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RESEARCH PAPER

Climate Change Vulnerability and Adaptation Strategies in Balochistan Focusing on Water Scarcity Agricultural Fragility and Extreme Heat

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ABSTRACT

This review assesses Balochistan's vulnerability to climate change, focusing on challenges such as extreme heat, water scarcity, and agricultural fragility. It emphasizes the need for targeted climate adaptation strategies tailored to local conditions. Balochistan, located in southwestern Pakistan, is highly vulnerable to climate change, experiencing extreme heatwaves, erratic rainfall, and severe water scarcity. The province's challenges are compounded by its geographical isolation, underdeveloped infrastructure, and minimal government presence. The review examines current adaptation strategies, including water management, agricultural resilience, disaster preparedness, and ecosystem-based adaptation. It integrates traditional practices and modern solutions, like rainwater harvesting, drought-resistant crops, and early warning systems, to address climate vulnerabilities. Balochistan's challenges, including groundwater depletion, agricultural fragility, and coastal vulnerabilities, require urgent adaptation. The review highlights the importance of local knowledge, national policies, and international support to enhance resilience. Recommendations include strengthening community-led initiatives and fostering collaboration between local, national, and international stakeholders to ensure strategies.

KEYWORDS Balochistan, Climate Change, Adaptation Strategies, Water Scarcity, Agricultural Resilience

Introduction

Pakistan is among the world's most climate-vulnerable countries, although its contribution to the greenhouse gas emissions is one of the lowest in the world. Prolonged periods of extreme heat, poorly distributed rainfall and severe and prolonged water scarcity impact Balochistan, located in the southwestern area of the country, the most. Continued increases in temperature and prevalence of extreme weather render the country the 8th most impacted by climate disasters (Zia, 2023; Ahmed, et. al., 2021). Questions on the severity of the temperature increases were raised when 52°C was recorded in 2019 at Balochistan's Turbat, the lower climate-affected area of Pakistan (Kamran & Yamamoto, 2024). Under such severe conditions, water scarcity, particularly in Balochistan, where the water shortage is extreme, is of grave concern. Groundwater is substantially depleted, with areas of the Quetta basin losing 2.5 metres of groundwater in a year and 6 metres in other areas (Muzaffar, et. al. 2018;Memon & Ahmed, 2022; Sarwar, G., & Farid, A. (2025).). It widens the impacts on the population's daily life, subsistence agriculture, and livestock. As in 2019, when persistent flash floods displaced thousands of people, extreme weather events like flash floods and droughts further worsen the conditions. Enduring droughts and flash floods damage infrastructure, shelter, and crops (Manzoor, 2021).

The geographical isolation, lack of infrastructure, and absence of state presence all pose challenges to climate adaptation in Balochistan (Shahzad et al., 2021; Muzaffar, et. al.,

2021).). As for Balochistan, national climate strategies are too general and for all intents and purposes ignore the province (Nadeem et al., 2022). Of all the province's citizens, rural dwellers, who practise subsistence farming and pastoralism, feel the impact of climate change the most (Rana et al., 2023). Traditional farming practices, rain-fed farming systems, and subsistence farming and pastoralism are all highly climate sensitive and pose considerable climatic risk (Faisal et al., 2021). Being highly resource deprived, families engage in climate change-induced migration, moving to Quetta, which has already strained infrastructure (Fatima et al., 2023). This review aims to assess the climate challenges that leave Balochistan particularly vulnerable to the impacts of climate change, such as extreme heat and water and fragile agriculture. It studies the integration of local climate-related knowledge systems and the country's climate adaptation strategies, as well as global frameworks. This review articulates the importance of involving Balochistan's stakeholders to demonstrate the need for climate-responsive commitment, climate finances, and the climate institutional frameworks to deliver a climate-resilient Balochistan sustainable for the years to come.

