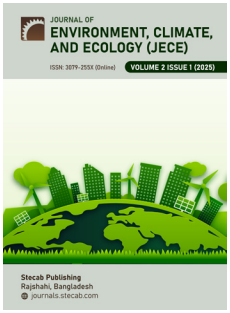

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Research Article

Global Warming and Its Impact on Rural Livelihood in Afghanistan: Challenges, Opportunities, and Pathways for Sustainable Development

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About Article

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ABSTRACT

Global warming has a greater influence on rural life in Afghanistan, with changes in temperature, rainfall patterns, and extreme weather events posing serious concerns to agricultural output, water supplies, and financial stability. Rural populations rely primarily on subsistence farming; therefore, environmental changes increase existing vulnerability, particularly among marginalized groups. This paper examines how global warming affects food security, water availability, and public health in rural Afghanistan as well as the potential for long-term development. This study discusses critical adaptation options such as climate-resilient agricultural practices, renewable energy alternatives, and enhanced water management methods. By combining current literature and case studies, this review proposes techniques for minimizing the negative effects of climate change and developing adaptive solutions to increase rural resilience. The study concludes with concrete recommendations for governments, local communities, and international stakeholders seeking to encourage sustainable rural development in the face of the mounting dangers of global warming.

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1. INTRODUCTION

Global warming is one of the most pressing concerns in the twenty-first century, with serious consequences for ecosystems, economies, and lives. Its effects are particularly severe in vulnerable areas such as Afghanistan, where rural inhabitants rely largely on climate-sensitive industries, such as agriculture and natural resource management. Afghanistan's geographical and socio-economic vulnerabilities, compounded by decades of conflict and instability, intensify the effects of climate change, threatening food security, water availability, and rural livelihoods (IPCC, 2021; Brown, 2019). The country has already undergone severe climate changes, including increasing temperatures, irregular rainfall, and extended droughts, which have affected agricultural output and exacerbated resource scarcity. These difficulties are especially important for Afghanistan's rural population, which accounts for over 70% of the nation, and relies mostly on subsistence farming and pastoralism (Afghanaid, 2022; UNEP, 2016).

The combination of climate change and rural livelihoods in Afghanistan poses two challenges: environmental deterioration and socioeconomic vulnerability. Water shortages and soil degradation have reduced agricultural production, resulting in severe hunger in more than half of the population (FAO, 2021). Women and children are disproportionately affected because they are typically responsible for water collection and farming, both of which become increasingly challenging under climate stress (ActionAid International, 2021). Although climate-smart agricultural practices, such as improved crop varieties and water conservation techniques, have shown promise in mitigating these effects, their adoption is limited owing to resource constraints, a lack of technical knowledge, and institutional barriers (Ahmadzai & Heydayat, 2020; Branca *et al.*, 2021). Addressing these difficulties requires a multifaceted strategy that combines climate adaptation and mitigation methods to strengthen rural resilience.

Despite these obstacles, there is a potential for transformational change. Climate smart agriculture (CSA) and sustainable land management methods provide realistic solutions for increasing agricultural output, reducing environmental degradation, and strengthening livelihood security (Asante *et al.*, 2024; Feng *et al.*, 2023). For example, new wheat cultivars and efficient irrigation systems have been shown to increase yield and lower sensitivity to climatic shocks (Ahmadzai & Heydayat, 2020; Gohar & Cashman, 2016). Furthermore, transboundary water management and renewable energy programs provide the potential for regional collaboration and sustainable resource use (Ahmadzai & McKinna, 2018; Habib *et al.*, 2021). However, to achieve these results, strong legislative frameworks, institutional support, and community participation are required to ensure that interventions are context-specific and inclusive.

This study critically investigates the link between global warming and rural livelihoods in Afghanistan, answering three main questions:

(1) What are the primary climate-related issues confronting rural communities?

(2) What are the chances of building adaptation and resilience?

(3) What policy and development approaches can improve long-term rural livelihood?

2. LITERATURE REVIEW

2.1. Climate Change and Socioeconomic Vulnerabilities in Afghanistan

Global warming is a major cause of environmental and socioeconomic problems, especially in fragile governments, such as Afghanistan. This section examines current research on the impact of climate change on rural livelihoods, with an emphasis on climate-related issues, socioeconomic vulnerabilities, and adaptive methods. While various studies have examined Afghanistan's climate hazards, there are few studies on integrated methods for resilience-building in rural areas.

