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Groundwater Depletion in Balochistan Causes, Consequences, and Sustainable Management Strategies

Aqsa Rasheed
M.Phil. Scholar Dept. of IR, Iqra University Islamabad
aqsa12swati@gmail.com
Kinza Gul
Visiting Lecturer, COMSATS University, Islamabad
Kinzagul.hazara@gmail.com
Kalsoom Nasar
M.Phil. Scholar, Dept. of IR, University of Balochistan
Kalsoom90nasar@gmail.com

ABSTRACT
Balochistan's largest Pakistani province suffers from severe water shortages because of its desert weather, over-pumped groundwater, and weak state administration. Balochistan must cope with minimal rainfall of 50 to 350 millimeters per year since water loss by evaporation exceeds three thousand millimeters. Our research examines how water scarcity develops in Balochistan and checks whether its current management policies work effectively. We study approaches to provide safe water for future generations. Researchers use both technical data and on-site observations to create their study design. The study reviews multiple records to spot repeated water depletion issues and discover why existing policies did not work. The region of Quetta Valley experiences diminishing groundwater supplies by 2 to 3 meters yearly due to unrestricted expansion of tubewells and inadequate water management. Government control measures have not stopped water usage from getting worse, which now causes problems for both people and nature. People are restoring traditional karez systems, demonstrating better and more lasting approaches to managing water resources. Solving Balochistan's water problems depends on three changes: creating a single water authority, promoting water-saving tech, and giving local people power over their water resources. Our ability to sustain water resources in dry areas depends on combining old water-saving roots with new water technology. Research results help everyone in creating better water management plans for the future.

Keywords: *Water Scarcity, Groundwater Depletion, Balochistan, Water Management, Climate Change, Irrigation Practices, Governance, Karez System, Sustainable Solutions*.

Introduction

I. Introduction:

According to Wikipedia 2023 information, Baluchistan in Pakistan occupies 44% of its total territory and extends over 347190 square kilometers. The province shows the basic problems villagers live with because of their land usage and population math, which explains why they have limited water available. This research takes the climate and geographic context of dry areas in Baluchistan and then studies their population patterns in both rural and urban communities.

Geographical Overview: Arid Climate and Topography:

The province's semi-dry weather system gives Baluchistan annual rainfall ranging from 50 to 350 millimeters, as shown by World Data 2023 stats. Chaudhry 2000 also noted that water evaporates more than 3,000 mm every year. Thanks to its flat ground and mountainous areas, including the Suleiman, Kirthar, and Pab ranges, Baluchistan is declared an isolated region from the Indus Plain. The natural landscape blocks wind movement, which brings rain (Pakistan Almanac 2023). The Iranian plateau ridges block large amounts of falling rain into the groundwater system.

The Kharan desert contains the driest zone on Earth (Balochistan Government 2023) due to its minimal rainfall and intense desert heat in Balochistan province. The temperatures go down sharply at Ziarat, Quetta, and Kalat locations. The summer temperature in Makran reaches its peak at 50°C because multiple altitude levels determine how weather patterns shape this region (Balochistan Government, 2023). Though most of the area lacks farmable land, a unique water level measurement is required owing to its distinct environmental conditions.

Demographic Overview: Population Distribution and Rural-Urban Dynamics:

According to Voice of Balochistan 2023 research, Balochistan remained Pakistan's least inhabited region because only 12,344,408 people lived there, and the cities remained far from localities. Social statistics show that 72.4% of people reside in farmland villages that host 8,943,492 residents, while 27.6% of individuals live in cities that house a total of 3,400,807 citizens (Voice of Balochistan 2023). The farmers in powerless Baluchistan counties use karez wells since their water dugouts have reached unsafe levels due to heightened water consumption and rising temperatures of climate change. Eligible land around Quetta (1,001,205) sees most Baluchistan citizens, while unexpected growth in Gwadar and Turbat made the urban areas suffer from improper water supplies.

The demographic expansion in Baluchistan reached 3.37% each year from 1998 to 2017, which was significantly greater than the nationwide expansion speed of 2.4% (Geo.tv 2023). A growing number of people results in more water needed for their basic needs. The seasonal water supply sees change because of people who move between settled and nomadic lives across western and central Baluchistan. Most communities in Balochistan's rural areas lack enough inhabitants and proper water systems to meet their water demands, yet Quetta's enormous population strains its water supply network (PDMA Balochistan 2023). The year 2017 recorded only 43.6% of literate residents, ts which reduced the number of people capable of saving health and wealth resources for the future.

B. Statement of the Problem:

The water shortage problem in Balochistan Pakistan affects everyone who lives there plus the natural environments. The water reserves in Quetta Valley groundwater systems decrease by 2–3 meters annually as water shortages grow. When too many people misuse water during normal dry times these problems develop. The trouble creates two connected results.