Literature Review

Pakistan's National Adaptation Framework

Emphasizing climate change policy, Pakistan's National Climate Change Policy's third restatement, first introduced in 2012, places an increasing focus on climate change adaptation. Since 2021, the policy seeks to be less vulnerable to climate change, strengthen coping mechanisms about climate change, and merge climate change adaptation into the national development framework (Ahmed et al., 2020). The 2021 policy revision focuses especially on water security, sustainable development of agriculture, and disaster-related risks (Khichi et al., 2021). Under this policy, NAPs (National Adaptation Plans) are to be implemented which focus on development and climate adaptation in the Balochistan region with NAP bottom-up adaptation (Sohail et al., 2021). Climate change project adaptation governance at the MoCC is implemented and funded through the Climate Change division of the MoCC (Sajjad, 2024). Strategic regional governance adaptation implemented with the collaboration of regional and community governance (Ishaque et al., 2023). According to Naz et al. (2025), the coherence of the MoCC's control and evaluation function, which outlines the national plan, permits local differences to be incorporated.

Sectoral Approaches

Water Management

In Pakistan, the combination of water scarcity and climate change remains one of the most pressing challenges. The National Water Policy (2018) continues to prioritise the improvement of water efficiencies and the resilience of water resources, particularly for Balochistan (Baocheng et al., 2024), which encourages the adoption of rainwater harvesting, groundwater recharge, and irrigation practices, particularly drip irrigation, for efficient irrigation. Improving water-use efficiencies, particularly intersectoral and interdisciplinary water-use efficiencies in Balochistan, is also targeted by the Pakistan Water Sector Capacity Building Project (Iqbal et al., 2024; Javed et al., 2020; Farid & Adnan, 2022).). The rehabilitation and maintenance of canals and the expansion of irrigation infrastructure have additional goals wherein maintaining water availability becomes integral. Nazli et al. (2024) emphasise the case of Balochistan, wherein the allocated and available water for irrigation, domestic use, and human supply falls very poorly resilient concerning critical water scarcity. These efforts help avoid the critical water stress Balochistan is experiencing.

Agriculture

Pervaiz and Umar (2024) describe agriculture, which remains the most important sector of the economy of Pakistan, as the most climate change-vulnerable sphere, mainly due to dependence on temperature and rainfall for irrigation. Climate-resilient agriculture under the National Climate Change Policy promotes, among other things, agroforestry, better seeds, and drought-resistant crops (Iqbal et al., 2024). Initiatives such as the National Program for Food Security and Agricultural Adaptation prioritise research on the development of climate-resilient crops and agricultural diversification (Javed et al., 2020). To enhance productivity, the use of climate-informed weather predictions and moisture sensors integrated with mobile phones is advocated as a precision agriculture method. For the development of extension services on sustainable farming, the government aims to enhance farmers' knowledge and practices regarding climate-adaptive water use, crop rotation, and other methods. (Iqbal et al., 2024).

Disaster Management

Considering the extreme weather and climate conditions regularly faced in the country, the scale and touch of the Disaster Management Plan must be comprehensive. The Responsiveness, Preparedness, and Recovery functions of the NDMA fall within the various Disaster Management Plans (Zaman et al., 2024). The 2013 National Disaster Risk Management Policy seeks to identify and institute mechanisms for resilient and community-focused disaster risk management policy (Iqbal et al., 2022. For Balochistan, the initiatives for the floods and community preparedness have sustained focus and integration (Khan et al., 2024). Community preparedness initiatives help allow for meaningful and local response and respond to local voiced concerns (Zaman et al., 2024). The integration of local knowledge into national strategies, as climate and extreme events unfold, helps to save lives, protect economies, and reduce the adverse impact of destructive climate events (Iqbal et al., 2024).

Balochistan's Specific Environmental Challenges

Water Scarcity and Groundwater Depletion

Groundwater is extracted unsustainably, which leads to severe unaddressed water issues in Balochistan. Surface water is virtually non-existent; therefore, groundwater is utilised for domestic and agricultural needs. In Quetta and other urban areas, significant over-extraction leads to groundwater drought, with the Quetta Basin having groundwater levels up to 2.5 metres each year (Khan, et. al., 2022; Akhtar et al., 2021; Baig et al., 2020; Farid & Ashraf, 2025; Nadeem, et. al., 2023). Groundwater drought activates over-extraction rainfall, which leads to water unfit for human use and agriculture (Irfan et al., 2022). The unsustainable use of water is due to poor water governance and the total absence of self-sustaining enforcement (Rizwan et al., 2021).

