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Review Article: The Impacts of Climate Change on Water Resources, Droughts, and Water Management in Afghanistan

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Abstract

The purpose of this study is to in-Depth analysis and Practicality of the proposed solutions in the relevant research topic. With major effects on Afghanistan's water resources and increased susceptibility to drought, climate change has become a major problem for the nation. Afghanistan's water crisis is getting worse due to rising temperatures, changing precipitation patterns, and more unpredictable weather. The nation has already struggled with societal issues and conflict for decades. Reduced snow packs in the Hindu Kush mountains, a vital supply of water, and declining groundwater levels are two consequences of climate change on the country's water supplies. Agricultural output, the backbone of Afghanistan's economy, is at risk because of severe droughts brought on by changing seasons and irregular rainfall. The ancient and insufficient water management systems that are currently in place are experiencing extreme stress due to climate change. Unfortunately, Water shortage, which makes it difficult for populations to obtain enough water for daily usage, irrigation, and drinking, is caused by weak policies, poor infrastructure, and inefficient water management. As Afghanistan's hydrological cycle continues to be affected by climate change, comprehensive water management techniques are essential. These strategies should include investments in sustainable water preservation techniques, irrigation system upgrades, and regional cooperation to address transboundary water challenges. Resolving these issues is essential for Afghanistan's long-term water security and human welfare in light of a dynamic environment. methods combining both quantitative and qualitative methods is used to study how climate change affects Afghanistan's water supplies, droughts, and water management.

Keywords: Climate Change, Water Resources**,** Water Management, Drought

Introduction

Afghanistan is not free from the effects of climate change, which is now considered as one of the most significant worldwide issues. Water resources are among the most damaged aspects of the nation, which is more prone to changes in weather patterns due to its hot and dry climate. Afghanistan is particularly vulnerable to environmental change because of its reliance on seasonal rainfall and snowmelt for its water supplies. The region's water supplies are severely affected by the changing precipitation patterns and a rise of extreme weather events like droughts brought on by global warming (Shroder & Weary, 2016). Climate change is making droughts more frequent and severe in Afghanistan. The nation has had long dry periods in recent decades, with decreasing water shortages and placing stress on individuals in both rural and urban areas (Qureshi, 2011). These droughts have increased competition for limited water supplies, reduced agricultural productivity, and impacted food security. Additionally, the Hindu Kush mountains' glaciers, which historically have been a crucial source of water in the summer, are melting more quickly, limiting the amount of water available over the long run (Mahmood et al., 2019). Climate change has affected Afghanistan's water management initiatives in addition to droughts. The country's ability to satisfy demands from industry, agriculture, and households will soon be put to the test because of scarce and irregular water supplies. Afghanistan's ongoing effects of conflict and instability, inadequate infrastructure, and low investment in new water systems. Urgent adaptation measures are needed to solve these challenges, such as creating stronger water management regulations and sustainable methods to reduce the effects of climate change (World Bank, 2017).

The impacts of climate change on water resources in Afghanistan

The high mountain ranges of Wakhan, Hindu Kush, and Baba, which are blanketed in snow and glacier deposits, make Afghanistan comparatively rich in water resources despite its arid location. The Hindu Kush mountain range and elevations above 2000 metres are the source of more than 80% of the nation's water resources, and throughout the summer, snowmelt in these areas keeps all rivers flowing continuously (Mahmoodi, 2008). Amu, North, Harirud-Morghab, Helmand, and Kabul are the five river basins into which this nation's water resources flow. According to recent estimates, the nation has an annual capacity of around 75 billion cubic metres of water, of which 18 billion cubic metres are subterranean and 57 billion cubic metres are surface water.Mahmoodi (2008). An estimated 20 billion cubic metres of water resources are utilised for irrigation each year, accounting for 99 percent of the nation's total water usage. An estimated 3 billion cubic metres of groundwater have been extracted overall.