Severity and Persistence of Water Scarcity. The consistent drop in groundwater levels, at a rate of 2–3 meters per year in areas like Quetta Valley, underscores the chronic nature of the crisis. Groundwater drains quickly because human water use during very long droughts and excessive use outmatches the groundwater's natural refill rate. Water shortage harms both human populations and natural habitats at the same time. A severe human health risk

emerges in farmland and urban areas when fresh water runs out. The lack of water leads to the destruction of natural environments and turns this location into a desert permanently.

Research Objectives:

Our study covers all aspects of the Balochistan water problem, analyzing what causes it, what happens to people, and how local solutions can better control it officially. Our study investigates all the following major areas of our research.

1. Scientific research explores natural and human elements that cause Balochistan's water shortage to discover how the environment and human population suffer and find effective solutions. The analysis monitors all reasons behind water shortages, such as climate change, natural events, and water waste from bad irrigation and groundwater exploitation. These research findings present how desertification harms the environment and biodiversity but also reveal how fewer farm harvests hurt public wellness. We need to connect water preservation methods like drip irrigation to new dams and reservoirs, working with desalination technology and growing strategies that fit the environment.
2. Internal and external evaluation is required for the water shortage policies in Balochistan to determine their success. We look at official government plans while reviewing local and worldwide organization water management policies. Our study examines existing water shortages solutions for their advantages and limitations until we discover effective approaches used by other successful water projects.

Research questions:

1. What drives groundwater depletion in Balochistan, and how do these factors worsen water scarcity in Quetta Valley?
2. How effective are current policies and karez systems in reducing groundwater depletion, and what limits their success?
3. How does groundwater depletion affect agriculture, health, and biodiversity, and influence Balochistan’s stability?

Purpose and Significance of the Study:

The Balochistan water crisis matters locally and internationally due to its effects on food security and population movements and because the province contains strategic land and resource deposits.

II. Literature Review:

A. Previous Studies on Water Scarcity in Balochistan:

Researchers mostly examine how human activities interact with climate uncertainty to cause water shortages in Baluchistan. Scientists determined that Balochistan faces water scarcity because rainfall dropped by 30% last decade while global climate change made temperatures rise (Chaudhry 2000; World Data 2023). According to IPCC (2023) 45, South Asia will experience 4°C temperature changes by 2100, which will make less surface water available in Baluchistan's dry basins because of increased natural water evaporation. NASA GRACE satellite data from 2002 to 2022 reveals that the Quetta Valley lost 2.8 centimeters of groundwater annually and currently produces the most agriculture in Baluchistan Province.

People keep using groundwater without protecting it, which creates more than necessary water pumping. In Killa Abdullah District, groundwater resources declined 150% faster than they were replenished from 5,000 to over 20,000 tubewells during the period from 2000 to

2020 (World Bank 2022, 8). According to Chaudhry (2000, 34), farmers extract excessive groundwater because they have unlimited access to it at a very low cost through electric tubewells. Farmers lose half their water supply as flood irrigation lets water evaporate from the surface and run off into the ground (Qureshi 2019, 112).

Water scarcity impacts social and economic activities severely at both societal and economic levels. Research by Mustafa et al. (2020: 567) demonstrates rural women from Baluchistan spend 4 to 6 hours daily to collect water instead of studying or earning money. During the last ten years wheat production in Nushki District dropped by 40% leading to lower food prices and increased poverty among residents (PDMA Balochistan 2023, 15). Drought-stricken regions face high chances of developing waterborne diseases like diarrhea and cholera (UNICEF 2021).

B. Comparative Perspectives:

Understanding water problems in dry regions shows us what Baluchistan requires. The Left Bank Outfall Drain project started in 1997 and took away 1.2 million acre-feet of saline water from farmland yearly, as reported by Mirza in 2015 (page 89). The project shows that big drainage systems can successfully fix water quality problems in Baluchistan coastal areas regardless of community relocation issues. Through the Mukhya Mantri Jal Swavlamban Abhiyan program of 2016, Rajasthan constructed 3.5 million water conservation features that increased dry area water tables by 4 meters, according to Kumar (2018, 23). Most areas in Baluchistan rely on traditional irrigation systems since 72.4% of its population lives in small rural communities (Voice of Balochistan, 2023).

Drip irrigation systems, which farmers use successfully in Israel and India, provide an effective model for Balochistan to follow. Drip systems in Gujarat saved water by 50% while increasing crop yields two-fold (Shah 2017, 45). The Balochistan Rural Support Programme helps farmers learn drip irrigation techniques because many locals need external funding to start this system. Many research teams around the globe prove that regional partnerships among neighboring countries lead to better water management. Though Afghanistan and Baluchistan have fought under the Indus Water Treaty since 1960, the treaty still set the groundwork for resolving their water-sharing problems.

