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Climate Smart Agriculture Opportunities and Challenges in Afghanistan

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ABSTRACT

Agriculture in dryland regions is directly affected by climate change. In Afghanistan, climate-smart agriculture (CSA) improves productivity resilience and reduces greenhouse gas emissions (GHG). However, climate change, water shortage, population growth, and food insecurity are major challenges in developing countries such as Afghanistan. In the face of climate change, traditional agriculture methods need to be transformed into CSA that are capable of improving food production within the constraints of climate change. A review study was conducted to identify opportunities and challenges for CSA in Afghanistan. Among the many CSA technologies in Afghanistan, the review found, the use of drought resistance varieties, implementation of conservation agriculture, the use of Zai and Half-moon techniques for planting pits, moisture conservation, rainwater harvesting, watershed management, drip irrigation system, soil carbon sequestration, control erosion techniques, and climate forecast services are the best opportunities and as promising options for risk management and adaptation to climate change. Still, unfortunately, most of these options have not yet been implemented by Afghan farmers, just followed by researchers. In addition, CSA in Afghanistan faces several solvable challenges. Limited understanding of the CSA concept and framework, limited investment to develop and implement CSA technologies, inadequate communication between government, policymakers, farmers, climate change impacts, GHG, and traditional agriculture. The review recommended that CSA practices be suitable options for all stakeholders to increase income and ensure food security and sustainable agriculture by adaptation practices against climate change. This review provides new strategies and ideas for strengthening sustainable agriculture, food security, environmental protection, and mitigating the impact of climate change.

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Introduction

Climate change poses unique and complex challenges to agriculture in Afghanistan. It is important to note that agriculture is especially vulnerable in Afghanistan due to its dependence on the weather and climatic conditions (OECD, 2022). Afghanistan has an

extreme continental arid and semi-arid climate, making it very vulnerable to climate change (Jawid & Khadjavi, 2019). Recent changes in climate and turmoil in Afghanistan have negatively affected agriculture, food security, and water resources, as well as degraded the environment. (Sharif SHOBAIR, 2016).

Because Afghanistan is mostly an agrarian nation, its agricultural sector contributes 22% to its national GDP (Sarwary et al., 2023). The agricultural industry provides livelihood opportunities for approximately 80% of the country's rural population(Jawid & Khadjavi, 2019). Compared to other countries, Afghanistan's farmers have been comparatively more vulnerable to the impact of severe weather events and have encountered challenges as a result of a lack of sufficient resources for adaptations, increasing their vulnerability (Sharif SHOBAIR, 2016).

Food insecurity and malnutrition in our country are at a high level due to climate change. In developing countries such as Afghanistan, food production needs to increase by 70-100 percent between now and 2050 to meet this challenge (Tumwesigye et al., 2019).

Afghanistan faces numerous challenges in agriculture, including inadequate irrigation infrastructure, water scarcity, agricultural land deficiency, traditional farming methods, lack of technology and machinery, and climate change impacts(World Bank., 2020). These issues have led to low agricultural production and yields compared to global standards. Moreover, the use of chemical fertilizers, pesticides, and water resources has resulted in land degradation. Many farming practices in the country are not sustainable and harm the ecosystem. Therefore, Afghanistan must transition from traditional to modern agricultural methods that are resilient to climate change(Sarwary et al.,2022)

CSA practices, which aim to increase productivity, build resilience, and mitigate greenhouse gas emissions, are crucial for the sustainable development of agriculture in Afghanistan(Sarwary et al.,2022). By focusing on the pillars of productivity, adaptation, and mitigation, CSA can help improve food security and ensure the sustainability of agriculture in Afghanistan. CSA practices are suitable options for all stakeholders to increase income and ensure food security and sustainable agriculture through adaptation practices against climate change Omerkhil et al .,2020). This review provides new strategies and ideas for strengthening sustainable agriculture, food security, environmental protection, and mitigating the impact of climate change.