Agricultural Fragility

In Balochistan, climate-sensitive agriculture primarily revolves around growing climate-sensitive crops, particularly wheat. Drought conditions have led to prolonged dry spells, which adversely impact the survival of certain crops, thus driving down overall yield, especially livestock (Panezai & Kakar, 2024; Durrani et al., 2021; Ashraf, 2021). Overgrazing and unsustainable farming have a synergistic effect on soil and land degradation, and over time, the land becomes desert-like, less arable, and poor-quality soil is left over relative to degraded soil of a given arable land. For instance, dry desert-like conditions in Nushki and Kalat are spreading to productive areas, causing potential agricultural production to shrink. This dry desert-like land is causing and relieving rural residents of their land; thus, displacement and desertification coincide (Hayat et al., 2021; Khan, 2022).

Extreme Heat Events and Climate-induced Disasters

Balochistan has recorded temperature extremes of up to 52ºC, with 2017 being Turbat's hottest year (Iqbal et al., 2024). Such extremes in temperature pose threats to human health, disrupt cultivation, cause the death of livestock, and worsen the already existing shortage of food and water (Khan, 2022). In addition to temperature extremes, heavy and unpredictable rains have caused flash floods, rapid glacial melting, and floods like in 2019 that were so devastating they destroyed homes, infrastructure, and crops and left thousands of people vulnerable and displaced (Panezai & Kakar, 2024). Such climate-induced catastrophes underscore the necessity to develop and maintain infrastructure, improve risk management, increase disaster preparedness and early warning systems to improve resilience (Jamil & Mahmood, 2024).

Coastal Vulnerabilities

Coastal Balochistan is disproportionately vulnerable to climate change because it experiences coastal erosion and rising temperatures and sea levels (Hayat et al., 2021). The erosion of coastal lands, intrusion of saltwater, and depletion of freshwater resources threaten loss of land and agricultural practices (Akhtar et al., 2021). Pollution and rampant urbanisation are causing the loss of biodiversity and the protective coastal mangrove forests (Khan, 2022). Unprotected coastlines increase the likelihood of flooding and storm surges to coastal communities when coastal mangroves are lost. Local fishers and the freedom to pursue their livelihoods are greatly impacted by the loss of marine biodiversity and the decline of ecosystems' health (Irfan et al., 2022). Communities and their livelihoods become more vulnerable because of the loss of marshes and the associated biodiversity infrastructures (Hayat et al., 2021).

Deforestation and Loss of Biodiversity

Illegal logging and subsequent deforestation have adversely affected biodiversity in Balochistan, particularly in Ziarat Juniper Forest (Iqbal et al., 2024). Ziarat Juniper Forest houses ancient and priceless juniper trees, and deterred land use has greatly affected Ziarat's unique ecosystem. The deterioration in the forest has caused the loss of wildlife and the ecological services these forests provide (Rizwan et al., 2021). Balochistan is also home to the endangered and poached Persian leopard and Balochistan bear, both of whom are losing habitat and suffering from poaching (Baig et al., 2020). Ecologically Balochistan is losing, and all the fronts decline when it loses such remarkable wildlife. The loss of wildlife is indicative of widespread and poorly managed degradation within the province. These failures in conservation have largely been due to under-resourcing and weak enforcement of the relevant environmental laws (Akhtar et al., 2021).

Material and Methods

A qualitative review of the literature, reports, and case studies on the impacts of climate change and adaptation for Balochistan provided the needed data. This review employed data contained in books and journals, government documents, and publications of agencies on climate issues. This review aimed to describe the region’s vulnerabilities and adaptation efforts, the use of local knowledge, and international assistance for the region. This review combined and assessed the policy gaps and implementation gaps of modern and traditional approaches to suggest improved climate change adaptation for Balochistan. This approach attempts to address the weaknesses, gaps, and issues.

Results and Discussion

Balochistan's environmental and other challenges are documented in Table 1. These challenges relate to impacts on water availability and the other important challenges of agriculture, biodiversity, and the coasts. Climate change, inadequate infrastructure, and

unsustainable practices further compound these challenges in different parts of the province.