According to the Intergovernmental Panel on Climate Change (IPCC, 2021), rising global temperatures, irregular precipitation patterns, and increased extreme weather events disproportionately affect disadvantaged countries. Afghanistan, with its dry and semi-arid environment, is particularly vulnerable to these changes. Aich *et al.* (2017) predict large temperature rises and less rainfall, worsening water scarcity and agricultural issues. These changes have serious repercussions for rural livelihoods, as more than 70% of the population relies on agriculture and natural resources for their survival (Afghanaid, 2022; UNEP, 2016).

2.2. Climate Change, Conflict, and Migration

The combination of climate change and war has exacerbated these difficulties. According to Abel *et al.* (2017), climate-induced resource scarcity can lead to increased social tension and forced migration, as seen in Afghanistan, where droughts and water shortages have uprooted rural people. Brown (2019) underlined that climate change exacerbates Afghanistan's vulnerability, jeopardizing food security and economic stability in rural regions. Women and children face the worst burden, as they are frequently responsible for resource gathering and subsistence farming in increasingly difficult conditions (Action Aid International, 2021). In response to these pressures, rural households deploy coping methods, such as relocation, livestock reduction, and alternative income sources (such as wage work or remittances) (Cole *et al.*, 2015). However, such interventions are not sustainable in the absence of long-term structural changes.

2.3. Agriculture and Climate Stressors

Agriculture, which is the foundation of Afghanistan's rural economy, is extremely sensitive to climate change. Ahmadzai and Heydayat (2020) demonstrated that conventional farming methods and restricted access to sophisticated technology have hampered agricultural production, particularly under climatic stressors, such as drought and soil degradation. The adoption of climate-resilient crop types, such as modified wheat, has shown promise for increasing yields and reducing vulnerability, but broad implementation is hampered by resource restrictions and a lack of technical expertise (Ahmadzai & Heydayat, 2020; Branca *et al.*, 2021).

2.4. Water Scarcity and Sustainable Resource Management

Water shortages are a major concern in Afghanistan's agriculture. Bakhtani (2002) emphasized the significance of

soil and water conservation methods, which are frequently overlooked owing to insufficient infrastructure and institutional support. Habib *et al.* (2021) emphasize the need of integrated water resource management in addressing transboundary water issues and promoting sustainable agricultural growth. Given Afghanistan's reliance on water-intensive agricultural techniques, resolving water shortages is critical for improving rural lives and reducing climate vulnerability. This decrease in water availability has resulted in lower crop yields, worsened food security, and exacerbated rural poverty.

3. METHODOLOGY

3.1. Population Selection

This study focused on Afghanistan's rural communities, which are particularly vulnerable to climate change. The research population was selected based on parameters such as agricultural dependency, susceptibility to extreme weather, and socioeconomic weaknesses. Reports and research on rural livelihoods, government policies, and climate adaptation measures have been examined to provide a thorough understanding of the impacted communities.

3.2. Data Collection and Processing

This study relies on secondary data sources, such as government publications, academic studies, policy documents, and climate assessments. A thorough document analysis was conducted to identify the important trends, issues, and solutions concerning global warming and rural livelihoods. The obtained data were divided into the following themes:

- Socioeconomic effects (e.g., income loss, migration, food security).
- Environmental vulnerabilities (e.g., droughts, water shortages, land degradation).
- Institutional solutions (e.g., government policies, international aid, and adaptation programs).

This classification enables the detection of trends and causal links between climate change and rural development.

3.3. Used Methods

The influence of climate change on Afghan rural lives was assessed using a combination of document analysis, critical review, and literature synthesis. To provide a comprehensive analytical viewpoint, this study incorporates data from other fields, including climate science, development studies, and rural economics. Data triangulation was used to improve the dependability of the results by comparing the information from several sources. However, depending entirely on secondary data is limited. This study may fail to reflect specific subtleties or real-time community experience. Future studies should use primary data-gathering methods, such as surveys and interviews, to confirm and build on the findings reported here.

