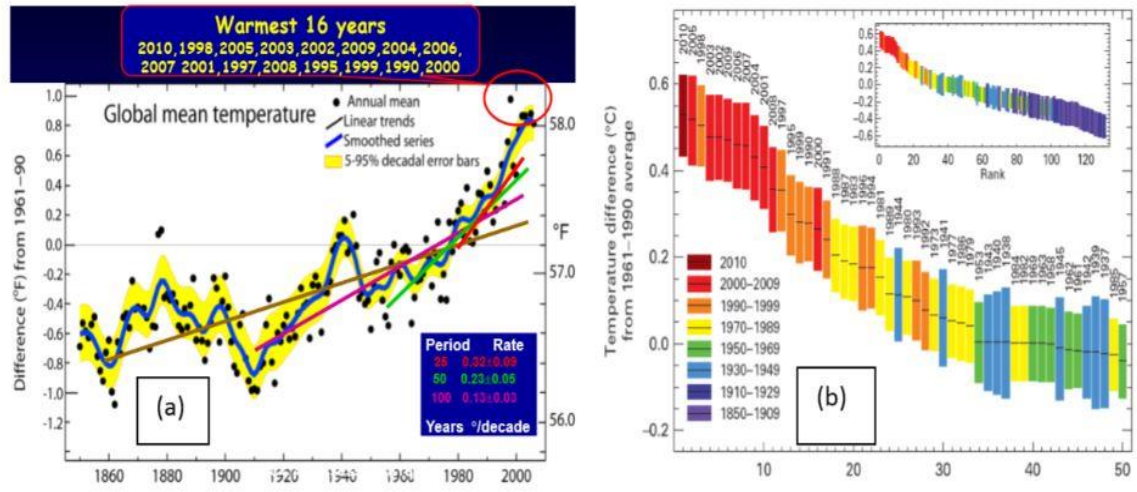

Figure 1. The worldwide average temperature trend (a) since 1850, with a ranking of the 16 warmest years (IPCC 2007 revised with new data) and color coded decadal average global temperatures compiled by WMO (2011).

It is commonly acknowledged that Pakistan is particularly susceptible to the effects of climate change. Over the preceding ten years, there has been a rise in extreme weather events such floods, droughts, glacial lake outbursts, cyclones, and heat waves, which has hindered the country's economic progress. For instance, the 2010 mega flood alone caused $10 billion in damage, claimed 1,600 lives, and inundated 38,600 km2. (Mondrow, 2016). Similar to this, around 1,200 people died in the June 2015 heat wave in Karachi.

Literature Review

The population and socioeconomic dynamics of Pakistan are significantly impacted by the country's unique terrain and climate. The 796,000 km2 of terrain in the nation receives a wide range of temperatures and precipitation patterns. The southern portion of the country experiences rain mostly in the northern and western regions during the winter monsoon, which lasts from December to March. In contrast, the eastern regions of the southern half are mostly affected by the southwest summer monsoon, which occurs from June to September (Iqbal & Lodhi, 2014). The yearly precipitation is contributed by the summer monsoon to the tune of about 60%. The majority of the country experiences less than 250 millimeters of yearly rainfall due to the country's dry to semiarid environment, with the exception of the northern sub-mountain region and southern Himalayan slopes, which see higher quantities ranging from 760 mm to 2,000mm.

The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) emphasizes the challenges faced by nations that depend on agriculture, like Pakistan, in breaking the cycle of poverty brought on by climate change. According to

estimates, South Asia would warm faster than the rest of the world, which will cause glaciers to melt and alter precipitation patterns (Pervaiz Amir & Habib, 2015). Industries that depend on water resources will be directly impacted by these changes, especially in the timing and intensity of the monsoon rains, which would lower their productivity and efficiency. Towering mountain peaks like K-2 and sizable glaciers like Siachen and Biafo, which feed the Indus River and its tributaries, are features of the northern region. The coldest months (January to March) see lows of -50°C while the hottest months (July to September) see highs of

Due to its extensive reliance on agriculture, Pakistan's economy is particularly susceptible to the effects of climate change. Crop yields and the availability of water for irrigation will be negatively impacted by changing monsoon dynamics and altered precipitation patterns, which will disrupt agricultural activity. Because a sizable section of the population relies on agriculture as their main source of income, this furthers the cycle of poverty. The nation also suffers socioeconomic difficulties, including as poverty and restricted resource access. With considerable provincial differences, over 50% of the population is estimated to be below the poverty threshold of $2 per day's purchasing power parity. The difficulties brought on by climate change are further worsened by socioeconomic considerations, furthering already-existing inequities (Caimotto, 2022).