Table 1
Environmental Challenges in Balochistan: Key Issues and Regional Impacts (Source: Author Created)

Challenge	Impact	Region Affected
Water Scarcity and Groundwater Depletion	Over-extraction reduces water availability.	Quetta, Kharan, Chagai
	Poor infrastructure leads to inconsistent supply.	Rural areas of Balochistan
	Lack of regulation leads to unsustainable practices.	Quetta, Nushki
	Groundwater salinization makes water undrinkable.	Quetta Basin, Kharan
	Low awareness increases water waste.	Rural Balochistan
	Reduced recharge deepens scarcity and affects crops.	Kharan, Chagai, Nushki
Agricultural Fragility	Irregular rainfall and heatwaves decrease yields.	Nushki, Kalat, Kharan
	Overgrazing reduces soil fertility.	Sibi, Nushki
	Droughts cause crop and livestock loss.	Nushki, Chagai
	Limited irrigation water reduces crop yields.	Rural Balochistan
	Lack of resilient crops increases vulnerability.	Nushki, Kalat
	Desertification leads to land loss and displacement.	Nushki, Chagai, Kalat
Extreme Heat and Climate Disasters	More heatwaves impact health and productivity.	Turbat, Quetta, Dera Bugti
	Heat stress causes crop and livestock loss.	Turbat, Sibi
	Flash floods cause destruction and displacement.	Sibi, Quetta, Rural areas
	Heat-related health issues increase mortality.	Turbat, Sibi
	Lack of preparedness delays disaster response.	Rural Balochistan
	Poor emergency systems increase casualties.	Rural Balochistan
Coastal Vulnerabilities	Coastal erosion causes land loss and infrastructure damage.	Gwadar, Pasni, Jiwani
	Saltwater intrusion damages crops and contaminates water.	Gwadar, Pasni
	Mangrove loss reduces coastal protection.	Gwadar, Jiwani
	Fishing communities displaced due to land loss.	Gwadar, Pasni
	Loss of marine biodiversity disrupts ecosystems.	Gwadar, Pasni, Jiwani
	Weak coastal protection increases storm vulnerability.	Gwadar, Jiwani
Deforestation and Biodiversity Loss	Deforestation leads to loss of biodiversity.	Ziarat, surrounding areas
	Illegal logging and land use destroys habitats.	Ziarat, Sibi
	Habitat destruction threatens endangered species.	Ziarat, Sibi, Chagai
	Poaching harms biodiversity.	Ziarat, Kharan
	Lack of resources hinders conservation efforts.	Ziarat, Nushki
	Loss of wildlife corridors affects species survival.	Ziarat, Kalat

Social Impact of Climate Change on Balochistan's Communities

Within the context of climate change, the social conditions of Balochistan province are suffering; extreme heat, poor rains, dried-up streams, dry farming and pastoral economy disruptions negatively affect the residents of the province (Panezai & Kakar, 2024). Rural farming-dependent families and social units suffer the negating rewards of the climate impacts and shifts of Balochistan (Rasheed & Sadozai, 2024). Rural social structural units of Balochistan suffer social conditions and health issues because heat, water, and climate

conditions negatively shifted their social and structural units (Abro et al., 2025). Social cohesion is affected deleteriously, and climate conditions as well as extreme heat increase the tension of societal units, and people interact negatively when water is scarce, and extreme heat impacts the social units adversely (Ashraf et al., 2021).

Climate-Induced Migration and Displacement in Balochistan

Climate-induced migration is one of the most urgent of these climate-related challenges in Balochistan. With the deterioration of the environment, especially in the rural areas, a growing number of families are abandoning their ancestral lands and moving in search of better opportunities. Quetta, like other urban centres, is experiencing increased internal migration as displaced people come to look for job opportunities and shelter (Ahmed & Ishrat, 2020). Overcrowded living conditions, poorly constructed housing, and increased urban resource scarcity as well as strain result from this migration which is poorly integrated into already constrained infrastructure (Makki et al., 2025). The socio-economic destabilisation of displaced, climate-affected people additionally heightens socio-psychological tensions with receiving populations, and these tensions are not constructively politicised (Saad et al., 2024). The absence of migration policy in Balochistan is a critical gap in the climate adaptation policy toolkit that prioritises direct climate impacts as well as socio-psychological ramifications of climate displacements (Iqbal et al., 2024).