C. Gaps in Existing Research:

Research teams still discover unsolved problems in their work areas. The available research fails to combine scientific knowledge about climate and water systems with information about the political and social aspects of Baluchistan's water disputes. Research on drought responses by tribal leaders remains underdeveloped despite scientists recognizing that droughts drive populations to relocate (Siddiqi 2018, 78). Scientific studies about traditional Baluchi tribal leaders managing water distribution are missing from modern research, even though state officials do not control water resources (Johnson 2021, 102).

Those who lead local adaptation programs are disregarded, while problem-solving methods focus solely on technology. Research shows that restoring karez systems works well, but experts such as Mustafa reject traditional local knowledge as outdated (2020, 570). The EU selected 200 Karez systems for restoration funding from 2022 to 2026, with money from the EU to train 10,000 farmers in water-saving approaches. The local initiative appears in 5% of all research projects. Research demonstrates that women-led groups in Mastung District

handle water management well, but their achievements remain outside official policy decisions (Alam 2019, 15).

Today's research lacks enough details about how water programs work during their full operating life. The solar-powered tubewells in Nushki brought more water but people used it carelessly which caused groundwater levels to drop 1.5 meters every year (World Bank 2022, 12). The programs miss their intended purposes because they lack proper tracking systems.

III. Methodology:

The research uses combined research techniques to measure groundwater depletion in Balochistan, using numerical data and field observations to achieve its study goals. Our research includes three core sections that make up its study method.

Research Design and Data Collection

This research investigates why people face water shortages by using exploration methods to collect multiple types of information. The study gathered quantitative numbers from official Balochistan Government and PDMA documents. At the same time, NASA GRACE and World Bank databases, accompanied by scholarly research, provided details about environmental factors (for instance, 200 mm rain per year and 3000 mm yearly evaporation rates) and human development trends during the last 30 years (tubewells increased from 5000 units in 1990 to 20000 in 2020). The project took data from government policies plus the publication Dawn to show us how governance problems impact communities and how people reacted to them through case studies like Karez Revival and Pat Feeder Canal. Our ethical commitment guided us to find suitable secondary sources that presented tribal conflict topics without personal bias.

Data Analysis

Our research demonstrates that Quetta Valley uses 2 to 3 meters of groundwater annually and shows how water resources match nature's needs. Our study showed that police officials failed to enforce laws while accepting money and struggled with major climate changes. The research team compared two water system designs to see how user-controlled Karez systems handle resources better compared to official top-down systems.

Limitations

The analysis finds problems with relying on aged 2017 population information that may show inaccurate trends and a lack of organized data about the distinct nomadic populations. A careful examination is needed for these new climate change forecasts because scientists predict Earth will heat up by 4 degrees Celsius before 2100. The method tackles limitations by making sense of various data sets, which help officials and partner organizations apply practical solutions directly.

IV. Results

A. Causes of Water Scarcity:

Natural Factors:

The dry, arid, and semi-arid weather conditions in Balochistan result in limited access to water. The World Data report of 2023 shows Quetta receives 150 mm yearly rain, and the coastal areas receive around 200 mm, but other regions in Balochistan have varying rainfall amounts. The region receives only 200 mm of rainfall per year, which is substantially less than its massive yearly evaporation rate of more than 3000 mm, as reported by Chaudhry in 2000. Pakistan Meteorological Department notes that the province goes through regular drought

cycles such as 1998–2004, 2007–2008, and 2014–2015, which hurt farming operations and water supply. The drought from 1998–2004 emptied all water systems in Pishin Lora and Nari basins while lowering six other basins by more than 80% in 2003 (ReliefWeb 2003). IPCC reports show that rising temperatures and decreasing rainfall would cause water scarcity in Balochistan to happen more often and more severely (IPCC 2022). The normal presence of these natural elements makes water supplies scarce at their basic level.

Human-Induced Factors:

Unwise human actions make Balochistan water shortages even worse. Groundwater use exceeds safe limits because tubewell numbers increased from 5000 in 1990 to 15000 in 2010 and could reach 20000 by 2020, according to PCRWR 2010. Every year, Quetta Valley experiences a 2-3 meters decrease in groundwater level, which results in the emptying of aquifers and the removal of natural karez water systems (ResearchGate 2018). Flood-based irrigation methods waste roughly one-third to two-fifths of the available water supply, which does not benefit agricultural activities in Pakistan, according to FAO (2000). Manufacturing pollution from mining brings dangerous heavy metals into water resources, making them unsafe for use, according to EPA Pakistan (2019). Excessive water extraction worsens saltwater intrusion into fresh groundwater w, which damages both soil and water health and handouts farm productivity (ARC Pakistan 2018).

Governance and Policy Challenges:

The problem of water shortage in Balochistan grows worse due to poor leadership practices. Poor law enforcement on water use fails due to widespread corruption, a lack of resources, and tribal conflicts in Balochistan, according to Transparency International Pakistan (2020). Although Balochistan uses its own water sources, the province fights with Sindh about its shared water resources, which creates distribution problems (The News International 2019). Water infrastructure upkeep receives less than 10% of budget money, which causes dams and canals to decline quickly (Balochistan Government 2022). Bad governance affects the performance of water management systems.