The Baluchistan Plateau and the Indus River basin plain are significant geographic features in Pakistan's western and southern regions. The Indus basin, which comprises 65% of the nation's total geographical area, is home to the Indus Basin Irrigation System, the largest continuous irrigation system in the world. The Indus plain experiences varied temperatures in the higher and lower plains with average annual rainfall of 230 mm. With around 20 to 30 millimeters of rain falling on average each month and less than 210 millimeters annually, the Baluchistan Plateau is made up of mountain ranges and a sizable desert. The population and socioeconomic dynamics of Pakistan are significantly impacted by the country's unique terrain and climate. The cycle of poverty is sustained by the nation's susceptibility to the effects of climate change, notably in the agricultural sector (Arias-Carrera et al., 2019). The difficulties brought on by climate change are further exacerbated by socioeconomic issues, a lack of adaptation capacity, and geographical differences. For Pakistan to develop sustainably and adapt, it is essential to comprehend and handle these difficulties.

Material and Methods

Research is generally defined as the purposeful gathering and examination of factual data on any topic. To investigate questions of philosophy and methodology, this project will take a qualitative approach. collecting information to support the study's. A descriptive analysis' main objective is to describe something. The objective of applied analysis is to evaluate practical problems and draw conclusions in a variety of areas, including product and process design. The goal of fundamental science is to stifle scientific curiosity, not to immediately apply discoveries to real-world issues. The project's objectives are to examine how climate change is affecting floods in Pakistan and offer flood control options. The aim of the project is to investigate Pakistan's flood vulnerability, particularly in the context of

changing weather patterns, a rise in the frequency and severity of extreme weather events, and other factors.

To efficiently manage floods, the creation and upkeep of infrastructure, such as dams and barrages, is emphasized. In order to overcome the difficulties of flood management, the study also emphasizes the significance of early warning systems, boosting international collaboration and extending their reach to remote places. Additionally, community-based solutions are emphasized as effective tactics for lessening the effects of floods, particularly in vulnerable areas. The study emphasizes the necessity for sustainable flood management practices while recognizing the importance of the monsoon season and its effects on agriculture, public health, and the economy.

Reasons of Climate Change in Pakistan

Climate change is the term used to describe the global change in long-term weather patterns and average temperatures. Pakistan is one of many countries that are feeling the effects of climate change. Deforestation is the elimination of trees from a region due to either natural or human-caused factors. Because they release oxygen and absorb carbon dioxide, trees are crucial for regulating the climate of the planet. Deforestation is a serious issue in Pakistan, where a lot of trees are being cut down for farming, logging, and urban development. (Pervaiz Amir & Habib, 2015)

Agriculture is a significant contributor to greenhouse gas emissions in Pakistan. When synthetic fertilizers and insecticides are employed, methane is created throughout the livestock production process and emitted into the atmosphere together with other gases. Numerous sizable glaciers exist in Pakistan, including the second-longest glacier on Earth outside of the polar regions is Siachen Glacier. (Iqbal & Lodhi, 2014) Pakistan is extremely concerned about these glaciers melting because it could cause flooding, landslides, and a shortage of water. Fossil fuel combustion, industrial activities, and transportation all contribute to air pollution, which has a number of detrimental consequences on the environment and human health. Many Pakistani cities, notably Lahore and Karachi, are experiencing an increase in air pollution.