Balochistan's Current Adaptation Strategies

Government and Institutional Responses

Balochistan is experiencing considerable challenges due to the absence of appropriate institutions meant to mitigate the impacts of climate change. While Pakistan has a national climate change policy, the provincial government in Balochistan has yet to resource the implementation of the policy, much less the solving of the challenges it has created (Makki et al., 2025). Balochistan has proposed regulations such as the Balochistan Environmental Protection Act to stem the destructive environmental degradation, but it has very poorly resourced, unsynchronised attempts to deal with the persistent situation (Iqbal et al., 2024). Local government efforts for climate change adaptation in the form of water storage for the dry period or flood control measures during the wet season have been very sluggish. Meanwhile, there has been the cultivation of more climate-resilient crops, efficient irrigation, and other water-saving practices, and rainwater harvesting to mitigate the impacts of climate change (Ashraf & Hasan, 2020). These activities will still lack a comprehensive provincial policy to guide them (Iqbal et al., 2024).

Community-driven Adaptation Practices

In Balochistan, climate change adaptation includes the utilisation of primitive indigenous knowledge systems, e.g., the karez system. Such methods remain invaluable in water-scarce regions, e.g., Kharan and Chagai (Ashraf & Hasan, 2020). Techniques such as the use of windbreaks, land terracing, and other soil conservation methods to combat desertification are also practised. Ecosystem equilibrium is attained through the combined use of sustainable livestock farming and rotational grazing (Panezai & Kakar, 2024). Adaptation methods are likely to remain challenged due to population pressures and the additional, far more complex challenges of climate change impacts, particularly drought and heat waves (Rehman et al., 2019). While the scale and broader impact will continue to be constrained, the absence of informal methods will, of necessity, render integration the only viable option (Makki et al., 2025).

NGO and International Support

International donors and NGOs implement climate adaptation strategies such as water management, sustainable agriculture, and reforestation in Balochistan. For instance, Nushki's solar-powered irrigation systems and rural rainwater harvesting systems have eased water access and reduced groundwater dependency (Ullah et al., 2024). Besides reforestation, NGOs restore coastal mangroves, which shield shore communities from storm surges, rising seas, and violent storms (Hayat et al., 2021). The sustainability and effectiveness of these interventions have, however, been questioned due to poorly planned, underfunded, and insufficiently monitored initiatives, as evidenced by large-scale interventions funded by UNDP and the World Bank (Makki et al., 2025). In the long run, the lack of a comprehensive plan will undermine these efforts (Qaisrani et al., 2022).

Key Adaptation Strategies for Balochistan

Water Management and Conservation

To mitigate the effects of climate change on water scarcity and to manage water sustainably for agriculture and domestic purposes, the region of Balochistan must incorporate water management practices, particularly rainwater harvesting. Community members can prevent over-extraction of groundwater, which shows signs of depletion, by constructing local collection systems and storage tanks (Ashraf & Hasan, 2020). Groundwater recharge, which can include artificial recharge systems, watershed management to restore over-utilised aquifers, and retention management, is yet another fundamental technique of water management (Qaisrani et al., 2022). The management of water resources also entails the restoration of water systems with karezes and rainwater ponds, which contributes to the increase of available water in dry areas and incorporates the local population's traditional knowledge. This is important to preserve (Ashraf & Hasan, 2020). Both the traditional and the modern systems will promote the effective management of water resources and the region's adaptation to climate change (Ullah et al., 2024).

Agricultural Adaptation and Food Security

Balochistan farms are at risk when a region has little water to grow winter crops. Research is required in the area to develop heat-resistant, drought-resistant, and regionally suited crops (Panezai & Kakar, 2024). Seed banks preserve economically important and climate-resilient seeds (Durrani et al., 2021). Biodiversity is grown in combination with crops, and the integration of trees (agroforestry) has proven ways to diminish erosion and enrich soil. This alternative also enhances food security by providing offseason timber and fruits and increasing the retention and fertility of soil water (Makki et al., 2025). Iqbal et al. (2024) identified sustainable irrigation, such as drip irrigation, as water efficient and productive for agriculture. Enhancing the integration of ecotourism and handicrafts within rural populations helps pull back people from agriculture (Makki et al., 2025). Implementing all the above will enhance food security and the agricultural capacity of Balochistan.