Approximately 85% of the water utilised each year comes from rivers and streams, with 15% coming from subterranean sources (Watkins & Development Programme United Nations, 2006). This nation has access to over 2,300 cubic metres of surface water annually per person, which is 50% more than what is needed for a nation to have enough water to meet its energy, industrial, environmental, agricultural, and domestic needs (Thomas, Azizi, & Behzad, 2016). Afghanistan is the origin of numerous rivers, and its topography offers plenty of chances to take advantage of these liquid resources (Fahim, 2016; King & Sturtewagen, 2010). According to Thomas et al. (2016), the ratio of different factors in this nation can utilise almost 33% of the 57 billion cubic metres of surface water that are accessible annually. According to American International Hydro-meteorological assessments, Afghanistan's water resources are limited because it is a landlocked nation (Nabavi & Mohammadi). It is estimated that the country receives 222 mm of rain annually on average, which varies by region and accounts for roughly one-third of global rainfall (Fahim, 2016). The country's high altitudes in the northeast receive 1222 millimeters of rain annually, while the southwest receives 112 millimeters (Ministry of Irrigation, Water Resources & Environment, 2004). Furthermore, the distribution of this nation's water resources is also disproportionate; the Amu River basin, which includes the Marghab and Harirud basins as well as other adjacent regions, makes up roughly 37% of Afghanistan's total area but accounts for 60% of its water flow. Approximately 12% of this country is covered by the Eastern Kabul River basin. Although the Helmand basin encompasses over 49% of this nation's area and only 11% of its water flow, it comprises roughly 26% of the water flow (King & Sturtewagen, 2010). Additionally, rivers and erratic precipitation and snowfall are major sources of Afghanistan's water resources. Seasonal water availability is impacted by early snowmelt and glacier retreat. Furthermore, at the moment, Afghanistan has the least amount of water storage capacity per person (King & Sturtewagen, 2010) in the area. For instance, the 1999–2005 drought that affected the nation. Most inhabitants of villages with scarce water supplies were compelled to leave their land and relocate to bigger cities (Yildiz, 2015). For millions of people in this nation, groundwater is a vital supply of drinking water. This resource has historically been utilized in agriculture. In Afghanistan, subterranean water sources such as wells, sinkholes, and springs supply between 16 and 22 percent of the country's overall water requirements. At the moment, the nation's inability to manage, monitor, and use this resource healthily is due to the absence of a thorough information system and broad monitoring systems.

River Basin	1969–1980 (BCM)	2007–2016 (BCM)	% Decrease (1969–2016)	2030 Projected (BCM)	% Decrease (1969–2030)
Kabul - RB	19.271	17.1	-11%	15.3	-21%
Panj-Amu - RB	21.5	18.7	-13%	16.2	-25%
Helmand - RB	10.4	8.4	-19%	7.1	-32%
Hari Murghab - RB	3.4	2.53	-26%	1.7	-50%
North - RB	2.1	2.2	+5%	2.0	-5%
Total	**57**	**49**	**-13%**	**42.3**	**-26%**

Source: Shokory, Schaffli, and Lane (2023).

Table 1. Surface water volume in five Afghanistan river basins between 1969-1980 and 2007-2016. BCM:z billion cubic metres.

The table highlights a notable drop in surface water volume in five key river basins in Afghanistan from 1969-1980 to 2007-2016, with the Hari Murghab Basin experiencing the steepest decline at -26%. Looking ahead to 2030, all basins are projected to see further decreases, except for the North Basin. Interestingly, the North River Basin had a slight uptick in water volume from 1969-2016 but is anticipated to shift back to a -5% decline. Overall, Afghanistan's surface water availability fell from 57 BCM in 1969-1980 to 49 BCM in 2007-2016, marking a 13% decrease.

Literature review

Climate change is really shaking up water resources globally, and some places, like Afghanistan, are feeling the heat more than others. Their water systems, which mainly rely on rivers and seasonal snow, are pretty fragile. The Hindu Kush and Pamir mountain ranges, which are super sensitive to climate shifts, are the main sources of water for Afghanistan. With glaciers melting, rainfall patterns changing, and temperatures rising, there's a noticeable drop in water availability in these regions. The Intergovernmental Panel on Climate Change (IPCC) warns that as glaciers shrink and snowmelt changes, areas that depend on snow-fed rivers will face serious consequences for ecosystems, farming, and local communities. Afghanistan is seeing these climate change effects happen more often. Extreme droughts are really hurting the economy, rural communities, and food security. Millions felt the effects of severe droughts

between 1999 and 2002, and again in 2018, leading to failed crops, water shortages, and many people having to relocate. The agriculture sector, which relies on 80% of the country's water for irrigation, is now even more vulnerable due to these droughts. Research shows that these droughts are linked to shifts in rainfall patterns and rising temperatures, and it's expected that water availability will keep decreasing because of earlier snowmelt and less annual snow cover. Water management in Afghanistan faces significant challenges due to its long history of conflict, outdated infrastructure, and limited institutional capacity. Efficient water use is tough because of damaged dams, poor irrigation systems, and a lack of water storage options. Afghanistan is facing some serious challenges when it comes to managing water rights. The country doesn't have strong regulations in place to handle conflicts, which often arise in shared river basins both with neighboring countries and internally. On top of that, tackling climate-related water issues has been tough for Afghanistan due to limited funding and poor coordination among government agencies.