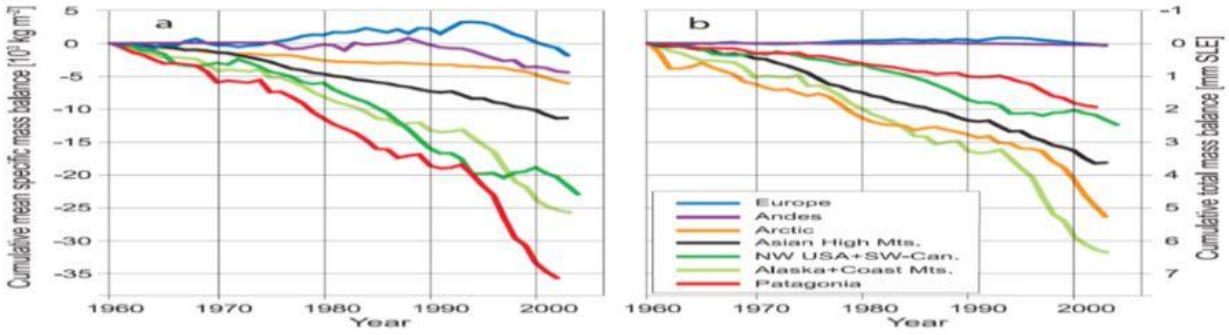

Figure 2. Global glacier status (a) as a result of global warming, with the Himalayan glacier's retreat indicated by a black line, and melt water contribution (b) to comparable sea level rise (IPCC 2007).

Pakistan suffers from a freshwater scarcity, and the Indus River and its tributaries provide the majority of the nation's water needs. Since melting glaciers alter river flows and altered rainfall patterns result in more frequent droughts and floods, climate change is having an effect on the country's water supplies. As a result of climate change, extreme weather events including heatwaves, droughts, floods, and cyclones are becoming more often and severe in Pakistan. These events have a huge impact on the nation's infrastructure, economy, and agriculture. (Caimotto, 2022). Climate change is a result of faulty waste management, which releases methane and other greenhouse gases. Trash management is a big problem in Pakistan because there are so many sites where there aren't adequate disposal facilities.

By 2050, Pakistan is expected to have the fifth-largest population in the world due to its high population growth. The natural resources of the nation are under increasing stress as a result of this growth, which also increases pollution and greenhouse gas emissions. (Arias-Carrera et al., 2019). Recent years have seen a tremendous industrial expansion in Pakistan, which has increased greenhouse gas emissions. One of the biggest emitters in the nation is the manufacturing sector, which includes important emitters like the steel, cement, and textile industries. In Pakistan, biodiversity is declining as a result of climate change, which is affecting ecosystems and the species that live there due to changes in temperature and rainfall patterns. The disruption of ecosystem services and harm to human well-being that can result from this loss of biodiversity can have far-reaching effects.

Important habitats like mangroves and coral reefs can be found throughout Pakistan's extensive coastline. Rising sea levels and more frequent, violent storms, on the other hand, are eroding the coast as a result of climate change. Because it can result in flooding, saltwater intrusion, and the loss of livelihoods, this erosion has severe effects on coastal populations. (Arias-Carrera et al., 2019). The energy industry in Pakistan is inefficient and does not invest enough in renewable energy sources. This has the effect of increasing greenhouse gas emissions and the effects of climate change. A more sustainable energy system may be created by making investments in renewable energy sources like solar and wind. (Rees et al., 2019). Deforestation, overgrazing, and urbanization are examples of land use practices that can have a big impact on the climate. Poor land use practices in Pakistan cause biodiversity loss, desertification, and soil erosion, all of which worsen the effects of climate change.

Floods are among the extreme weather occurrences that climate change is predicted to make more frequent and severe in Pakistan. Changes in temperature, precipitation patterns, and the melting of glaciers in the Himalayas, the source of the majority of the nation's rivers, are already being felt in the country. Because of this, flood management strategies in Pakistan must put a special emphasis on climate change adaptation and mitigation measures. A variety of natural disasters, such as floods, earthquakes, landslides, and droughts, are common in Pakistan. These disasters often occur simultaneously, exacerbating the impacts on the population and the economy. An integrated approach to disaster risk reduction is necessary to reduce the risk of floods and other natural disasters in Pakistan.

Table 1
The life cycle, global warming potential, and changes in the concentration levels of various Greenhouse Gases (GHGs) in the atmosphere are all factors to consider. The reference for life time and warming potential is CO2.