Methods and Materials

In a present review, the study considered various search topics, books (The FAO sourcebook on climate-smart agriculture, as well as other relevant e-books), articles, and reports to retrieve scientific documents regarding CSA research in Afghanistan. From 2003 to 2023, keywords and relevant phrases were used to conduct a systematic literature search. As a result of the search, several reports, articles, and books have been retrieved, from which 38 were considered for review during the preparation of this manuscript, climate-related search

topics, climate-smart agriculture, best adaptation practices and opportunities, challenges and areas around policy and decision-making, governance, and the technologies involved.

Results and Discussion

Opportunities for CSA (Adaptation strategies) in Afghanistan

CSA has numerous opportunities for productivity, adaptation, and mitigation in Afghanistan to reduce the adverse effects of climate change. These opportunities are discussed as follows:

Drought Resistance Varieties

A wide range of adaptations to drought resistance has been observed in plants at different levels in Afghanistan (ICARDA, 2020). Drought resistance in a crop or a variety can be expressed differently:

1. The capacity of the plant to survive for long periods under water stress;
2. The ability of plants to produce more dry matter;
3. It is possible to give a higher yield under water stress Reddy, 2017.

Fortunately, drought-resistant wheat varieties have recently been released by ICARDA and Afghanistan's Agricultural Research Institute of Afghanistan (ARIA) to help combat recurring droughts and support agriculture in Afghanistan. These new varieties, Mirdad-19, Sharq-19, and Jawahir-19 produce optimum yields in water-scarce regions and show excellent productivity when supplemental irrigations are used (2-3 irrigations). Additionally, these varieties can resist yellow rust infection, which causes significant yield losses in many regions of the country. (ICARDA, 2020).

Implementation of Conservation Agriculture

In Afghanistan, some Adaptation programs to climate change, such as mulching, conservation agriculture, improvement of the canal system and water storage facilities in the target areas, and water-saving irrigation methods were made, which gave excellent results but, unfortunately, were short-term. (NCSA and NAPA., 2009).This approach aims to achieve increased water and nutrient use efficiency by improving biodiversity and natural biological processes, enhancing water infiltration and moisture retention, reducing erosion, increasing yield, improving soil organic matter, decreasing CO_2 emissions, and sustaining crop production(Aini, 2007). Additionally, it supports sustainable land management, reduces labor and machinery costs, and contributes to environmental protection and climate change adaptations and mitigation. Therefore, CA offers possibilities for adapting to and mitigating climate change, as well as improving food security by intensifying sustainable production and enhancing productivity in Afghanistan (Sarwary et al., 2022; Omerkhil et al., 2020)

The Use of Zai and Half-Moon Techniques for Planting Pits

Planting pits, zai, and half-moon techniques are some of the most important CSA practices for water and soil conservation, and they provide the best opportunity for rainfed cultivation in our country. Planting pits, zai, and half-moon techniques, which were carried out in some

provinces of Afghanistan, such as Badghis and Kabul, played an important role in groundwater research (ICARDA and USID., 2016). The recent drought in Afghanistan has left one million hectares of rainfed agricultural land cultivated (Sharif SHOBAIR, 2016). In dryland regions such as West Africa, farmers follow the practice of planting pits(Partey et al., 2018). Both zai and half-moon techniques involve digging pits with a diameter of 20-40 cm and a depth of 10-15 cm for zai and about 2 m for half-moons to collect water before planting. Compost, plant residue, or animal manure is then applied to the pits. These techniques not only save soil and water but also increase soil fertility, moisture conservation, and erosion control and reduce plant diseases, weeds, pests, and insects. Smallholder farmers are most vulnerable to soil degradation, rainfall shortages, and climate change, especially in dryland regions (Barasa et al., 2021). Indicators of smallholder farmers' incomes were determined for zia pits and Half-moon, according to Coulibaly (2018). For example, users of Zai Pit, half-moon, and Zai-Half-moon in Kita Cercle, Mali, have a higher income from the main crop and general household income than non-users. Therefore, planting pits, zai, and half-moon techniques are the most effective solutions for cultivating rainfed areas in Afghanistan ICARDA and USID., 2016.