Since Afghanistan shares key rivers like the Amu Darya and Helmand with countries such as Pakistan, Iran, and others in Central Asia, it's crucial to foster regional cooperation and develop adaptive strategies. The situation has become more tense because of the lack of collaboration and agreements on water sharing. Afghanistan is facing some serious challenges when it comes to managing water rights. The country doesn't have strong regulations in place to handle conflicts, which often arise in shared river basins both with neighboring countries and internally. On top of that, tackling climate-related water issues has been tough for Afghanistan due to limited funding and poor coordination among government agencies.

Since Afghanistan shares key rivers like the Amu Darya and Helmand with countries such as Pakistan, Iran, and others in Central Asia, it's crucial to foster regional cooperation and develop adaptive strategies. The situation has become more tense because of the lack of collaboration and agreements on water sharing. One way to tackle ongoing water resource issues is by promoting collaboration on international water-sharing deals and enhancing local skills in water management. This approach can lead to sustainable solutions over the long haul.

Methodology

The methodology for researching the impact of climate change on water resources, droughts, and water management in Afghanistan involves combining qualitative and quantitative techniques. This will help provide a comprehensive understanding of how climate change is affecting water resources in the country. The steps of the methodology are outlined below:

Data Collection

a. Quantitative Data

Quantitative data will be gathered from multiple sources:

Climatic Data: Historical and current climate data (temperature, precipitation, evaporation rates, etc.) from the Afghanistan Meteorological Authority. Historical and current climate data (temperature, precipitation, evaporation rates, etc.) from the Afghanistan Meteorological Authority.

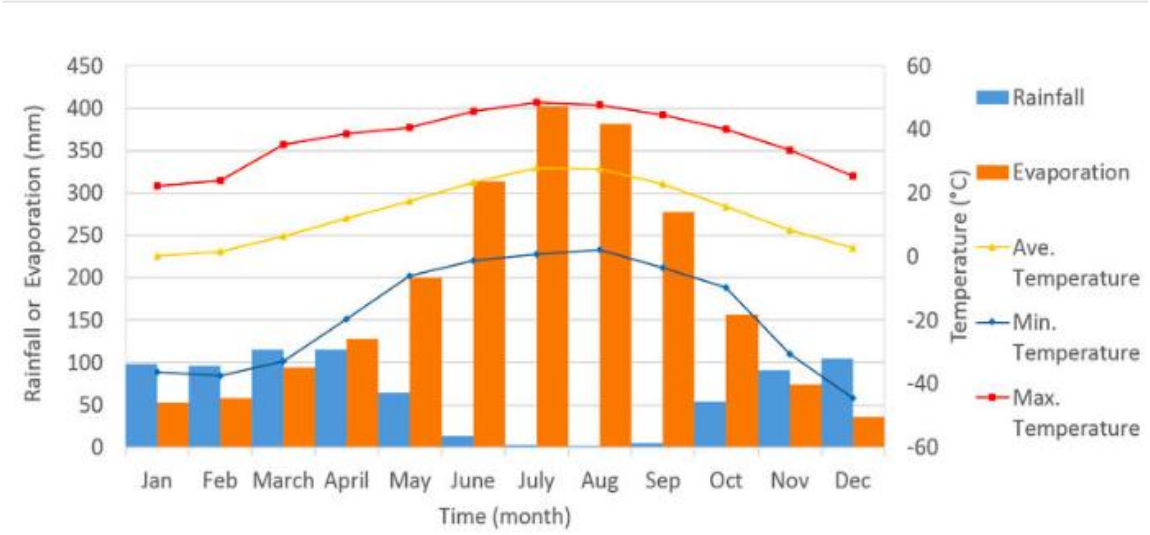


Figure 2: Average monthly precipitation, evaporation, minimum temperature, maximum temperature, and average temperature. We used 96, 15, and 21 meteorological stations for the average calculation of precipitation, evaporation, and temperature for the whole basin area, respectively.

- IPCC reports, and satellite data sources will be collected and analyzed to identify trends and changes in climate over time.