Disaster Preparedness and Early Warning Systems

Successively responding to disasters requires preparation in advance, especially considering historical patterns of flooding, prolonged heatwaves, and periods of drought in Balochistan. Prioritised localised Early Warning Systems (EWS) enable flow and communication, ensuring vulnerable and exposed populations receive clear, timely, and actionable instructions (Panezai & Kakar, 2024). EWS must be localised to centre community and regional climate predictors to monitor and provide increased advanced warning for actions for extreme weather and cover gaps for extreme weather events (Abro et al., 2025). Integrating Effective disaster response systems also account for coordination of provincial and local systems for rapid deployment of community disaster management committees for resource mobilisation and immediate counter relief (Rehman et al., 2019). Countering local community crisis capacity to climate events takes community training, and

to respond, training for cross disciplines and community-centred disaster preparation training must include climate adaptation and resilience fortification (Ullah et al., 2024). Expanded training initiatives ensure that community self-sufficiency initiatives provide climate resilience and improve climate crisis control.

Ecosystem-Based Adaptation (EBA) and Biodiversity Conservation

Ecosystem-based adaptation (EBA) focuses on the preservation and restoration of ecosystems that provide ecosystem services for climate change. In Balochistan, the restoration of mangroves is important for the preservation of biodiversity and protection of the coast. Hayat et al. (2021) assert the restoration of mangroves due to the impact of climate change, such as flooding and rising sea levels, as vital in protection from storm surges and saltwater intrusion. Restoring mangroves will help protect the coastal livelihood and fishery (Makki et al., 2025). Additionally, in Ziarat, prescribed deforestation and afforestation practices will help in the restoration of some of the deforested and degraded terrains. Such deforested landscapes will help recapture and reforest, restoring the redundant habitats and fostering biodiversity, and curtailing erosion, desertification, and the sequestration of atmospheric CO_2 (Ullah et al., 2024). Along with the habitat restoration, the conservation of the Balochistan bear and Persian leopard land will also be important. The climate-assisted conservation of such lands will help the Balochistan bear and Persian leopard conservation, improve climate resilience of the region and increase biodiversity of the region (Qaisrani et al., 2022).

Table 2 highlights important adaptation strategies for Balochistan and integrates strategies in water management, climate-resilient agriculture, disaster risk management, and restoration of ecosystems. For each of these strategies, explicit climate vulnerabilities of the Balochistan province have been integrated through the articulation of specific strategies, opportunities, constraints, and case study illustrations.

Table 2
Building a Resilient Future: Key Adaptation Strategies for Balochistan's Climate Challenges (Source: Author Created)

Strategy	Approach	Description	Benefits	Implementation Challenges	Examples
Water Management and Conservation	**1. Rainwater Harvesting**	Collecting rainwater for dry periods.	Reduces groundwater reliance.	Infrastructure cost, seasonal rainfall.	Household tanks in rural areas.
	2. Groundwater Recharge	Replenishing aquifers through recharge.	Restores aquifers ensure long-term supply.	Needs monitoring and infrastructure.	Recharge pits in Quetta Basin.
	3. Restoration of Traditional Systems	Reviving karez systems for irrigation.	Promotes sustainable water use.	Needs modernization and funding.	Karez systems in Kharan and Chagai.
	4. Efficient Irrigation Techniques	Using drip irrigation and sprinklers.	Increases efficiency, reduces waste.	High initial cost, farmer training.	Drip irrigation in Nushki.
	5. Water Conservation Campaigns	Educating communities about water-saving.	Reduces waste, fosters conservation.	Cultural resistance, limited awareness.	Awareness programs in rural Balochistan.
Agricultural Adaptation	**1. Drought-resistant Crops**	Introducing crops resilient to drought.	Enhance food security, resilience to climate.	Limited seed availability, adoption barriers.	Drought-tolerant wheat in Nushki.