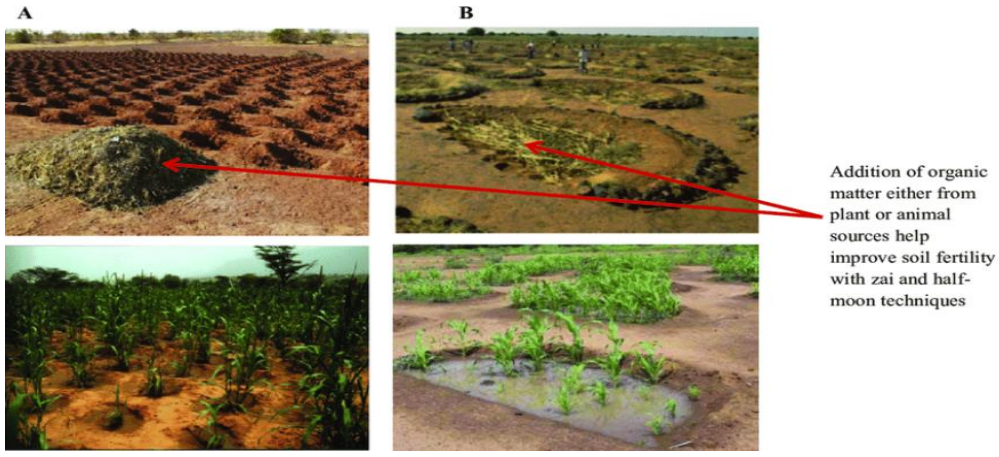

Figure 3: Zai and Half-moon techniques for planting pits

Moisture Conservation

Despite the potential for sustainable agriculture, soil moisture conservation is the best opportunity for improving soil quality, soil conservation, moisture storage, prevention of soil erosion, and a good performance against climate change (Hashimi et al.,2019). Moisture conservation is a crucial approach to combat climate change, variability, and drought stress in dryland regions (Wakweya, 2023). The major reason for crop failures in rainfed areas, especially in Afghanistan, is the deficient moisture of soil (Aini., 2007). There are several ways to increase soil moisture in Afghanistan: mulching, an opportunity for water to enter the soil and growing infiltration, increasing soil water-holding capacity and storage capacity, water use efficiency, and decreasing evapotranspiration, which conserves water in the soil . (SHAMS., 2016). Several methods can be used to reduce runoff, including contour cultivation, conservation furrows, and compartmental bunding. Organic matter and tank silt can be added to increase water holding capacity. Additionally, water storage capacity can be

increased through various techniques such as mulching, weeding, and shelter belts, as well as by reducing evapotranspiration (Reddy, 2017).

Rainwater Harvesting

In order to ensure the best possible utilization of water, harvesting rainwater during the rainy season is a mandatory requirement, and it has given satisfactory results in Kabul and Kandahar provinces (Haziq and Ibrahim, 2022). A key strategy to minimize dry spell-induced crop failures is focusing on the use of rainwater harvesting as supplemental irrigation systems in Afghanistan(Rahmani et al.,2018). For water harvesting systems to take hold, Integrated Water Resource Management (IWRM) must undergo a paradigm shift, where rainfall is viewed as a gateway to freshwater governance, integrating both green water resources and blue water resources (local runoff). (Sarwary et al., 2023). Rainwater harvesting is possible even in areas with as little as 50-80 mm average annual rainfall in dryland regions such as Afghanistan (Rahmani et al.,2018). Meso-catchments must be emphasized instead of the basin level and farmers' fields, which are currently the primary focus of agricultural improvement. (Zhao et al., 2023). Small-scale agricultural systems have the best opportunities to build resilience through water investment at the catchment scale by trading water for food and other ecosystem functions. By reducing soil evaporation, collecting runoff on cropland, and using it when necessary, on-farm water management can increase global and national crop production. (Reddy, 2017).