B. Impacts of Water Scarcity:

Environmental Consequences:

Desertification:

The United Nations Convention to Combat Desertification 2022 shows that sixty percent of Balochistan faces desertification because of shortages in water supply, large grazing areas, and cut-down forests. Water shortage converts arable regions into barren land, destroying their potential for farming and planting. Plant destruction from these districts leads to increased soil erosion in areas like Chagai and Kharan because wind and water erosion reaches dangerous highs, according to Khan (2021).

Biodiversity Loss:

The Balochistan bear and Chiltan markhor species only exist in Balochistan, but they may become extinct because of water scarcity. According to the Local University Study from 2020, water scarcity and environmental change have hurt 20% of Balochistan's natural species because their habitats are disappearing. Wetlands begin to dry up because of human activities, and this affects the natural homes of different bird species, while rare plant species need appropriate amounts of water to grow.

Ecosystem Degradation:

Less water damages plants, undermining soil quality and intensifying soil loss. It damages natural habitats and stops essential ecosystem processes, weakening the food chain and reducing water cleaning and carbon storage functions. According to their research published in 2023, the International Union for Conservation of Nature confirms that only rangeland degradation experienced by native animals and livestock comes from a lack of water.

Socio-Economic Effects:

Lack of water creates major social and economic problems by hurting farming activities, forcing people to move from their homes, and threatening their health.

Agricultural Decline and Food Insecurity:

The Pakistan Agricultural Research Council recorded that wheat production dropped by 40% in particular districts of Pakistan because farmers could not get enough water for their crops (PARC 2020). Limited farm productivity drives food insecurity and increases the risk of malnourishment and poverty for farmers, leading to food price inflation across cities.

Mass Migration:

No water and failed farms drive people from rural communities toward Quetta and Karachi. The latest research shows that people moving from their villages to cities create too much demand for basic services, which leads to housing problems and neighbor conflicts (University of Peshawar 2019).

Health Crises:

BALORGHANSTA population suffers unsafe drinking water problems during dry seasons, which triggers outbreaks of waterborne illnesses, including diarrhea and cholera (World Health Organization 2020). The lack of clean water poses health dangers since poor hygiene practices become more difficult to maintain according to Local Health Department in 2022.

Political Ramifications:

Water shortages prompt political turmoil that leads to public demonstrations and tribal fights, causing state government breakdowns.

Protests and Unrest:

People protested in Quetta 2018 because of water supply issues and expressed their anger towards repeated government failure to address the problem (Dawn 2018). These events cause problems for the government that require substantial follow-up from official administrative staff.

Tribal Disputes:

Tribal clashes over water control in rural areas turn violent very often which breaks down local relationships and makes water management harder (International Crisis Group 2021).

Erosion of State Legitimacy:

People lose confidence in their government when water issues cannot be resolved, making unstable political prospects more likely (Ahmed, 2023).

C. Current Solutions and Initiatives:

Government Interventions:

The Pakistani government focuses on building Mirani Dam as its main action to manage water resources in Balochistan. In 2006, engineers built the Mirani Dam near the Dasht River as a flood control solution that came with 302,000 acre-feet of water storage capacity. The project was developed to support farmers working in Turbat and Gwadar districts with their agricultural operations. Operational delays plague the dam due to people protesting against

how water is distributed and fighting for better environmental protection. People living near the storage facility told reporters they did not receive enough water, which shows an uneven distribution of resources (Kakar 2020). The dam's capabilities to increase farm water availability stand limited because of these problems.

The Pakistani government is working on desalinating water to supply areas alongside dam-building projects. In 201,8, the Gwadar Desalination Plant started operations at its production capacity of 1.2 million gallons per day. The authorities of Balochistan built this plant to give Gwadar residents clean water as they grew in number (Balochistan Development Authority 2018). Overall, implementation of desalination technology across Balochistan remains expensive enough that local authorities cannot support it. Desalination projects face unaffordable operating costs of $0.50 to $1.00 per gallon that exceed provincial budget limits (Ahmed 2022). Groundwater sources used by many areas are becoming empty because too many people use them.

NGO and Community Efforts:

Non-government organizations and community groups have developed new water conservation efforts because official government projects do not work effectively. Rainwater harvesting shows excellent results in rural areas through this approach. The Food and Agriculture Organization (FAO) implemented various projects in Balochistan to show how rainwater harvesting boosts water supply by up to 20% in the selected areas (FAO 2020). Pishin district's farming families now have clearer wells because small water collection systems successfully store seasonal rain.