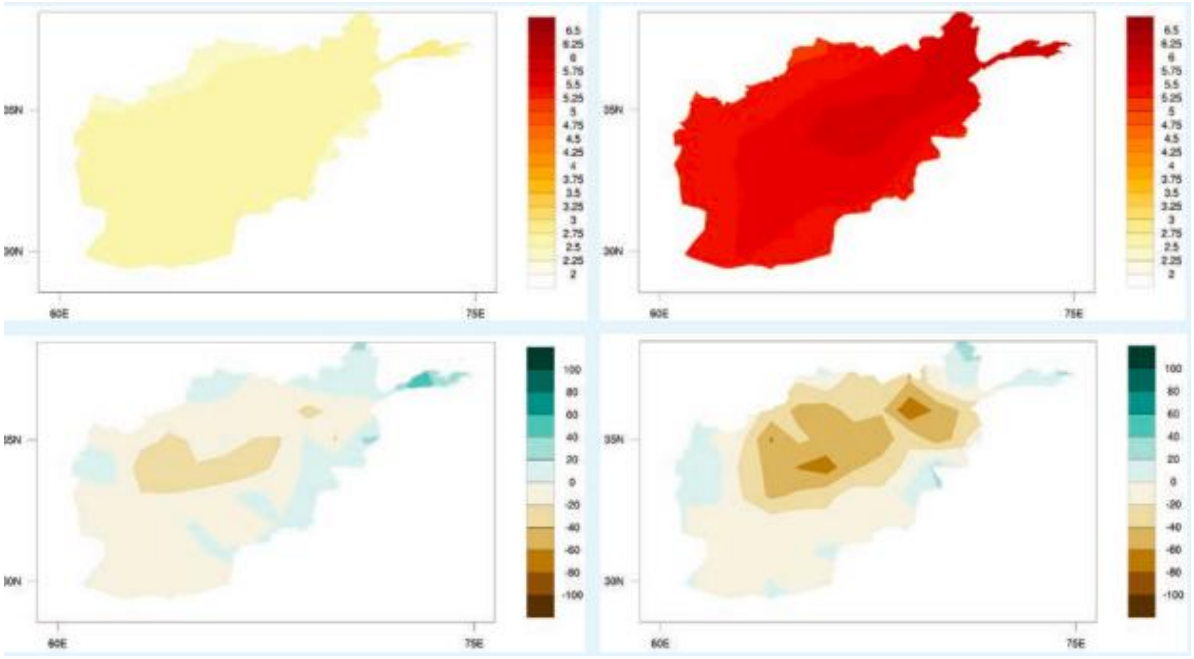


FIGURE 3. CMIP5 ensemble projected change (32 GCMs) in annual temperature (top) and precipitation (bottom) by 2040–2059 (left) and by 2080–2090 (right) relative to 1986–2005 baseline under RCP8.520

Hydrological Data: Water flow rates, groundwater levels, snowmelt patterns, and drought frequency data from river basins in Afghanistan (e.g., Helmand River, Kabul River) will be collected. These will come from government reports, the Ministry of Energy and Water (Afghanistan), and international organizations monitoring water resources.

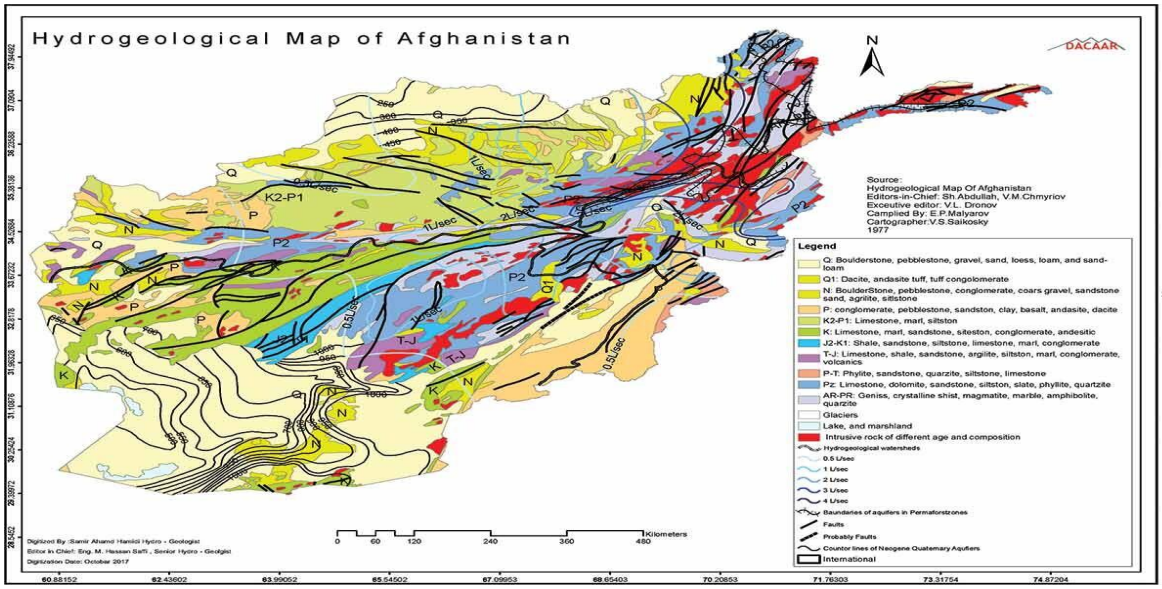


Figure 4 . Hydrogeological map of Afghanistan. Compiled by Malyarove and digitized by Hamidi and Saffi in 2017 (Saffi *et al.*)