4. RESULT AND DISCUSSION

4.1. Global Warming and Its Implications for Afghanistan

4.1.1. Brief Overview of Global Warming and Climate Change Trends

Global warming, induced by an increase in greenhouse gas emissions, has resulted in dramatic changes in Earth's climate system. The Intergovernmental Panel on Climate Change (IPCC, 2021; 2023) reports that global temperatures have risen by approximately 1.1°C from the pre-industrial period. This warming is accompanied by more frequent and intense heat waves, unpredictable rainfall patterns, and extreme weather events such as droughts and floods. These changes have far-reaching consequences for ecosystems, agriculture, water supplies, and human livelihoods, especially in vulnerable areas, such as Afghanistan.

4.2. Overview of Afghanistan's Geographic and Climatic Conditions

Afghanistan is a landlocked country with a semiarid to dry environment. Due to its unique geography, the country's temperature and precipitation vary greatly. Winters are hard, whereas summers are hot and dry, with most rainfall occurring in the spring months. Afghanistan's geographical position, hilly topography, and reliance on rainfed agriculture make it particularly vulnerable to climatic fluctuations and changes (Aich *et al.*, 2017; UNEP, 2016). Afghanistan's water supply relies mostly on snowfall and glacial runoff from the Hindu Kush mountain range. However, rising temperatures and shifting precipitation patterns pose a growing danger to these resources (Ahmadzai & McKinna, 2018; Habib *et al.*, 2021). These climatic circumstances, combined with decades of violence and limited institutional capability, make the country more vulnerable to climate change.

4.3. Specific Effects of Global Warming on Afghanistan

Owing to its geographical position and socioeconomic environment, Afghanistan is highly sensitive to the effects of global warming. Rising temperatures, shifting precipitation patterns, and an increased frequency of extreme weather events pose major threats to the agricultural sector, water supplies, and general socioeconomic stability.

(i) **Temperature Rise:** Afghanistan's average temperature has risen significantly, with forecasts of 1.4°C to 4.0°C by the end of the century (Aich *et al.*, 2017; IPCC, 2021). This rising trend has resulted in longer droughts, less snow cover, and faster glacier melt, endangering water supplies for agricultural and domestic usage (Chernov, 2021; Brown, 2019).

(ii) **Changing Rainfall Patterns:** Climate change has changed the conventional rainfall patterns, causing more irregular and severe precipitation events. Some areas receive less rainfall, whereas others experience flash floods, resulting in soil erosion, agriculture, and infrastructure damage (Chandrasiri *et al.*, 2020; UNEP, 2016). These changes have serious consequences for rain-fed agriculture, which supports the livelihoods of more than 70% of Afghanistan's population (Afghanaid, 2022; FAO, 2021).

(iii) **Water shortage:** A decline in snowmelt and glacier runoff, along with excessive groundwater exploitation, has resulted in acute water shortages in several sections of the country. Water shortages affect irrigation systems, diminish agricultural output, and exacerbate food poverty (Ahmadzai & McKinna, 2018; Gohar & Cashman, 2016).

(iv) **Impact on Agriculture and Food Security:** Agriculture is the foundation of Afghanistan's economy, employing roughly

60% of the population and contributing considerably to GDP. However, global warming has lowered crop yields, particularly for staple crops such as wheat and rice, owing to water scarcity, heat stress, and insect outbreaks (Ahmadzai & Heydayat, 2020; Kakar *et al.*, 2019). Food insecurity disproportionately affects rural people, particularly women and children (ActionAid International, 2021; FAO, 2023).

(v) **The increased Frequency of Extreme Weather Events:** Droughts, floods, and sandstorms, has become more frequent and severe in Afghanistan. These occurrences devastate crops, animals, and infrastructure, displacing people and exacerbating poverty (Abel *et al.*, 2019; Brown, 2019). For example, the 2021 drought, one of the worst in decades, rendered millions of Afghan food insecure and reliant on humanitarian relief (Chernov, 2021; FAO, 2021).

(vi) **Socioeconomic and environmental consequences:** Climate change four decades of war, economic instability, and poor infrastructure have created a vicious circle of vulnerability in Afghanistan. Rural populations that are already grappling with poverty and restricted access to resources face increased risks of relocation, loss of livelihood, and social instability (Abel *et al.*, 2019; Brown, 2019). Environmental deterioration such as deforestation and soil erosion exacerbates these difficulties (Bakhtani, 2002; Jacobs *et al.*, 2015).