Watershed Management

Watershed management plays an important role in the development of CSA and sustainable agriculture in Afghanistan (Sarwary et al., 2023). Precipitation mostly occurs in Afghanistan between November and March and lasts 50-60 hours. This water must be captured and stored by the watershed management system until the growing season, and it is the best opportunity against climate change (Bhattacharyya et al.,2004). Management of watersheds is the most fundamental hydrological unit for maximizing soil and water conservation and preventing floods (Wani & Garg, 2009). The main objectives of watershed management are land utilization based on its capability, protection of fertile topsoil, and reducing the reservoirs silting up. Lower fertile land, in situ, rainwater conservation, through grassed waterways, surface runoff can be safely diverted to storage structures, stabilization of gullies and construction of check dams for groundwater recharge, increased cropping intensity through intercropping and sequence cropping, alternate land use, water harvesting, dairy farming, poultry, sheep, and goat farming, improved infrastructure for agricultural marketing, establishment of small-scale agro-industry, and socio-economic upliftment of farmers. (Reddy, 2017).

Drip irrigation System

Ministry of Agriculture, Irrigation and Livestock or MAIL, in the 1400 year through Horticulture Value Chain Development Project or "HVCDSP," builds forty-five drip irrigation systems in six provinces of Afghanistan such as Maidan Wardak, Logar, Khost, Kunar,

Laghman, and Nangarharin for better manage water with the help of the Asian Development Bank, "ADB", As a result, it is an effective measure to solve water shortage and climate change. (MAIL., 1400). In addition, with population growth and increased need for food resources until 2050, the world will face the problem of severe water shortage in Afghanistan (Sarwary et al., 2023). In the present water shortage in the country, drip irrigation is an efficient method of irrigation, which saves up to 70 percent of water. (UNODC, 2023) Also, surface irrigation efficiency is 40-50 %. In contrast, drip irrigation efficiency is 70-90%. (Maisiri et al., 2005). In 2020, the UNODC Alternative Development program introduced a project in Afghanistan to promote licit crop cultivation and improve water efficiency. Therefore, 70 hectares of barren land were put under a drip irrigation system. As a result, smallholder farmers were able to increase their incomes as a result of this program. It is clear that the need for modern agriculture and applying solutions to preserve our limited water resources has increased; therefore, drip irrigation has become a suitable alternative to increase the prosperity of agriculture in Afghanistan. By using the drip irrigation system, it is possible to reduce the negative impact of climate change and drought on the production of food, prevent contamination of underground resources by fertilizers, and support local farmers and rural communities (Partey et al., 2018).

Soil Carbon Sequestration

Soil health and agricultural productivity can be improved by soil carbon sequestration (Lal et al., 2007). Therefore, organic manure improves soil total, N, P, Ca^{2+}, and Mg^{2+} content and carbon sequestration and promotes sustainable Agriculture in the Khost province of Afghanistan(Hashemi et al.,2020). Healthy soils are more resistant to droughts as well as heavy rainfalls, therefore making farms more resilient to climate change (Lal, 2004). A major contributing factor to the climate change problem is agriculture. Thus, some practices are used in CSA to minimize GHG emissions and to improve the sequestration of carbon in soil. In addition to this, such practices also assist in the conservation of soil and water, which is essential for the preservation of soil health and the increase of productivity.

Techniques for Controlling Erosion

There is a lack of data about erosion control in Afghanistan due to a lack of research. Because of the topography of the country, the arid and semi-arid climate, and the barren nature of the land, soil erosion techniques are the most important opportunities for controlling erosion throughout Afghanistan. The farmers in Paktya Province use gypsum minerals to reduce surface runoff and soil erosion on their farmlands (Dawlatzai., 2018). Techniques for controlling erosion include the half-moon, Zia pit, stone bund, contour, tie ridge, terrace drilling, sand dams, and filter dams. These simple techniques increase the amount of water infiltration in the soil and prevent floods and various types of erosion. This is very beneficial in arid and semi-arid areas, especially in Afghanistan, where there is low to moderate rainfall. In addition, these approaches can improve soil quality and increase agricultural yield. Therefore, taking appropriate measures to control soil erosion will enhance the environment

and raise the standard of living of the society in arid and semi-arid regions, especially in Afghanistan (Reddy, 2017).