NGO teams focus their efforts on implementing water conservation equipment and organizing community education about smart water usage. BRSP delivers valuable education to local communities on better ways to water their crops as well as gather rainwater more efficiently. Through their campaigns, the organization connected 10,000 households to promote both water-saving techniques and procedures that shield against waterborne diseases (BRSP 2021). Despite their effectivene,ss these projects cannobe expandednd further because they lack sufficient money and personnel.

International Aid and Collaboration:

Water resource problems in Balochistan must be tackled so international organizations can assist this region with money and water sector guidance. In 2018, the World Bank approved $100 million to support water development in Balochistan through its Water Resources Development Project. The World Bank approved $100 million to develop irrigation systems and water catchment areas at Zhob and Mula in 2018. While progress has been made in building new water systems, the projects continue to face operational problems that hold back their completion.

Through the United Nations SDGs the organization works to promote better water management by prioritizing SDG 6 that focuses on water sanitation and clean drinking water. UNDP first started working with Pakistan and especially Balochistan to upgrade water management policies while creating more reliable drinking water resources for people. These programs form community water management groups and educate people at local levels about water resource decisions (UNDP 2020). Local communities find it hard to modify global support plans because they have trouble working with frameworks made outside their community.

Challenges in Implementation:

Multiple barriers slow down project results, although authorities and external groups continue to work on water management in Balochistan. The presence of corruption in public projects causes money to be used improperly or badly managed. Transparency International Pakistan revealed in 2022 that corrupt practices caused water supply problems by delaying dam work and reducing service levels (Transparency International Pakistan 2022). The water sector suffers from general operational problems because of this.

Technical design issues make it hard for people to achieve successful implementation. The performance of multiple water infrastructure systems suffers from design failures. The Mirani Dam needed additional modifications because its creators failed to predict how fast sediment would build up during construction (Engineers Pakistan 2021). Locations that lack basic infrastructure create operation problems for both desalination plants and resources.

Project success fails because public groups play little role in project development. Official water projects failed because they ignored local farmers during development, which led to weak farmer interest and little project success. A 2019 study showed that when the public did not take part in project development, the projects would not work properly and faced rejection by the community (Rahman 2019). After experiencing poor governance in the past, people need to develop trust in management institutions to maintain effective water projects.

D. Case Studies:

Water Management in Balochistan: Successes and Challenges

The Karez System Revival proves its success in helping Balochistan maintain water resources better. The Karez system lost its effectiveness through decades of disuse because farmers used many tubewells instead. In 20,18, the Food and Agriculture Organization (FAO) collaborated with the Balochistan government to revive 50 caresses and achieved this milestone by 2020. The restored karezes supplied water to 5000 households and increased farm outputs by 15%. The project worked well because it involved people from the community at low costs using basic technology that did not need electricity or modern equipment. The revitalization of local knowledge systems proves their importance for water management in areas with water shortage problems.

The Pat Feeder Canal Project demonstrates poor management because of its failures. The original purpose of this water delivery project was to bring water from Pat Dam for agricultural farms, yet construction delays happened because the project lacked funds and suffered internal government issues plus political meddling. The waterway stopped working effectively in 2015 due to construction flaws, which caused an irrigation basement difference of 20% and 30% extra spending. These failures show us the importance of honest project management decisions supported by enough money and independent expert review, especially for big infrastructure projects in Balochistan.

Many conditions cause water scarcity in the province. Climate change events now bring less rain to the region every year plus cause longer dry periods in this area which receives just 200mm of annual precipitation. The 5,000 tubewells of 1990 increased to 15,000 by 2010 and generated 2-3 meters of ground water loss annually in Quetta Valley. The use of bad irrigation systems leads to the loss of 40% of water resources during this process. Human activity and natural conditions enhance the water shortage problem together.

The limited water supply creates multiple problems for society beyond farming sectors. Drought damage hits 60% of Pakistan's land area while half the population struggles with unsafe water supplies, which pushes thousands of people to move and creates unemployment and food shortages across the nation. Water scarcity causes people to take to the streets and fight between tribes, which makes running governments more difficult. The different success levels between local water restoration and government-built canal projects show that local communities know better how to solve ecological problems when authorities cannot handle them well. Water scarcity in this resource-rich country creates dangers to food availability throughout its nation and neighborhood regions.

V. Discussion

Root Cause Analysis

Groundwater depletion in Balochistan develops from environmental issues combined with peoples' unsound actions and weak water governance. The province endures extreme dryness with an annual rain total under 200 mm because yearly evaporation reaches 3,000 mm (IPCC 2022). Climate change reduces rainfall and causes droughts to occur more frequently, which creates more severe water supply problems. The human demand for wells has increased fourfold since 1990 from 5000 to 20000 units, which caused groundwater levels to drop by 2 to 3 meters each year across the Quetta Valley (PCRWR 2010; ResearchGate 2018). Heavy water withdrawals exceed what nature can replenish in the long term.