4.4. Challenges Faced by Rural Afghanistan Due to Global Warming

Climate change has a wide-ranging influence on rural Afghanistan, affecting everything from agriculture and water supply to health and socioeconomic stability. As climate patterns change, rural people face difficulties that exacerbate their existing vulnerabilities and jeopardize their livelihoods.

(i) **Impact on Agricultural Productivity and Food Security:** Global warming has severely hampered agricultural production in rural Afghanistan, whose livelihoods rely mainly on rain-fed cultivation. Rising temperatures, variable rainfall patterns, and extended droughts have impacted crop yields, particularly for key crops such as wheat and rice (Aich *et al.*, 2017; Kakar *et al.*, 2019). This decrease in agricultural productivity has worsened food insecurity, with rural households experiencing chronic hunger and malnutrition (FAO, 2021; Afghanaid, 2022). Furthermore, climate change has increased the frequency of extreme weather events such as floods and droughts, which harm crops and animals and jeopardize food production and availability (Chernov, 2021; UNEP, 2016).

(ii) **Decreased Water Availability and Its Impact on Agriculture and Daily Life:** Water shortage is one of the most urgent concerns facing rural Afghanistan as a result of global warming. Reduced snowfall in the Hindu Kush mountains, a key supply of fresh water, has resulted in lower river flows and groundwater recharge (Ahmadzai & McKinna, 2018; Habib *et al.*, 2021). This drop in water availability has had a significant impact on irrigation-dependent agriculture, lowering water supply for crops and cattle. Rural populations also experience difficulties in obtaining safe drinking water, which not only disrupts everyday living but also heightens health hazards (Gohar & Cashman, 2016; Bakhtani, 2002). Furthermore, competition for limited water supplies has prompted community disputes, further destabilizing rural regions (Brown, 2019).

(iii) **Health Risks Associated with Global Warming:** Global warming has increased health hazards in rural Afghanistan, particularly among vulnerable people. Rising temperatures have increased the risk of heat stress, particularly among farmers and outdoor workers (IPCC, 2021). Water shortages and inadequate sanitation have contributed to the increase in waterborne illnesses, including cholera and diarrhea, which disproportionately affect children and the elderly (ActionAid International, 2021). Furthermore, the changing climate has altered the spread of vector-borne illnesses such as malaria, posing new health issues for rural areas (IPCC, 2023).

(iv) **Economic Impacts (Income Loss, Increased Poverty, and Migration Trends):** The economic consequences of global warming in rural Afghanistan were significant. Decreased agricultural production and water shortages have resulted in huge economic losses to farmers, forcing many people into poverty. The loss of livelihood has pushed many rural inhabitants to travel to cities or adjacent countries in search of work, resulting in growing urbanization and social dislocation. These migratory trends have upended conventional social structures, leaving behind vulnerable people, such as women and the elderly, who are unable to travel (Brown, 2019).

(v) **Social Inequalities and Vulnerability of Marginalized Groups:** Global warming has worsened socioeconomic inequities in rural Afghanistan, with vulnerable communities suffering the brunt of the consequences. Women, children, and the elderly are more susceptible because they have limited access to resources and decision-making abilities (Action Aid International, 2021). Women who frequently play an important part in agricultural operations and water collection face additional challenges as resources become scarcer. Children are more vulnerable to starvation and sickness, while the elderly struggle to meet the physical and economic obstacles posed by climate change (FAO, 2021). These disparities are exacerbated by a lack of infrastructure and social services in rural regions, giving underprivileged communities limited alternatives for adaptation (UNEP, 2016).

4.5. Opportunities for Sustainable Development in Rural Afghanistan

While global warming poses significant concerns in rural Afghanistan, there are several attractive options for long-term development that might boost resilience and enhance lives. Leveraging local resources, adjusting to climate change, and encouraging innovation are critical steps toward overcoming environmental and socioeconomic constraints.