	2. Agroforestry	Integrating trees into farming systems.	Enhances soil fertility, prevents erosion.	Requires investment and training.	Agroforestry projects in Nushki.
	3. Sustainable Irrigation Systems	Drip irrigation and sprinklers for water use.	Reduces water use, increases yield.	High cost, maintenance.	Drip irrigation in Nushki.
	4. Climate-Smart Agricultural Practices	Crop rotation, organic farming, and water conservation.	Improves soil health, crop resilience.	Lack of awareness, limited technical expertise.	Sustainable farming training in Balochistan.
	5. Diversified Livelihoods	Shifting to eco-tourism, handicrafts, etc.	Reduces dependency on agriculture.	Market access, training.	Eco-tourism in desert regions.
Disaster Preparedness and EWS	**1. Localized Early Warning Systems**	Tailored flood and drought alert systems.	Timely evacuation protects lives.	Infrastructure limits, need for local data.	Flash flood alerts in monsoon areas.
	2. Climate Forecasting	Using meteorological data to predict weather.	Help prepare for disruptions.	Inaccurate forecasts, reliance on external data.	Climate models for flood predictions.
	3. Disaster Response Systems	Improve coordination for quick relief.	Speeds up relief, reduces damage.	Coordination difficulties, resource issues.	Emergency teams in flood areas.
	4. Community-based Preparedness	Training locals in disaster management.	Improves self-sufficiency in crises.	Lack of funds, inconsistent participation.	Preparedness workshops in rural areas.
	5. Infrastructure Upgrades	Strengthening infrastructure against weather.	Reduces damage, protects livelihoods.	High cost, logistical issues.	Upgrading flood barriers and roads.
Ecosystem-Based Adaptation (EBA)	**1. Mangrove Restoration**	Replanting mangroves to reduce coastal erosion.	Protects coastal areas, enhances biodiversity.	Needs funding, long-term monitoring.	Mangrove restoration in Gwadar.
	2. Afforestation and Reforestation	Planting trees to restore ecosystems.	Reduces soil erosion, increases carbon storage.	Long-term commitment, land issues.	Reforestation in Ziarat.
	3. Biodiversity Conservation Programs	Protecting endangered species and habitats.	Preserves biodiversity, supports ecosystems.	Poaching, habitat destruction, enforcement.	Conservation of Balochistan bear and leopard.
	4. Sustainable Land Management	Using sustainable practices to restore land.	Improves soil fertility, combats desertification.	Local engagement, resource constraints.	Land restoration in Chagai and Kharan.
	5. Ecosystem Health Monitoring	Monitoring ecosystem health for better management.	Informs better management, supports policies.	Insufficient data, need for technical expertise.	Monitoring coastal and forest ecosystems.

Institutional and Governance Framework for Adaptation in Balochistan

Improving Governance and Institutional Coordination

The governance perspective of climate change adaptation for Balochistan to achieve targets is critical. The lack of action on climate adaptation plans is the result of misalignment

on the part of the federal, provincial, and local governments (Talal et al., 2023). There is no doubt that climate change plans require governance to serve as the primary function for all the avoidable impediments. Federal, provincial, and local governments operate with a lack of coordination when it comes to climate adaptation, and this is part of the problem (Talal et al., 2023). Communication and collaboration across all levels of government are necessary. To enhance the spreading of climate adaptations while closing the gaps of accountability and trackability, the functions and duties of the various institutions should be defined (Makki et al., 2025). Adaptation from the centre is possible through the coordination of climate-related data, assets, and policy (Rasheed & Sadozai, 2024). Also, as identified, local climate adaptation priorities will be addressed by local governments and local authorities. Local authorities are key partners to identify climate adaptation plans and implement relevant climate change policies (Panezai & Kakar, 2024). Supported local governments will receive the necessary resources, training, and preparation to carry out bottom-up climate adaptation, monitor climate resilience to forecast changes, and sustain deep resilience over the long term (Sultan et al., 2022).

Data and Knowledge Management

Improving the collection and management of data on climate change and its impact on Balochistan remains a priority. The absence of a fully integrated climate data collection system hampers the decision-making process and the provision of resources within the province (Khan et al. 2021). Collection of more granular data on the dynamics of temperature shifts, water budgets and soils will strengthen assessments and preparedness for climate risk (Abro et al. 2025). The use of spatial technology in conjunction with climate models will optimise the management of data and the allocation of resources to address the challenges of land and climate (Qasim et al. 2025). Climate models assist in the advanced planning of emergency climate scenarios and the prediction of extreme weather, such as droughts and floods (Khan et al. 2024). The province will be in a stronger position to refine its governance and improve climate adaptation through climate risk management to address the climate risks proactively and positively (Makki et al. 2025).