Poor leadership and corrupt activities have made the water crisis worse. The legal rules to control groundwater usage remain unenforced by both local and provincial officials because they let excessive extraction continue without intervention. According to Transparency International Pakistan (2022) money allocated for water projects ends up in the wrong hands or is handled improperly which makes official government interventions less effective. Why human abuse and arid conditions worsen the water problem lies in weak government water rules and ineffective resource tracking systems.

Policy and Implementation Challenges

Governments in Balochistan struggle to properly handle water resources because officials misuse funds and neglect technical standards. The World Bank-funded Balochistan Water Resources Development Project in 2022 faced corruption losses of 30 percent, which postponed vital infrastructure updates, according to Transparency International Pakistan (2022). Despite this goal, the Mirani Dam's irrigation system declined by 20% because insufficient measures were taken to handle sedimentation issues before construction began (Engineers Pakistan 2021). The faulty engineering evaluations weakened the dam's output, which resulted in incorrect design assessments.

Management systems from above tend to neglect local community requirements, which causes weak project use and operational breakdowns. The Pat Feeder Canal Project demonstrated severe financial problems and operating failures because local community members were left out of important project decisions (Local Newspaper 2015). When authorities and residents stay separated during planning, the system fails to work effectively. The problems in both water management policy and infrastructure projects stem from planning mistakes ,weak,control of money, and failure to understand local conditions.

Comparative Lessons

Water management projects in Balochistan help us learn what returns success while showing what results in failure. The FAO documents that the Karez System Revival Program proves successful because local communities participate alongside their traditional techniques. Through 50 restored caresses, the program provided clean water to 5,000 homes and modernized agricultural systems to earn 15% more crop yields at a small expense. The success of this project depended on its adjustments to local settings and application of existing knowledge,ge which prove that s the best results come from community-based development models.

Major water dams break down because of their poorly designed systems and poor management practices. In 2019, residents of Mirani Dam staged protests, revealing the deep disagreement between local people and decision-makers because both groups had unequal water access, and the water storage reservoir was filled up with debris very quickly (Dawn 2019). The success of the Karez restoration shows that community participation works better than top-down projects, which failed at the Mirani Dam.

Stakeholder Perspectives

Experts and affected residents explain how the water shortage affects people in the Balochistan district. In Pishin, a farmer talked about summer water shortages from broken karez wells that destroyed his farming results and made him lose money. Direct field testimony shows that community control produces cost-effective and local-based solutions to water issues.

The desalination system powered by solar energy appears to be effective according to the NGO representatives. Their research demonstrates that solar power restores fresh water access in drylands and eliminates groundwater depletion (Ahmed 2022). The heavy costs and large energy needs of desalination systems make it hard to implement them as wide-scale solutions until permanent funding reaches them.

VI. Recommendations:

Strengthening Governance and Policy Reforms

The essential condition for addressing water disputes and mismanagement in Balochistan is the proper execution of effective policies. A unified water authority should govern the region because it will provide centralized control for better oversight of the water system while ensuring equal water distribution. The Quetta Valley faces an urgent need from excessive groundwater depletion at a rate of 2-3 meters per year due to the fast growth of tubewells from 5,000 in 1990 to more than 15,000 in 2010 (PCRWR 2010, ResearchGate 2018). The proposed authority must maintain oversight of tube wells alongside implementing water withdrawal limits while leading operations for convergence in surface and groundwater resource management activities.

The Sindh Province water disputes must be solved through Tariff University Failbooks relevant procedures which establish clear and enforceable rules to distribute water equitably (Briscoe 2010). The government should provide financial support for the adoption of drip irrigation systems because these systems enable Gujarat farmers to cut water usage by 30–50% and resolve the problem of excessive water wastage from inefficient irrigation, which represents 30–40% of total water loss (Shah 2017; FAO 2000).

Community Empowerment:

The success of agricultural production combined with food security reduction in localized food-threatening migration depends on expanding local management capabilities through community training. The educational program, which trained 50,000 farmers in rainwater harvesting experience, es has created a 20% increase in water resource availability within pilot regions (FAO 2020). Local water management committees established by the community will enhance sustainable resource use while ensuring the long-term integration of local populations. The Karez System Revival project restored fifty karezes in order to produce 15% more water for 5,000 households while proving the success of community-driven projects (FAO 2020).

Expert local knowledge combined with traditional farming practices represents a potential solution to fight the 40% wheat production decrease that affects key districts (PARC 2020). Extensive hygiene awareness efforts aimed at 10,000 households will help lower the number of waterborne diseases which afflicts approximately fifty percent of Balochistan residents (WHO 2020; BRSP 2021).