b. Qualitative Data

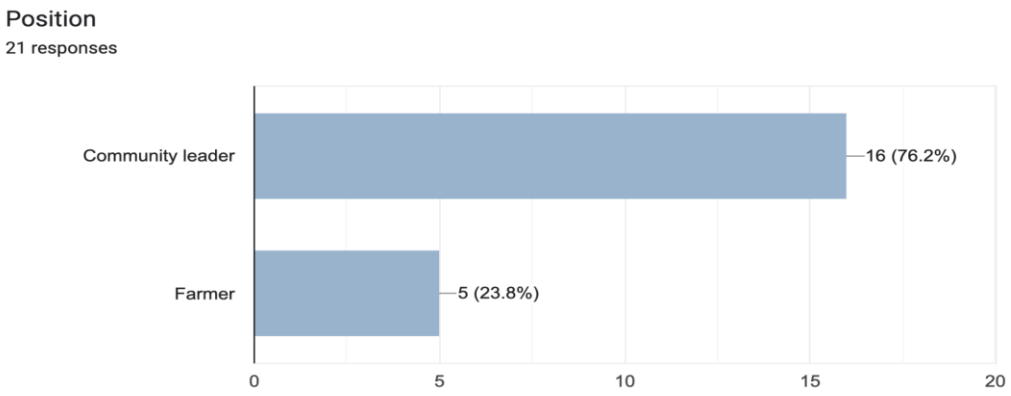
Qualitative data will be collected through:

Survey

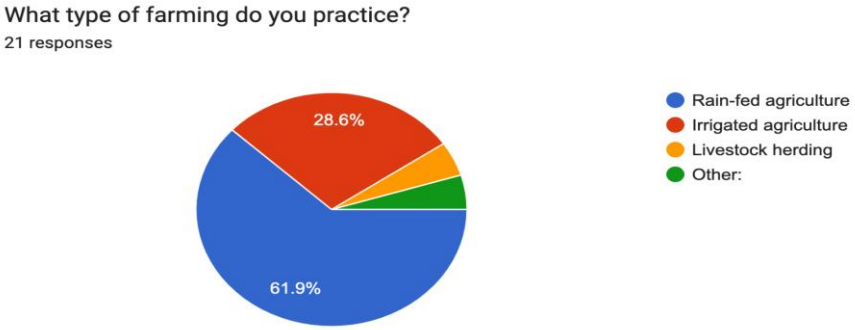
The data is collected through An investigative survey as a google form with community leaders, and farmers by the assistance of my friends in different provinces of Afghanistan. This essay consists of four sections and eleven (11) multiple choice questions which will provide insights into their perceptions of climate change, water scarcity, and water management challenges.

Findings

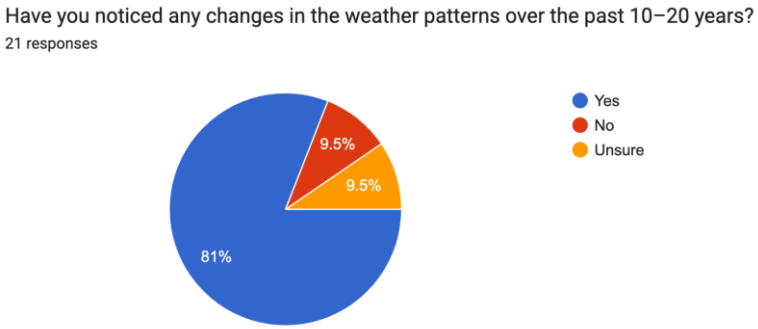
A survey was conducted in Afghanistan to understand the effects of climate change on water resources. 21 participants, including farmers and community leaders, from ten provinces participated. Their perspectives are crucial for understanding the local impacts of climate change. The survey involved local acquaintances from various regions, ensuring diverse participation. The findings provide insights into climate change's impact on agricultural productivity, water availability, and local water resource management initiatives.



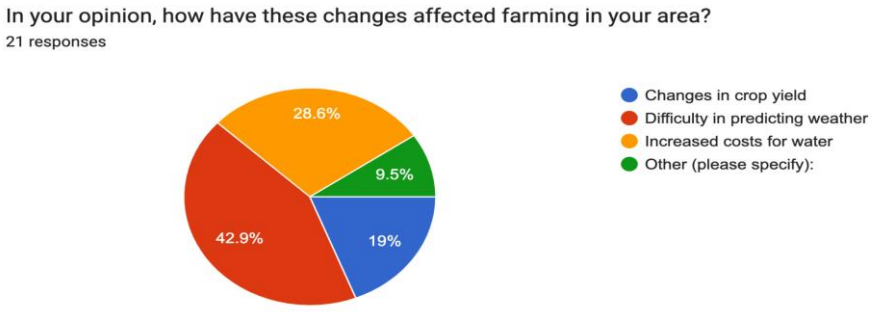
In the responses section, there is a bar chart showing the distribution of respondents' positions. The majority of respondents (76.2%) are community leaders, while 23.8% are farmers.