S.No.	GHGs	Level in 1870	Level in 2007	Life Time in years (Relative to CO_2)	Warming Potential (Relative to CO_2)
1	Carbon Dioxide	280ppm	399ppm	1	1
2	Methane	700ppb	1745ppb	12	72
3	Nitrous Oxide	270ppb	314ppb	114	310
4	CFC-12	0	533ppt	270	12000
5	Sulphur Hexafluoride	0	480ppt	3200	16300

The development of infrastructure, particularly dams and barrages, has been a key focus of flood management in Pakistan. The country has a large network of dams and barrages on its major rivers, which are used for irrigation, hydropower generation, and flood control. However, there is a need to maintain and upgrade this infrastructure, particularly in light of changing weather patterns and increased demand for water. Early warning systems are critical in reducing the impacts of floods in Pakistan. The government has established a national flood forecasting and early warning system, which uses weather data, river flow data, and satellite imagery to provide alerts to vulnerable communities. However, the coverage of the early warning system needs to be expanded, particularly in remote areas that are more vulnerable to floods. Pakistan has received assistance from the international community in responding to floods. This has included financial assistance, technical expertise, and humanitarian aid. International cooperation is important in addressing the challenges of flood management in Pakistan, given the scale and complexity of the problem.

Social Implications of Climate Change in Pakistan

Climate change has a significant social influence in Pakistan, notably on the population's weaker segments, such as the disadvantaged, women, and children. The following are a few of Pakistan's most important social impacts of climate change. Climate change will make natural disasters like floods and droughts more frequent and severe, which may compel people to leave their homes and communities. Millions of Pakistanis have recently been compelled to evacuate their homes due to floods, which has resulted in extreme hardship and social turmoil. ("Pak. Forms Parliamentary Committee to Prevent Forced Conversions of Minorities," 2019). Climate change is having an influence on Pakistan's agricultural production, with changed rainfall patterns and increased temperatures leading to crop failures and food shortages. This might have significant societal effects, especially for marginalized communities who may already be struggling with hunger and poverty. (Granqvist et al., 2010)

Increased heatwave exposure, air pollution, and vector-borne diseases like dengue fever and malaria can all have a significant impact on people's health. These health issues may have a disproportionately negative impact on vulnerable populations like the elderly, children, and the impoverished. (Bergan & McConatha, 2001). Due to their potential lack of

resources and capacity to adapt to the effects of climate change, vulnerable groups are more likely to exacerbate already existing social disparities. Increased inequality and societal instability may result from this, especially in regions with limited natural resources. Water availability in Pakistan is being impacted by climate change, with more frequent and severe droughts being caused by altered rainfall patterns and melting glaciers. Significant societal repercussions may result from this, especially for women and girls who frequently have to go fetch water for their families.

Conflicts and disagreements over natural resources, such water and land, might be made worse by climate change. Conflicts over water resources are already commonplace in Pakistan; but, as a result of climate change, these conflicts are anticipated to become more severe and frequent. (Zarkasyi, 2008). Disasters and displacement brought on by climate change might interfere with education, resulting in missed classes, dropouts, and lower academic success. Given that education is a crucial component of social and economic mobility, this may have long-term effects on both individuals and communities. Due to their social and economic positions, women and girls may be more susceptible to the effects of climate change, which can worsen gender inequality. For instance, in Pakistan, women are frequently in charge of gathering fuel and water, which can be more challenging and time-consuming during droughts or other climatic disruptions.

Increased incidence of melancholy, anxiety, and post-traumatic stress disorder (PTSD) have been linked to floods and other climate-related disasters in Pakistan. In locations where resources are few or there is intense rivalry for resources, climate change can weaken social cohesion and raise social conflicts. Conflicts between communities and even between nations have been attributed in Pakistan to water resource problems related to the climate. Climate-related disturbances like droughts, floods, and crop failures may push people to abandon rural areas, which might result in migration and urbanization. Because of the potential for more resource competition and increased community diversity, this may cause social unrest.

Particularly in nations that are already suffering political instability, climate change may have a huge political impact. Conflicts over resources and calamities caused by climate change could make Pakistan's political unrest worse and deepen instability. (Waterman, 2021). In Pakistan, the social effects of climate change are widespread and complex, having an impact on everything from political stability and social cohesion to education and mental health. Building a more sustainable and fair future for all Pakistanis depends on addressing climate change in a way that considers these socioeconomic repercussions.

Community-based approaches to flood management have been successful in reducing the impacts of floods in Pakistan. These approaches involve working with communities to identify flood risks and develop measures to reduce the impacts of floods, such as building flood shelters and establishing community-based early warning systems. Such approaches are particularly effective in remote and vulnerable areas, where government resources may be limited. The monsoon season in Pakistan runs from July to September, during which heavy rainfall can cause flooding in low-lying areas. The monsoon rains are essential for agriculture,

but they can also be destructive, causing landslides and flash floods in mountainous regions, and inundating large areas of the Indus River basin.