Climate Forecast Services

Climate services play an important role in managing present and future climate risk in some provinces of Afghanistan(Morshed et al., 2024). Weather forecasting is a very important service for agricultural activities, and it includes effective use of rainfall, plowing, planting, fertilizing, irrigation, harvesting, and threshing in arid and semi-regions like Afghanistan. Still, unfortunately, the weather in the country's districts is not predicted by the National Meteorological Department, and farmers cannot manage their agricultural operations. Farmers are extremely vulnerable to climate-related risks due to repeated droughts and unpredictable rainfalls. The provision of weather information services (WIS) is viewed as one of the most important strategies for mitigating climate risk (Partey et al., 2018). In dryland regions such as Mali, Senegal, Burkina Faso, West Africa, and Afghanistan, more than a million farmers are using WIS through mobile phones and social networks to manage their farms (Etwire et al., 2017).

Afghanistan's Challenges for CSA Development

Despite the benefits of CSA, there are still some challenges to overcome. There is a lack of understanding of concepts related to CSAs, a lack of financial investment, and a lack of effective communication between the government, policymakers, CSA farmers, etc. CSA faces the following challenges in Afghanistan:

Limited Understanding of the CSA Concept and Framework

Unfortunately, the concept of "climate-smart agriculture" is very new in Afghanistan, and most agriculture students and farmers don't understand the concept and framework of climate-smart agriculture, which is related to the educational situation in Afghanistan (Sarhadi et al., 2014). Therefore, several factors contribute to this problem, including inadequate textbooks in universities, a lack of capacity building and journals, weak media, and illiterate farmers(Sarhadi et al.,2014.) Understanding CSA, its linkages to sustainable agriculture, and the pathways to promote CSA is essential to integrating climate change response and CSA practices for food security and sustainable development(Saleem and Raouf.,2011). The goal of achieving a more sustainable and prosperous future requires the reinforcement and dissemination of CSA approaches at the field level (Wakweya, 2023). Thus, CSA approaches must be reinforced and disseminated at the field level to achieve sustainability and prosperity.

Limited Investment to Implement and Develop Climate-Smart Agriculture Technologies

Afghanistan is a country that is heavily dependent on agriculture (Sarwary et al., 2023). According to the report of the United States International Cooperation Agency (USAID) and agricultural statistics, 80% of Afghan people are engaged in agriculture and livestock, and 31% of the national gross income is obtained from agricultural products. Considering that

Afghanistan's agricultural sector has a favorable environment for agriculture, but this opportunity remains unexploited due to a lack of investment in this sector. Imports cover the food deficit, so it seems necessary that more investment should be made in this sector, and Afghanistan should be self-sufficient in terms of food (Saleem and Raouf.,2011). In addition, there is an absence of more foreign investment attraction policies and the introduction of new technology and new management for sustainable and climate-smart agriculture in Afghanistan. Unfortunately, the governmental and non-governmental institutions responsible in this regard, especially the Ministry of Agriculture and Livestock and international agricultural organizations, have not acted strongly in this field and have not taken any noteworthy measures. All the problems mentioned above have joined hands and kept our agriculture backward. The time has come for government officials and international organizations to pay more attention to Afghanistan's agriculture. With the development of this sector, the country's problems will end.