Capacity Building for Local Authorities

The local authorities in Balochistan need to be enabled to plan for climate change. Local governments lack the technical capacities, skills, qualifications, training, and funds to design and execute climate change projects (Shah & Qasim, 2025). This makes training in climate change and training in climate risk appraisal, resource management, and project implementation frameworks vital (Riaz et al., 2024). Local authorities could also be trained in design skills for adaptation interventions, prioritisation of adaptation needs, and vulnerability assessments (Irfan et al., 2024). Moreover, local authorities need to be funded to be equipped for the implementation of climate-adaptive projects (Makki et al., 2025). Local governments also need to be properly resourced, while local community organisations and NGOs should also be engaged in grassroots climate adaptation planning. NGOs can assist community members in climate adaptation and in the organisation of local, context-sensitive, and community-accepted adaptation activities (Riaz et al., 2024). Empowered local authorities will ensure climate change adaptation stewardship and climate resilience in the region (Sultan et al., 2022).

Financial Support for Adaptation

National and International Climate Finance

Achieving climate adaptation in Balochistan requires acquiring climate finance. Examples of global financing that offer funds for climate adaptation projects that focus on Balochistan's water, renewable energy, and climate disaster risk projects include The Green Climate Fund (GCF), The Global Environment Facility (GEF), and The Adaptation Fund

(Kalinowski, 2024). However, weak local institutions and the limited feasibility of projects to access and utilise funds of Balochistan make this quite challenging (Anjanappa, 2024). Potential funders look for well-conceived and actionable proposals, along with detailed documents concerning the subsequent monitoring and evaluation for their implementation (Morandi & Lewis, 2022). In addition to this, uncoordinated federal and provincial systems complicate the effective mobilisation of these funds (Makki et al., 2025). The existing local institutions concerning data compilation for climate adaptation, local climate adaptation project institutional frameworks, and remaining local institutional frameworks must be strengthened to access these international funds (Morandi & Lewis, 2024)

Private Sector and Public-Private Partnerships (PPPs)

For Balochistan, scaling up adaptation efforts hinges on the participation of the private sector. Private companies have the potential to finance renewable energy, climate-resilient infrastructure, and sustainable agriculture. As an illustration, solar energy, efficient irrigation systems, and climate-smart farming technologies would usher in solutions to the province's most pressing challenges (Nguyen et al., 2025). The public sector's willingness to form public-private partnerships (PPPs) and obtain public sector resources to finance adaptation projects constitutes a climate policy game changer (Kalinowski, 2024). The establishment of PPPs depends on the optimisation of the adaptation regulatory framework and the alignment of private interests with the local adaptation challenges (Owojori & Erasmus, 2025). These partnerships would significantly improve Balochistan's climate change adaptation capacity.

Innovative Financing Models

To address climate financing challenges in Balochistan, new and unique financing strategies are needed. Initially, Balochistan also uses blended financing for climate-adaptation projects. Balochistan projects also use blended financing, which is claimed to enhance the climate-adaptation projects' financial viability and sustainability (Anjanappa, 2024). Something similar is seen in financing the adaptation of climate infrastructure projects in the water and renewable energy extensions (Morandi & Lewis, 2024). Attention to Balochistan’s climate finance challenges also needs to consider the construction of financing frameworks with green bonds, climate bonds, climate insurance, and climate-financing tools. These would support long-term financing of complex adaptation strategies (Kalinowski, 2024). In the interest of equitable targeting of climate adaptation funds to avoid the concentration of funds in resource-rich areas, Balochistan climate adaptation funds and resource-marginalised vulnerable communities climate adaptation funds need to be merged (Makki et al. 2025). This ensures that the most vulnerable are targeted in the most efficient and resource-effective manner (Kalinowski, 2024).

Conclusion

Balochistan is highly vulnerable to climate change, with extreme heat, water scarcity, and agricultural fragility posing significant challenges. Current adaptation strategies, including water management, agricultural resilience, and ecosystem-based solutions, are crucial but insufficient to address the severity of these issues. The integration of modern practices, which include the use of drought-resistant crops and implementation of early warning systems, is critical to balance with the traditional ones. The combination of local expertise with national/international resources is the key to climate resilience in the region. Groundwater depletion, fragile agriculture, and vulnerable coasts require immediate advanced and coordinated action.

Recommendations

The adaptation practices that the communities have for Balochistan, such as agroforestry and rainwater harvesting, require attention for future studies. The integration of traditional systems, such as karez, which provide scale and flexibility in modern climate adaptation strategies, calls for further examination. It is equally important to study the socio-economic consequences of climate change on migration and displacement in Balochistan to get holistic insight on the issue. Finally, the evaluation of international funding and local adaptation initiatives, and the impact of such funding on local initiatives, will inform climate finance for the region.

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