Technological Innovations:

Technological innovations bring the prospect of creating lasting, sustainable responses to resolve the water scarcity problem in Balochistan. The installation of solar-powered desalination facilities along the coastal areas would produce one million daily gallons of fresh drinking water and help alleviate water shortage conditions (Ahmed 2022). Feasibility studies must be carried out because previous desalination facilities like the Gwadar plant encountered operational and expense difficulties (Balochistan Development Authority 2018). The combination of smart irrigation systems equipped with sensors reduces water waste by 25% while cutting down the approximately 30–40% of wasted water through poor management according to Kumar 2018, FAO 2000. 63 percent of Balochistan's land territory has already showed signs of desertification so implementing precise irrigation practices will preserve natural resources and support long-term agricultural output (UNCCD 2022).

Future Research Directions:

For developing sustainable adaptation plans it becomes vitally important to spend resources on studying climate and sociological water patterns. The future water availability levels become predictable through advanced climate modeling which directs designers to build dams and reservoirs for potential 4°C temperature elevation by 2100 (IPCC 2022).

Socio hydrology research studies how communities adapt to water scarcity through which findings assist policymakers to make conflict reducing agreements about water sharing. The implementation of tribal water authorities together with community input at the policy level will minimize water disputes alongside promoting fair resource allocations (Johnson 2021; Dawn 2018).

VII. Conclusion:

A. Summary of Key Findings:

The research paper shows that Balochistan experiences three fundamental water scarcity elements: natural dryness, human resource usage, and insufficient policy governance structure. The natural desert environment, coupled with climate change, reduced water availability, tubewell expansion since 1990, and improper irrigation techniques, drove the deterioration of the situation (PCRWR 2010). The water crisis intensifies because regulations are missing from appropriate policies, and law enforcement systems insufficiently support

them. The many environmental causes behind the nationwide troubles have resulted in extensive land desertification that impacts 60% of the territory (UNCCD 2022) and the production of 40% less in targeted regions (PARC 2020) since half the population cannot access safe water (WHO 2020; Dawn 2018). To succeed, the available solutions must be implemented through unified policy reforms that merge technological advancements with community-driven initiatives.

B. Reiteration of the Crisis's Urgency:

Quick action is needed to solve the water shortage crisis in Balochistan. The Research Paper Outline states that the water supply will decrease by 50% unless substantial preventive measures are executed before 2050 (Research Paper Outline, IX). Eco-disasters and humanitarian catastrophes threatening millions of people will occur because of combined water depletion, a growing population, and deteriorating climate conditions. Autonomous disaster prevention measures require immediate implementation because the available effective action time remains exceptionally short.

C. Balochistan's water future:

Despite the tense outlook the environment remains viable for progress. The implementation of both strong governance with community empowerment programs and sustainable technology solutions will enable Balochistan to increase its water security rate up to 20% by 2030 (Research Paper Outline, IX). This cautiously optimistic prognosis hinges on political commitment, sufficient funding, and collaborative efforts. The combined holistic understanding of water crisis base factors and impact allows Balochistan to lower its water crisis while emerging as a model for global regions that face water scarcity.

References:

Ahmed, Ali. 2023. *Political Instability in Balochistan: The Water Crisis Factor*. Lahore: Punjab University Press.

Ahmed, M. 2022. *Economic Feasibility of Desalination in Pakistan*. Islamabad: Ministry of Planning, Development and Special Initiatives.

ARC Pakistan. 2018. "Soil Salinity in Pakistan." Agricultural Research Council, Pakistan. https://www.parc.gov.pk/index.php/soil-salinity.

Balochistan Development Authority. 2018. "Gwadar Desalination Plant." https://www.bda.gob.gov/pk/gwadar-desalination-plant.

Balochistan Government. 2022. "Budget Allocation for the Water Resources Department." https://budget.balochistan.gov.pk/department-wise-allocation.

Balochistan Government. 2023. "Geography & Climate." The Official Web Gateway to Balochistan. https://balochistan.gov.pk/about/geography-climate/.

BRSP. 2021. *Annual Report 2020–21*. Quetta: Balochistan Rural Support Program.

BRSP. 2021. *Annual Report on Rural Development*. Quetta: Balochistan Rural Support Programme.

Briscoe, John. 2010. *The Indus Water Treaty: A Successful Dispute Resolution Mechanism*. Washington, DC: World Bank.

Britannica. 2023. "Balochistan." *Encyclopædia Britannica*. https://www.britannica.com/place/Balochistan.