Absence of Appropriate Communication between the Government, Policymakers, and Farmers

The absence of a suitable and correct strategy between the government, policymakers, and farmers in Afghanistan causes the lack of development of sustainable agriculture and the implementation and development of CSA. Furthermore, A major barrier to the development of agriculture is the lack of adequate research, education, and extension services (Saleem and Raouf.,2011). In fact, despite the absence of regular communication, Afghanistan's agricultural sector suffers from the lack of two key indicators, water, and arable land; the root of these problems is related to climate change and its management (Sarwary et al., 2023). The most important factors of agricultural mismanagement include traditional methods of cultivation and old technologies, neglecting the proper cultivation pattern according to the state of water resources in the region, lack of infrastructure and dams and terracing systems, etc. (Wakweya, 2023). Therefore, the government has the responsibility to encourage and financially support researchers, policymakers, and experts to do climate-smart agriculture research and its results directly and indirectly transferred to farmers

Water Shortages in Agriculture

In the south of Afghanistan, the availability of water for irrigation has decreased due to less snowfall and rain. Therefore, irrigation does not take place in these areas during the summer(Bhattacharyya et al.,2004). The sustainable development of CSA in some parts of Helmand and Farah is limited due to water shortages. Afghanistan has been increasingly suffering from severe shortages of agricultural water and drinking water for several years up to now (Sharif SHOBAIR, 2016). Drought in Afghanistan destroyed most of the crops in Ghor province (AAid, 2018). It is expected that agricultural water will reach medium-high levels of risk by 2030. (*2000 World Census of Agriculture*). According to experts, climate change exacerbates drought, which in turn increases the pressure on water resources. Based on the global index of risks caused by climate change, Afghanistan ranks sixth in terms of the irreparable and adverse effects of climate change (FAO, 2003). In comparison to normal years, irrigation

water availability has decreased by up to 70% in canals, resulting in a reduction in irrigated land of up to 60% throughout the country. Kanats (Karezes) have dried up in more than 36% of areas, and their discharge has declined by as much as 83 percent (Sharif SHOBAIR, 2016).

Climate Change and its Impacts

Many parts of Afghanistan have experienced an increase in temperatures and a decrease in precipitation; Afghanistan is frequently affected by climate change-related challenges (Sarwary et al., 2023). Human activities are responsible for causing climate change, which poses challenges to global food production, water resources, sustainable agriculture, and sustainable development of CSA in dryland regions (Zougmoré et al., 2016). Climate change has changed the distribution of water, light, heat, moisture, temperature, and other agroclimate conditions in Afghanistan. Smallholder agriculture in Afghanistan is adversely affected by climate variability, resulting in lower crop yields, reduced income, and food insecurity (Sarwary et al., 2023). In addition, the adverse effect of climate change decreased crop quantity and quality because of reduced crop growth period due to high-temperature levels (Sarwary et al., 2023). Furthermore, reduced carbohydrate, protein, and other nutritional value plants lessen the life of fruit in storage, increase diseases and pests, increase land degradation, decomposition of organic matter, and decrease soil productivity and fertility (Zhao et al., 2023).

Greenhouse Gasses Emissions

Afghanistan's greenhouse gas (GHG) emissions in 2020 were 31,119 metric tonnes, which is extremely high and needs to be reduced (World Bank., 2020). Traditional agriculture plays a significant role in GHG emissions and the expansion challenges of CSA development in dryland regions such as Afghanistan (Zhao et al., 2023). Additionally, there has been an increase in the amount of GHG emissions from anthropogenic sources due to the use of fossil fuels, changes in land use, and deforestation in our country. One of the most important sources of production and emission of GHG is waste disposal centers, which cause the output of nitrous oxide, methane, and carbon dioxide (Fawzy et al., 2020). Unfortunately, in Afghanistan, there has been no correct and regular approach to collecting and burying garbage from previous years until now to prevent the emissions of these gases. In addition, the absence of regulation of carbon tax has become one of the reasons for the more emission of greenhouse gases, especially in the winter season in Afghanistan. Therefore, controlling GHG emissions can reduce agricultural greenhouse gas emissions as well as increase GHG absorption (such as carbon fixation technology) and adapt to climate change by implementing CSA practices.