(i) **Adoption of Climate-Resilient Agricultural Practices:** Adopting climate-resilient agricultural method is crucial for enhancing food security and rural livelihoods in Afghanistan. Climatic-smart agriculture (CSA) technology, such as drought-tolerant crop varieties, conservation agriculture, and enhanced irrigation practices, can boost productivity while lowering the sensitivity to climatic shocks (Asante *et al.*, 2024; Feng *et al.*, 2023). For example, the introduction of enhanced wheat varieties in Paktia Province has shown more technical efficiency than conventional varieties, paving the way for increasing yields

and food security (Ahmadzai & Heydayat, 2020). Agroforestry and soil conservation measures can also help recover degraded lands and increase ecosystem services, as observed in other dry locations (Jacobs *et al*., 2015; Branca *et al*., 2021).

(ii) **The role of Renewable Energy (Solar, Wind, etc.) in Rural Energy Access:** Renewable energy technologies, particularly solar and wind power, offer significant opportunities to address energy poverty in rural Afghanistan. The country's abundant solar resources make it well suited for decentralized solar energy systems, which can provide reliable electricity for households, schools, and healthcare facilities (Ahmadzai & McKinna, 2018). Renewable energy can also power irrigation systems, reduce dependence on fossil fuels, and enhance agricultural productivity (Gohar & Cashman, 2016). Furthermore, adoption of renewable energy can create local employment opportunities and stimulate economic growth in rural areas.

(iii) **Sustainable Water Management and Conservation Techniques:** Water shortages are a major issue in Afghanistan, compounded by climate change and poor water use. Rainwater collection, drip irrigation, and watershed management are examples of sustainable water management strategies that can increase water availability while reducing waste (Bakhtani, 2002; Habib *et al*., 2021). Community-based water management initiatives, such as the rehabilitation of traditional irrigation systems (e.g., karezes), have been successful in other dry regions and may be scaled up in Afghanistan (UNEP, 2016). Furthermore, transboundary water cooperation is required to provide equitable access to shared water resources, which are critical for agriculture and livelihood (Ahmadzai & McKinna, 2018).

(iv) **Opportunities for Local Entrepreneurship and Innovation:** Promoting local businesses and innovation can help foster long-term development in rural Afghanistan. Access to financing, training, and market connections can help smallholder farmers and rural communities adopt sustainable practices and diversify their revenue streams (Issahaku & Abdulai, 2020). Digital agricultural technology, such as mobile advising services and precision farming tools, has been shown to improve decision-making and production in other developing nations (Chandio *et al*., 2024). Furthermore, women-led businesses in industries such as renewable energy, handicrafts, and agro-processing may empower underprivileged communities and contribute to inclusive growth (ActionAid International, 2021).

(v) **Community-based adaptation (CBA):** Community-based adaptation initiatives are critical to increasing resistance to climate change in rural Afghanistan. These initiatives involve local communities creating and implementing solutions that are suited to their unique needs and settings. For example, participatory methods for land and water management can improve natural resource sustainability while reducing conflicts over finite resources (Abel *et al.* 2019; Brown, 2019). Strengthening social networks and traditional knowledge systems can also help with adaptation capacity, as has been observed in other climate-vulnerable places (Di Falco & Chavas, 2009; Jha *et al*., 2021).

4.6. Pathways for enhancing rural resilience

Rural areas in Afghanistan are among the most susceptible to climate change, with issues such as diminishing agricultural output, water shortages, and increasing poverty. Building resilience in these communities is critical to maintaining sustainable development and food security. This study presents a comprehensive framework that combines policy measures, capacity training, international collaboration, traditional knowledge, and community engagement to boost resilience and support long-term rural development.

(i) **Policy framework for sustainable rural development:**

- *Integrated Climate Adaptation Policies:* Create and implement national policies that include climate adaptation and mitigation methods for rural development. Focus on food security, water resource management, and sustainable agriculture (FAO, 2021; UNEP, 2016).
- *Incentives for Climate-Smart Agriculture (CSA):* Offers farmers' financial and technological incentives to adopt CSA methods, such as better crop varieties, conservation agriculture, and efficient irrigation systems (Asante *et al*., 2024; Feng *et al*., 2023).
- *Land and Water Governance:* Strengthen land tenure systems and water governance frameworks to promote fair access to resources and prevent disputes over finite resources (Habib *et al*., 2021; Bakhtani, 2002).