The primary river system in Pakistan is the Indus River, which has many tributaries that originate in the Himalayas. Water for irrigation and the production of hydroelectric power are provided by the river system, which is essential for agriculture. The river system is, however, equally vulnerable to floods, especially during the monsoon season. Floods have a huge impact on Pakistan's agriculture, which contributes significantly to the nation's GDP and employs a sizeable section of the workforce. Crops may be destroyed, infrastructure may be harmed, and soil erosion may result. Floods can also cause waterlogging, which can have a long-term negative influence on the health of the soil and agricultural productivity. Public health can be significantly impacted by floods in Pakistan. Floods can raise the danger of vector-borne illnesses like malaria and dengue fever as well as the development of water-borne diseases like cholera and typhoid. Floods can disrupt services and harm health infrastructure, making it challenging to respond to medical emergencies.

Recommendations for Climate Change Disaster Management:

A flood disaster happens when water spills beyond its predetermined borders and destroys infrastructure, buildings, and other property. Floods can be brought on by human or natural causes, such as inadequate land usage or failed dams, high rainfall, snowmelt, or storm surges. Effective flood management involves a variety of tactics and actions to lessen the risks and effects of floods. Some important flood management tactics include. (Iqbal & Lodhi, 2014; Moghaddam, 2005). By locating development in less susceptible regions and putting in place measures to limit water flow, land use planning and management can help to lower the risks of floods. By retaining and rerouting water, infrastructure like dams, levees, and flood barriers can offer flood protection. In order to limit development in high-risk areas and to enable the natural retention and absorption of floodwater, floodplain management entails actions like zoning and property acquisition (Mondrow, 2016; Pervaiz Amir & Habib, 2015).

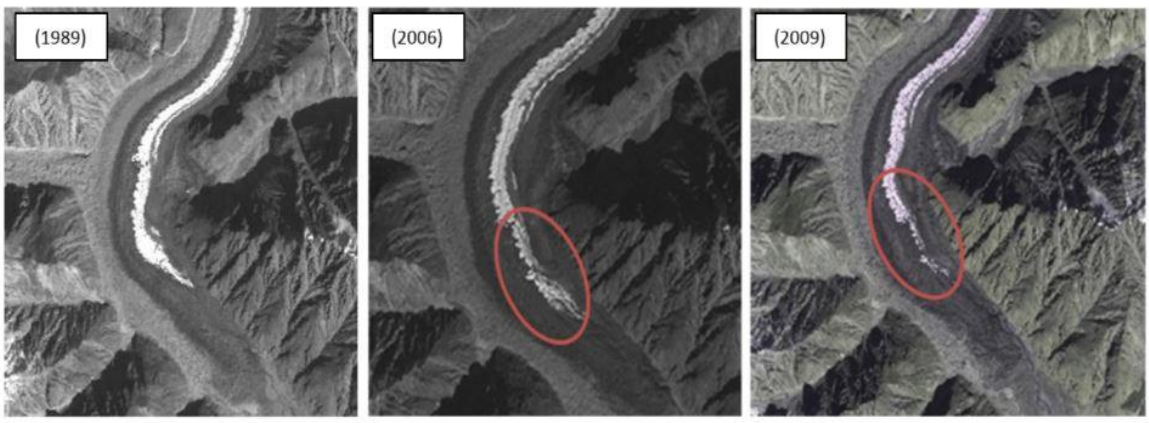

Figure 3. Siachen Glacier (HKH's largest glacier) receded 5.9 km in 21 years and lost 17% of its ice mass.

Promoting preparedness and resilience can be accomplished through educating and increasing awareness among communities about the dangers and effects of floods. This can involve educating people on flood prevention measures, flood safety measures, and flood response and recovery procedures. By ensuring that the necessary precautions are taken to safeguard people and property both during and after a flood, effective emergency response planning can assist to reduce the effects of floods (Afzal, 2018). It is possible to lessen the financial toll that floods have on people, businesses, and governments by having adequate insurance coverage and financial security. Governments may also offer grants or low-interest loans to flood victims in order to help them financially.