Traditional Agriculture

Agriculture consists of traditional agriculture and old methods due to government neglect: irrigated lands rely on rivers and streams, and kariz and rainfed lands rely on rainfall. Farmers still use traditional and primitive methods of seeding and harvesting, and tractors, combines, drip and pump irrigation, modified seeds, and other modern agricultural technologies are

rarely used. In addition, absence of a regular and national plan to control and save water, develop agricultural land, familiarize farmers with new agricultural technologies, modernize agriculture, improve the capacity of farmers, and promote new agriculture, government support for farmers and investment in this sector, is the most reason, that climate-smart agriculture does not develop in Afghanistan.

Conclusions and Recommendation

From the above review, we conclude that Afghanistan is a country that is very vulnerable to climate change. Therefore, climate-smart agriculture is the best strategy for developing sustainable agriculture and reducing the negative impact of climate change in Afghanistan. In addition, Afghanistan has several promising opportunities and options for managing risk and adapting to climate change, such as drought-resistant varieties, conservation agriculture, Zai and Half Moon techniques for planting pits, moisture conservation, rainwater harvesting, watershed management, drip irrigation systems, erosion control techniques, and climate forecast services. Unfortunately, the development of CSA in Afghanistan faces some solvable challenges that include a limited understanding of CSA concepts and framework, limited investments in climate-smart agriculture, inadequate communication between government, policymakers, and farmers, water shortages, greenhouse gas emissions, climate change, and traditional agriculture. Therefore, these problems can be removed with financial assistance and government attention in the short term. Hence, I recommend that the government make more investments in the development of CSA in Afghanistan. To minimize the adverse effects of climate change, it is necessary to transform traditional agriculture into climate-smart agriculture. To eradicate poverty in Afghanistan, all stakeholders (national government, ministry of Agriculture and livestock, universities, researchers, smallholder farmers, policymakers, research institutes, private sector, etc.) need to work together and put in enough effort for the development of CSA. Climate change-resilient agriculture should embrace CAS technological practices such as conservation agriculture, drought-resistance varieties, rainwater harvesting, moisture conservation, and improved irrigation systems. For the management of climate risk, Afghanistan's government should establish automatic climate stations at the provincial and sub-provincial levels to improve agricultural advisory services for farmers. There is a need for local agriculture experts trained in sustainable agriculture to teach farmers in Afghanistan the skills required for climate-smart agriculture. Controlling greenhouse gas emissions through changing traditional farming methods, regulating garbage and waste disposal centers, and implementing carbon tax laws.

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References

(AAID)Dry Spell Assessment in Ghor Province - Afghanistan, April 2018 - Afghanistan | ReliefWeb. (2018, May 23). Reliefweb. int. https://reliefweb.int/report/afghanistan/dry-spell-assessment-ghor-province-afghanistan-april-2018

2000 World Census of Agriculture. (n.d.). https://www.fao.org/3/i1595e/i1595e00.htm

Afghanistan National Capacity Needs Self-assessment for global environmental management (NCSA) and National Adaptation Programme of Action for climate change (NAPA) : final joint report / United Nations Environment Programme (UNEP). (2009). https://doi.org/10.29171/azu_acku_ge149_a636_2009

Aini, A. N. (2007). Water conservation in Afghanistan. *Journal of Developments in Sustainable Agriculture*, *2*(1), 51–58. https://doi.org/10.11178/jdsa.2.51

Bhattacharyya, K., Azizi, P. M., Shobair, S. S., & Mohsini, M. Y. (2004). Drought impacts and potential for their mitigation in southern and western Afghanistan. *RePEc: Research Papers in Economics*, *91*. https://doi.org/10.22004/ag.econ.92659

Dawlatzai, A. M., & Mihara, M. (2016). Current agricultural conditions and constraints in Paktya province of Afghanistan. *International Journal of Environmental and Rural Development*, *7*(2), 44–51. https://doi.org/10.32115/ijerd.7.2_44

FAO. (2003). *National Livestock Census 2002/03 Final Report, FAO Rome, 2008 Afghanistan*. https://www.fao.org/3/i1595e/i1595e01.pdf