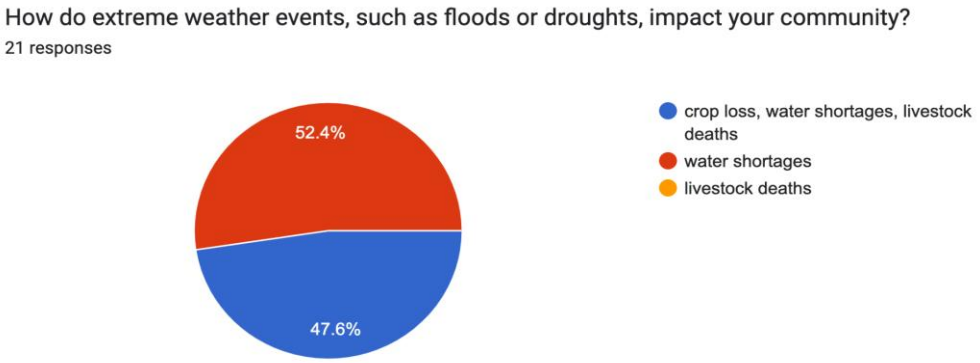
In the responses section, there is a pie chart showing the distribution of respondents' answers to the question "What type of farming do you practice?". The majority of respondents (61.9%) practice rain-fed agriculture, followed by irrigated agriculture (28.6%), livestock herding (7.1%), and other (2.4%).



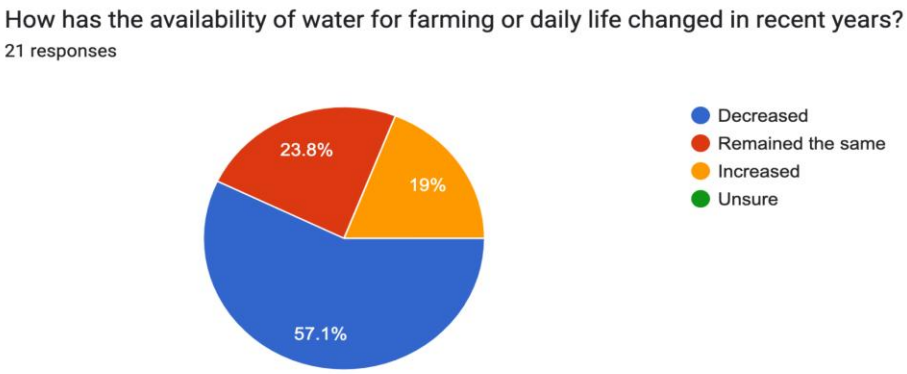
In the responses section, there is a pie chart showing the distribution of respondents' answers to the question "Have you noticed any changes in the weather patterns over the past 10-20 years?". The majority of respondents (81%) answered "Yes", 9.5% answered "No", and 9.5% answered "Unsure".



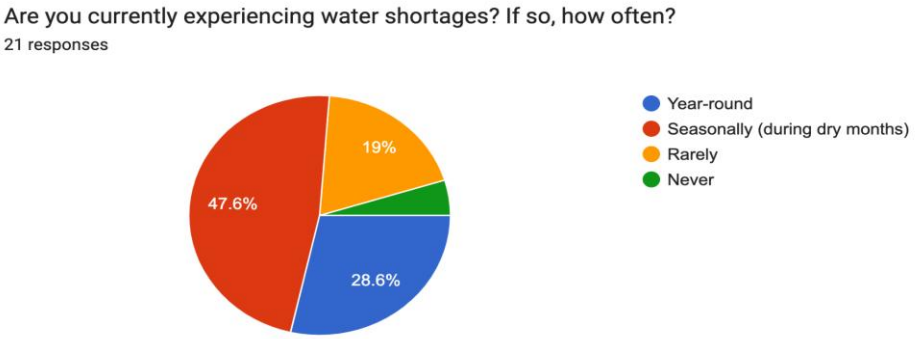
In the responses section, there is a pie chart showing the distribution of respondents' answers to the question "In your opinion, how have these changes affected farming in your area?". The most common answer is "Changes in crop yield" (42.9%), followed by "Difficulty in predicting weather" (28.6%), "Increased costs for water" (19%), and "Other (please specify)" (9.5%).