Climate change is expected to increase the frequency and severity of extreme weather events, particularly floods. (*GHRD Human Rights Report 2019*, 2019)As a result, it's crucial to incorporate climate change adaptation methods into flood control plans, such as bettering infrastructure and land use planning to take shifting weather patterns into account. International collaboration and coordination are crucial for effective flood management since floods can cross international borders and harm numerous nations. This can involve exchanging data and assets, working together on research and development, and carrying out collaborative flood management initiatives. (Karamat et al., 2019)

Following a flood, it's crucial to support and aid in recovery and restoration operations. This can involve giving those affected by the flood temporary accommodation and shelter, repairing the infrastructure and necessary services, and providing counselling and mental health care. Prioritizing actions to lower the risk of future floods and increase preparedness for catastrophes is also crucial. Using natural processes to reduce the risk of flooding, such as planting trees, restoring wetlands, and developing spaces for temporary water storage, is known as natural flood management (NFM). NFM can help to improve water quality, lessen the effects of floods downstream, and increase biodiversity.

Public-private partnerships can contribute to better flood management by combining the expertise and assets of the public and private sectors. This may entail working together on the creation, funding, and application of flood management plans (Afzal, 2018). By creating new instruments and methods for flood monitoring, modelling, and prediction, technology and innovation can contribute to better flood management. This can involve utilizing drones, advanced analytics, and remote sensing to better evaluate flood hazards and choose the best course of action. (Iqbal & Lodhi, 2014). The restoration of degraded ecosystems, the promotion of sustainable land use methods, and the preservation of natural infrastructure like coral reefs and mangroves are just a few examples of the nature-based flood risk reduction strategies used in ecosystem-based approaches to flood management.

The ability of communities and systems to adapt to and recover from floods must be strengthened in order to increase resilience to floods. This can involve taking steps to strengthen social networks and community cohesion, increase access to necessities, and encourage economic innovation and diversification. (ARUP, 2014). Overall, a variety of tactics and methods that are adapted to the unique hazards and vulnerabilities of each community are needed for efficient flood control. In many habitats, flooding occurs naturally, and it may

even be necessary to some extent in order to preserve biodiversity and maintain healthy ecosystems.

Conclusion

Climate change could pose a major challenge for Pakistan. To mitigate these threats, civil society and government must collaborate effectively at all levels. The yearly mean temperature in Pakistan has risen by around 0.5°C over the last 50 years. The number of days with a heat wave has nearly doubled in the last 30 years. Although annual precipitation has traditionally varied greatly, there has been a little increase over the last 50 years. The water level along Karachi's coast has risen by around 10 centimeters during the last century.

The annual mean temperature in Pakistan is expected to rise by 3°C to 5°C by the end of the century under a central global emissions scenario, whereas higher global emissions could result in a rise of 4°C to 6°C. The average annual rainfall is expected to be highly variable between years, with no obvious long-term pattern. Sea level is expected to rise by a further 60 centimeters by the end of the century, affecting low-lying coastal community's south of Karachi, towards Keti Bander, and the Indus River delta.

Future climate change models suggest that Pakistan's river flows will be more volatile as a result of more variable precipitation and glacier melting. Higher evaporation rates may increase demand for irrigation water. Due to expected losses in wheat and basmati rice yields, production may shift north based on water availability. It is possible that there may be less water available for hydropower production. Warmer temperatures are projected to increase energy usage due to higher air conditioning needs. Warmer air and water temperatures may reduce the efficiency of nuclear and thermal power plant generation. Extreme heat waves have been linked to an increase in mortality.

Crop cultivars that are more resistant to heat and drought may be created or used. Water-saving methods and modern irrigation infrastructure may also be utilized. Integrated watershed management, reforestation of catchment areas, additional water storage construction, diversification of energy sources, including investment in renewable and small hydropower projects, improved weather forecasting and warning systems, and critical infrastructure retrofitting may also be used.

Pakistan's main climate change strategy, the National Climate Change strategy of 2012, lays out the country's climate-resilient development goal and calls for climate change to be mainstreamed in the nation's most economically and socially vulnerable areas. Between 2010 and 2014, climate change-related spending in Pakistan accounted for over 6% of the federal budget, particularly in the energy and transportation sectors. As stated in its Nationally Determined Contribution to the Paris Agreement under the United Nations Framework Convention on Climate Change, Pakistan intends to reduce up to 20% of its projected greenhouse gas emissions by 2030, subject to the availability of international grants to cover the estimated $40 billion in total abatement costs. The estimated range of the nation's annual adaptation needs is $7 billion to $14 billion.

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