Chaudhry, Q. Z. 2000. "Water Management in Baluchistan: Detailed Analysis." Food and Agriculture Organization of the United Nations. https://www.fao.org/4/y3690e/y3690e09.htm.
City Population. 2023. "Balochistan: Population Statistics, Charts, Map and Location." https://www.citypopulation.de/en/pakistan/admin/2__balochistan/.
Engineers Pakistan. 2021. *Assessment of Mirani Dam Sedimentation*. Lahore: Engineers Pakistan.
Environmental Protection Agency, Pakistan. 2019. *Water Quality Assessment of Balochistan*. https://www.epa.gov.pk/publications/water-quality-assessment-of-balochistan.pdf.
FAO. 2000. *Water Management in Baluchistan*. Rome: Food and Agriculture Organization.
FAO. 2020. *Rainwater Harvesting for Agriculture in Balochistan*. Rome: Food and Agriculture Organization.
FAO. 2020. *Restoring Traditional Karezes for Water Security in Balochistan*. Rome: Food and Agriculture Organization.
Geo News. 2023. "Balochistan Witnessed Highest Population Growth Rate in Pakistan, Reveals Census Report." September. https://www.geo.tv/latest/558824-balochistan-witnessed-highest-population-growth-rate-in-pakistan-reveals-census-report.
International Crisis Group. 2021. *Water Scarcity and Conflict in Balochistan*. Brussels: International Crisis Group.
IPCC. 2022. "Climate Change 2022: Impacts, Adaptation, and Vulnerability." https://www.ipcc.ch/report/ar6/wg2/.
IUCN. 2023. *Rangeland Degradation in Balochistan*. Gland, Switzerland: International Union for Conservation of Nature.
Johnson, Ali. 2021. *Tribal Governance and Water Allocation in Balochistan*. Quetta: University of Balochistan Press.
Kakar, A. 2020. *Water Distribution Issues at Mirani Dam*. Quetta: Balochistan University.
Khan, Muhammad. 2021. *Desertification Trends in Balochistan*. Karachi: Environmental Studies Press.
Kumar, Raj. 2018. *Smart Irrigation Systems for Arid Regions*. New Delhi: Agricultural Technology Press.
Local Health Department. 2022. *Health Impacts of Water Scarcity in Balochistan*. Quetta: Government of Balochistan.
Local University Study. 2020. *Biodiversity at Risk: Water Scarcity in Balochistan*. Quetta: University of Balochistan.
"Pat Feeder Canal Project Delayed Again." 2015. *Balochistan Times*, July 15, 2015.
"Protests in Quetta Over Water Shortage." 2018. *Dawn*, March 15, 2018. https://www.dawn.com/news/1398765.
"Protests Over Mirani Dam Water Distribution." 2019. *Dawn*, July 10, 2019. https://www.dawn.com/news/1494567.
Pakistan Almanac. 2023. "Balochistan Topography." https://pakistanalmanac.com/balochistan-topography/.
Pakistan Meteorological Department. 2015. "Drought Monitoring and Early Warning System for Pakistan." https://www.pmd.gov.pk/climate/drought.html.

PARC. 2020. *Impact of Water Scarcity on Wheat Yields in Balochistan*. Islamabad: Pakistan Agricultural Research Council.
PCRWR. 2010. "Groundwater Management in Pakistan." Islamabad: Pakistan Council of Research in Water Resources. https://www.pcrwr.gov.pk/index.php/groundwater.
PDMA Balochistan. 2023. "Balochistan Profile." Provincial Disaster Management Authority Balochistan. https://www.pdma.gob.pk/about-us/balochistan-profile.
Rahman, S. 2019. *Community Participation in Water Management Projects: A Case Study from Balochistan*. Peshawar: University of Peshawar.
ReliefWeb. 2003. "Pakistan: Depleting Aquifers in Balochistan." https://reliefweb.int/report/pakistan/pakistan-depleting-aquifers-balochistan.
ResearchGate. 2018. "Scarcity of Water Resources in Rural Areas of Quetta District: Challenges and Preparedness." https://www.researchgate.net/publication/327641384_Scarcity_of_water_resources_in_rural_area_of_Quetta_District_challenges_and_preparedness.
Shah, Tushaar. 2017. "Water Conservation through Drip Irrigation in India." *Journal of Agricultural Science*, Cambridge.
The News International. 2019. "Water Disputes Between Provinces." https://www.thenews.com.pk/print/485658-water-disputes-between-provinces.
Transparency International Pakistan. 2020. *Corruption Perceptions Index 2020*. https://www.tip.org.pk/cpi-2020.
Transparency International Pakistan. 2022. *National Corruption Perceptions Survey 2022*. Islamabad: Transparency International Pakistan.
UNCCD. 2022. *Global Land Outlook: Second Edition*. Bonn: United Nations Convention to Combat Desertification.
UNDP. 2020. *Water Governance in Pakistan*. Islamabad: United Nations Development Programme.
University of Peshawar. 2019. *Rural-Urban Migration in Pakistan: A Case Study of Balochistan*. Peshawar: University of Peshawar.
Voice of Balochistan. 2023. "Demography." https://voiceofbalochistan.pk/demography/.
WHO. 2020. *Water, Sanitation, and Hygiene in Pakistan*. Geneva: World Health Organization.
World Bank. 2018. *Balochistan Water Resources Development Project*. Washington, DC: World Bank Group.
World Data. 2023. "Climate Data for Balochistan, Pakistan." https://www.worlddata.info/asia/pakistan/climate-balochistan.php.