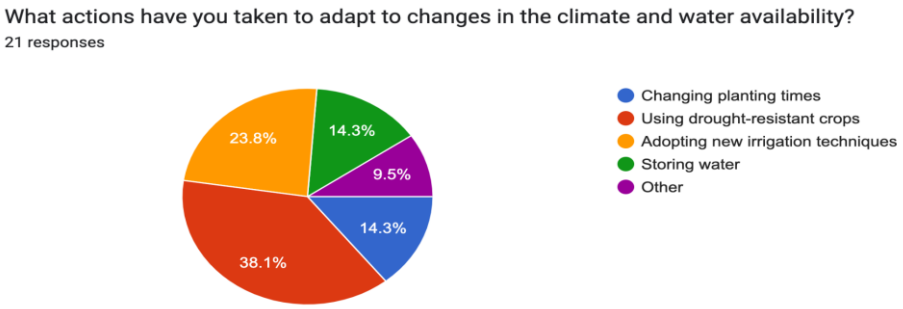
In the responses section, there is a pie chart showing the distribution of respondents' answers to the question "How do extreme weather events, such as floods or droughts, impact your community?". The majority of respondents (52.4%) answered "crop loss, water shortages, livestock deaths", while 47.6% answered "water shortages".



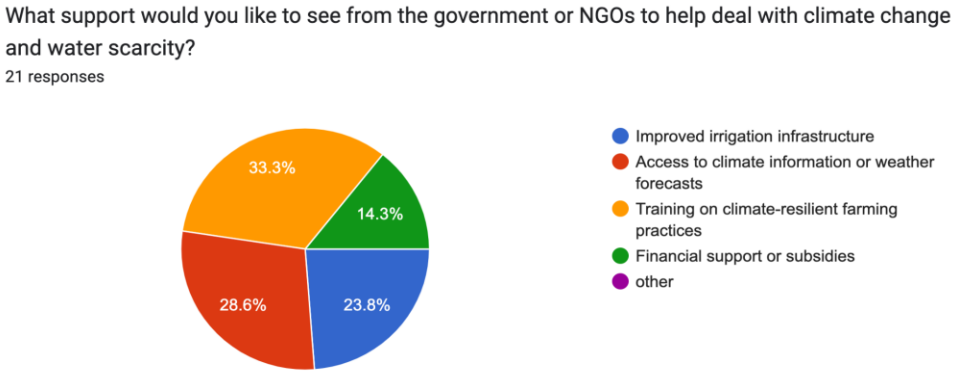
In the responses section, there is a pie chart showing the distribution of respondents' answers to the question "How has the availability of water for farming or daily life changed in recent years?". The majority of respondents (57.1%) answered "Decreased", 23.8% answered "Remained the same", 19% answered "Increased", and 0% answered "Unsure".



In the responses section, there is a pie chart showing the distribution of respondents' answers to the question "Are you currently experiencing water shortages? If so, how often?". The majority of respondents (47.6%) answered "Seasonally (during dry months)", followed by "Never" (28.6%), "Rarely" (19%), and "Year-round" (16%).



In the responses section, there is a pie chart showing the distribution of respondents' answers to the question "What actions have you taken to adapt to changes in the climate and water availability?". The most common answer is "Changing planting times" (38.1%), followed by "Using drought-resistant crops" (23.8%), "Other" (14.3%), "Adopting new irrigation techniques" (14.3%), and "Storing water" (9.5%).



In the responses section, there is a pie chart showing the distribution of respondents' answers to the question "What support would you like to see from the government or NGOs to help deal with climate change and water scarcity?". The most common answer is "Improved irrigation infrastructure" (33.3%), followed by "Financial support or subsidies" (28.6%), "Other" (23.8%), "Access to climate information or weather forecasts" (14.3%), and "Training on climate-resilient farming practices" (14.3%).

DISCUSSIONS

The study highlights how crucial it is to manage Afghanistan's water resources in light of the combined effects of sociopolitical unrest and climate change. The results show that there is a notable decline in the amount of water available in Afghanistan's major river basins, which presents serious problems for household water consumption, agriculture, and energy generation. This study emphasizes how climate change exacerbates already-existing vulnerabilities in water resource management by acting as a danger multiplier. Water quantities in major river basins have significantly decreased between 1969–1980 and 2007–2016, according to the analysis, and by 2030, these declines are expected to be substantially more pronounced. For example, it is predicted that by 2030, the Helmand River Basin, a crucial water supply for southwestern Afghanistan, will have 32% less water available. These decreases are associated with decreased snowfall, early snowmelt, and increased temperatures, all of which are consistent with worldwide patterns seen in other water systems that receive water from glaciers (Huss et al., 2017; IPCC, 2021). These results shed important light on how Afghanistan's hydrological systems, which rely on seasonal snowmelt, are especially susceptible to climate change. These changes disproportionately affect Afghanistan's agriculture, which uses around 70% of the country's water. As demonstrated by previous droughts, decreased water availability has a direct impact on crop productivity, irrigation systems, and food security (Favre & Kamal, 2004; World Bank, 2017). The study's conclusions are consistent with other studies that demonstrate how water shortage in arid areas causes a series of negative social and economic effects, such as increased migration, rural unemployment, and resource-related conflict. Additionally, In order to lessen these effects, the anticipated reduction in water availability calls for quick changes in water efficiency and allocation.