(ii) **Capacity Building and Knowledge Transfer**

- *Farmer Training Programs:* Establish programs to teach farmers about contemporary agricultural techniques, climate-resilient crops, and sustainable water management practices (Ahmadzai & Heydayat, 2020; Kakar *et al*., 2019).
- *Extension Services:* Expand agricultural extension services to spread CSA methods and provide on-the-ground assistance to rural populations (Jha *et al*., 2021; Kakraliya *et al*., 2018).
- *Digital Agriculture:* Leverage digital tools and technologies to improve access to weather forecasts, market information, and best practices in agriculture (Chandio *et al*., 2024).

(iii) **Role of International Cooperation and Foreign Aid**

- *Funding for Climate Adaptation:* Increase foreign investment in climate adaptation programs in rural Afghanistan, with an emphasis on infrastructure development, catastrophe risk reduction, and livelihood diversification (ActionAid foreign, 2021; Brown, 2019).
- *Technical Assistance:* Collaborate with international organizations to provide technical expertise and share best practices in climate-resilient agriculture and water management (Aich *et al*., 2017; Gohar & Cashman, 2016).
- *Humanitarian Aid and Food Security:* Increase collaboration with organizations such as the World Food Programme (WFP) and FAO to meet immediate food security needs while fostering long-term resilience (FAO, 2023; Afghanaid, 2022).

(iv) **Integration of Traditional Knowledge and Modern Climate Adaptation Practices**

- *Blending Indigenous and Scientific Knowledge:* Combine conventional agricultural methods such as crop rotation and water harvesting with cutting-edge technologies, such as drought-resistant seeds and precision irrigation (Di Falco & Chavas, 2009; Branca *et al*., 2021).
- *Community-Based Adaptation:* Creating community-

driven adaptation techniques that include local knowledge and cultural traditions to increase acceptance and efficacy (Jacobs *et al*., 2015; Jha *et al*., 2021).

• *Participatory Research:* Involve local people in research and pilot projects to co-create context-specific and culturally relevant solutions (Issahaku & Abdulai, 2020).

(v) **Importance of Local Governance and Community Involvement**

• *Decentralized Decision-Making:* Empower local governments and community leaders to develop and carry out climate adaptation activities (Habib *et al*., 2021; UNEP, 2016).

• *Strengthening Social Capital:* Encourage community networks and cooperatives to improve collective action and resource sharing, especially in water management and agriculture (Chandrasiri *et al*., 2020; Jiang *et al*., 2023).

4.7. Case Studies of Successful Adaptation Strategies for Enhancing Rural Resilience in Afghanistan and Beyond

The table below highlights notable case studies and successful adaptation techniques in response to climate change to highlight effective measures to increase resilience and enhance livelihoods in rural Afghanistan.

Table 1. Case studies of successful adaptation strategies for increasing rural resilience in Afghanistan and globally

Case study	Initiative	Outcome	Key Success Factors	Relevance to Afghanistan
Wheat Varieties in Paktia	Drought-resistant wheat varieties through extension programs.	20-30% yield increase, improved food security.	Farmer-researcher collaboration, affordable seeds, training.	Enhances local food security under drought conditions.
Water Harvesting & Soil Conservation	Traditional karez systems combined with modern soil conservation.	Better water availability, reduced soil erosion, and higher yields.	Community planning, NGO/government support.	Adapts to water scarcity and erosion issues.
CSA in Ghana	Agroforestry, conservation agriculture, improved irrigation.	Increased yields, higher incomes, reduced climate risks.	Integration of CSA practices for resource efficiency.	Applicable to resource-limited Afghan areas.
Digital Agriculture in China	Mobile apps and satellite forecasts for optimized irrigation and crop management.	Improved resource use, higher yields, lower carbon footprint.	Use of technology for precision farming and weather forecasts.	Technology could boost farming efficiency and crop yields in Afghanistan.
Agroforestry in Tanzania	Trees integrated with crops and livestock to improve soil and income.	Enhanced resilience, food security, biodiversity.	Combining agriculture and forestry for sustainability.	Useful for Afghanistan's arid regions with climate stress.