Afghanistan's water management infrastructure has been badly undermined by decades of fighting; numerous dams, reservoirs, and irrigation systems are either destroyed or nonfunctional. Attempts to alleviate water scarcity are made more difficult by the absence of

institutional capacity and legal frameworks. Since unresolved transboundary water-sharing issues with neighbors like Iran and Pakistan increase tensions and make it more difficult to manage shared resources cooperatively, the debate of water rights disputes is especially pertinent (Ahmad & Wasiq, 2004; Alam et al., 2007). Adopting sustainable water management techniques and adjusting to climate change are severely hampered by these governance issues. Notwithstanding these obstacles, the study shows promise to effectively respond to climate change, necessitating international cooperation and outside aid. According to the IPCC (2021) and the World Bank (2017), this is in line with international recommendations for focused investments in climate-resilient infrastructure and capacity-building programs in vulnerable areas. Future research on the socioeconomic effects of water shortage in Afghanistan, specifically with regard to gender dynamics, migration, and rural livelihoods, is made possible by this study. Additionally, it emphasizes the necessity of managing water resources through a multidisciplinary approach that incorporates hydrology, climate science, and sociopolitical research. The results also emphasize how crucial it is to involve local populations in water management programs in order to guarantee sustainability and climate change resilience.

CONCLUSIONS

Using descriptive and analytical approaches to evaluate relevant literature, the primary goal of this research is to analyses the effects of climate change on Afghanistan's water resources as well as other underlying elements. This study made it evident that the adverse effects of climate change on Afghanistan's water crisis are transient and insignificant. Afghanistan's uneven surface water distribution, which exacerbates during drought, is the primary cause of the nation's water woes. The country's people are now vulnerable and helpless against even the smallest issues, such as climate change, due to a combination of long-term political and socio economic instability, inadequate water storage capacity at the national and local levels, and poor management of transboundary water and hydro-political issues shift. Furthermore, only about 33% of Afghanistan's available surface water resources are being used, with the remainder being drained into neighboring countries due to a lack of coordination among pertinent institutions, ineffective policies, a lack of integrated water resource management, and development that disregards scientific methods. Furthermore, in Afghanistan, irrigation wastes almost 40% of the water supply. Last but not least, raising the standard of living for the growing population will result in a relative increase in their water requirements. Therefore, in order to promote sustainable development and avoid hydro political conflicts over water resources at the national and regional levels, it is imperative to handle water crises at these levels. Therefore,

we recommend that interested scholars look into a number of the water crisis, such as how climate change contributes to the nation's water crisis, how to build national and local water storage infrastructure, how political unrest affects the management and preservation of water resources, how neighboring nations affect the management of water resource issues, and hydro political issues in Afghanistan Last but not least, strategies like integrated and cohesive water resource management, building water storage infrastructures at the local and national levels, applying creative and scientific methods to the design and implementation of water projects, utilizing water-saving technologies (like drip irrigation systems), creating water recycling technologies, and protecting surface and groundwater resources are all effective and efficient ways to manage Afghanistan's water resources.

Recommendations

To address Afghanistan's water crisis, compounded by climate change and socio-political challenges, the following measures are proposed:

1. Invest in Water Storage Infrastructure
   - ✓ Develop and rehabilitate dams, reservoirs, and groundwater recharge systems to store surplus water and ensure availability during droughts.
2. Implement Integrated Water Resource Management (IWRM)
   - ✓ Establish comprehensive water management policies that align with scientific methodologies.
3. Modernize Irrigation Systems
   - ✓ Upgrade and maintain irrigation networks to enhance efficiency in agricultural water usage.
4. Enhance Transboundary Water Management
   - ✓ Initiate dialogue with neighboring countries to establish equitable water-sharing agreements.
5. Promote Water Recycling and Conservation Technologies
   - ✓ Introduce wastewater recycling systems to meet the growing water demands of urban and rural populations.
6. Encourage Further Research
   - ✓ Investigate the linkages between Afghanistan's water crisis and climate change impacts.

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