Resources: (Ahmadzai & Heydayat, 2020; Bakhtani, 2002; Asante et al., 2024; Issahaku & Abdulai, 2020; Chandio et al., 2024; Han et al., 2023; Jha et al., 2021)

4.8. Lessons Learned and Best Practices

The case studies focused on essential measures for increasing rural resilience in Afghanistan. Successful adaptation incorporates both traditional and modern methodologies, encourages community involvement, seeks international assistance, and stresses scalable solutions.

Table 2. Key lessons for enhancing rural resilience in Afghanistan

Best Practices	Key Insights
Blending Tradition & Innovation	Combining indigenous methods (e.g., karez systems) with modern technologies (e.g., drought-resistant seeds) enhances resilience.
Community-Led Adaptation	Local participation and governance ensure sustainability and effectiveness.
Global Support & Cooperation	International funding and expertise help scale adaptation efforts.
Scalability & Replication	Successful strategies should be adaptable across regions.

Sources: (Di Falco & Chavas, 2009; Branca et al., 2021; Habib et al., 2021; UNEP, 2016; Kakraliya et al., 2018; Jiang et al., 2023)

4.9. Results

Global warming is a major issue, with far-reaching consequences for both rich and developing countries, and its impacts are more severe in countries such as Afghanistan, where climatic sensitivity is exacerbated by socioeconomic weaknesses. This study examines the effects of global warming on rural livelihoods in Afghanistan, identifying key vulnerabilities and adaptation issues. The findings showed that Afghanistan's reliance on rain-fed agriculture, along with inadequate infrastructure and institutional support, has worsened climate-related hazards. Rising temperatures, erratic rainfall patterns, and protracted droughts have affected agricultural production,

particularly for key crops such as wheat and rice. These findings are consistent with those published by Aich *et al.* (2017), who found that decreased precipitation and rising temperatures lead to severe water scarcity and crop failures. The absence of a proper irrigation infrastructure exacerbates these difficulties, making rural farmers very susceptible.

Climate-induced agricultural losses have exacerbated food insecurity, prompting many rural households to adopt negative coping methods such as limiting food consumption or relocating to cities. According to the FAO (2021) and Afghanaid (2022), climate change, increased rural poverty, and malnutrition are all directly linked. While climate-smart agriculture (CSA) methods have the potential to alleviate these risks, their implementation in Afghanistan is restricted due to budgetary limitations, lack of understanding, and insufficient institutional support. This contradicts the findings of Asante *et al.* (2024) and Issahaku and Abdulai (2020), who found increased CSA adoption rates in Ghana owing to improved extension services and financial incentives. Without focused policy initiatives, Afghan farmers struggled to effectively deploy CSA techniques.

Water shortages are a serious concern, aggravated by inadequate water management, transboundary disputes, and out-of-date irrigation infrastructure. Ahmadzai and McKinna (2018) raised similar concerns, emphasizing the importance of improved water governance and infrastructure investments. Addressing these issues through sustainable water management practices, such as community-led conservation campaigns and improved irrigation systems, is critical for long-term resilience.

Furthermore, resource scarcity has fueled migration and has exacerbated local disputes over land and water. These findings are consistent with those of Abel *et al.* (2019) and Brown (2019), who link environmental stress to displacement and conflict in fragile countries. The rising socioeconomic pressure of climate change erodes rural resilience and impedes efforts to achieve sustainable development.

Overall, this study emphasizes the critical need for comprehensive policy interventions to address climate vulnerability. Strengthening agricultural resilience, improving water management, and increasing institutional capacity are critical steps toward sustainable rural development in Afghanistan.

4.10. Discussion

The findings of this study are consistent with global and regional studies on climate change impacts and adaptation while underlining the specific vulnerability of Afghanistan's rural livelihoods. A comparison with other research demonstrated both parallels and variations in climate-related difficulties and adaptation options.

The loss in agricultural output caused by unpredictable rainfall and long-term droughts is consistent with the worldwide patterns. Chandrasiri *et al.* (2020) discovered that rainfall unpredictability considerably impacted paddy productivity in Sri Lanka, whereas Sabbaghi *et al.* (2020) reported comparable agricultural and water resource difficulties in Iran. However, Afghanistan's reliance on rain-fed agriculture, along with inadequate access to irrigation infrastructure and alternative livelihood alternatives, heightens its vulnerability.

The adoption of climate-smart agriculture (CSA) methods in Afghanistan remains low because of budgetary restrictions, a lack of understanding, and insufficient institutional support. In contrast, research from Ghana (Asante *et al.*, 2024; Issahaku & Abdulai, 2020) and northeastern China (Feng *et al.*, 2023) shows greater adoption rates, which are aided by better resource availability, government backing, and farmer training programs. Expanding knowledge-sharing platforms and providing more financial help may dramatically boost CSA use in Afghanistan, particularly in drought-prone areas.

Water shortages are a major issue, as seen in other dry and semi-arid countries. Habib *et al.* (2021) underline the need of integrated water management techniques, whereas Chandio *et al.* (2024) discuss how China has increased water efficiency through technology improvements and regulatory interventions. Implementing cost-effective water conservation technologies, such as rainwater collection and efficient irrigation systems, might boost resilience in water-stressed areas in Afghanistan.

The association between climate change, resource depletion, and migration is consistent with studies from other locations. According to Abel *et al.* (2019) and Brown (2019), environmental deterioration contributes to rural livelihood displacement and change. In Afghanistan, where rural economies are already unstable, strengthening agricultural resilience via sustainable practices may help alleviate migratory pressures.

Institutional support is critical for climate adaptation. Branca *et al.* (2021) underline the relevance of policy frameworks in boosting CSA in Southern Africa, whereas Han *et al.* (2023) demonstrate how financial investments in green technology have increased China's climate resilience. Strengthening institutional support in Afghanistan, such as enhanced climate policy, rural infrastructure investment, and farmer capacity-building initiatives, might help accelerate adaptation efforts.

Overall, the findings of this study are consistent with global climate change studies, highlighting the significance of effective adaptation measures in agriculture, water management, and community resilience. Lessons from other places indicate that improving financial access, establishing knowledge-sharing networks, and enacting effective climate policies may considerably improve Afghanistan's climate resilience.

5. CONCLUSION

This paper focuses on the considerable issues that climate change has on agriculture, food security, and water management in Afghanistan. The results are consistent with global studies on rising temperatures, variable rainfall, and longer droughts, all of which diminish agricultural production, intensify food poverty, and increase resource scarcity. The limited adoption of climate-smart agriculture (CSA) methods, along with budgetary restrictions, lack of knowledge, and inadequate institutional support, impede adaptation efforts. Afghanistan's unique geopolitical backdrop, which includes transboundary water conflicts and continuing violence, exacerbates these issues. However, successful adaptation strategies from other regions, such as the adoption of CSA practices in Ghana and China, suggest that targeted interventions such as strengthening institutional support, improving access to financial resources,

and integrating traditional knowledge with modern techniques, can boost resilience and promote long-term rural development in Afghanistan.

RECOMMENDATIONS

Regarding the challenges addressed in this study, the following suggestions were made to assist sustainable development and climate resilience in Afghanistan:

1. **Promoting climate-smart agriculture (CSA):** To improve agricultural output and resilience, it is critical to provide accessible financial assistance as well as innovative irrigation systems. Furthermore, comprehensive farmer training programs would encourage the adoption of CSA practices that promote long-term sustainability in the face of climate change.
2. **Enhance Water Resource Management:** Given the significant water scarcity concerns, Afghanistan needs to deploy scalable and effective solutions. Rainwater collection technologies, smarter irrigation methods, and community-led water management efforts can help alleviate water scarcity and promote a fair distribution.
3. **Strengthen Food Security:** To ensure food security in the face of climate unpredictability, efforts should be directed boosting agricultural variety, establishing robust early warning systems for climate hazards, and developing decentralized food storage networks. These approaches will lessen vulnerability and provide a consistent food supply during unpredictable times.
4. **Improving Institutional and Policy Frameworks:** A solid institutional and policy foundation is required for effective climate action. This includes drafting and implementing national adaptation strategies, forging public-private collaborations, and establishing forums for knowledge exchange and capacity building to improve climate resilience.

By concentrating on these ideas, Afghanistan may improve its rural lives, alleviate the effects of climate change, and provide groundwork for long-term sustainable development.

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