Fawzy, S., Osman, A. I., Doran, J., & Rooney, D. (2020). Strategies for mitigation of climate change: a review. *Environmental Chemistry Letters*, *18*(6), 2069–2094. https://doi.org/10.1007/s10311-020-01059-w

Hashimi, R., Komatsuzaki, M., Mineta, T., Kaneda, S., & Kaneko, N. (2019). Potential for no-tillage and clipped-weed mulching to improve soil quality and yield in organic eggplant production. *Biological Agriculture & Horticulture*, *35*(3), 158–171. https://doi.org/10.1080/01448765.2019.1577757

Partey, S. T., Zougmoré, R. B., Ouédraogo, M., & Campbell, B. M. (2018). Developing climate-smart agriculture to face climate variability in West Africa: Challenges and lessons learnt. *Journal of Cleaner Production*, *187*, 285–295. https://doi.org/10.1016/j.jclepro.2018.03.199

Prince Maxwell Etwire, S. S. J. Buah, Mathieu Ouédraogo, Zougmoré, R. B., Partey, S. T., Martey, E., Sidzabda Djibril Dayamba, & Bayala, J. (2017). An assessment of mobile phone-based dissemination of weather and market information in the Upper West Region of Ghana. *Agriculture & Food Security*, *6*(1). https://doi.org/10.1186/s40066-016-0088-y

Rahmani, S. A., Nakajima, T., & Mihara, M. (2018). Development of water harvesting technique in Qargha Reservoir Watershed of Paghman District, Afghanistan. *International Journal of Environmental and Rural Development*, *9*(1), 142–149. https://www.cabdirect.org/cabdirect/abstract/20193212218

Reddy. (2017). *Dryland agriculture principles and practices*.

Saleem, S., & Raouf, M. E. (2011). Sustainable agricultural development and the challenges facing agricultural education in Afghanistan. *Journal of Developments in Sustainable Agriculture*, *6*(1), 45–49. https://doi.org/10.11178/jdsa.6.45

Sarhadi, W. A., Fahim, S. A., & Tangutan, K. (2014). Sustainable agricultural development in Afghanistan. *Journal of Developments in Sustainable Agriculture*, *9*(1), 41–46. https://doi.org/10.11178/jdsa.9.41

Sarwary, M., Samiappan, S., Khan, G. D., & Moahid, M. (2023). Climate change and cereal crops productivity in Afghanistan: Evidence based on panel Regression model. *Sustainability*, *15*(14), 10963. https://doi.org/10.3390/su151410963

Sarwary, M., Samiappan, S., Saravanakumar, V., Arivelarasan, T., & Manivasagam, V. (2022). Climate risks, Farmers perception and adaptation strategies to climate variability in Afghanistan. *Emirates Journal of Food and Agriculture*. https://doi.org/10.9755/ejfa.2021.v33.i12.2797

Hashimi, R., Matsuura, E., & Komatsuzaki, M. (2020). Effects of Cultivating Rice and Wheat with and without Organic Fertilizer Application on Greenhouse Gas Emissions and Soil Quality in Khost, Afghanistan. *Sustainability*, *12*(16), 6508. https://doi.org/10.3390/su12166508

Haziq, M. A., & Ibrahmi, A. R. (2022). Identification of suitable sites for rainwater harvesting using GIS in Kandahar province, Afghanistan. *Indian Journal of Science and Technology*, *15*(47), 2646–2661. https://doi.org/10.17485/ijst/v15i47.1289

How a Drip Irrigation System Allowed Farmers to Turn Away from Poppy Cultivation in Nangarhar, Afghanistan. (n.d.). United Nations : Office on Drugs and Crime. https://www.unodc.org/unodc/en/frontpage/2023/June/how-a-drip-irrigation-system-allowed-farmers-to-turn-away-from-poppy-cultivation-in-nangarhar--afghanistan.html

HVCDSP to build 45 Drip Irrigation Systems | AfGOV. (n.d.). https://mail.gov.af/en/hvcdsp-build-45-drip-irrigation-systems

Jawid, A., & Khadjavi, M. (2019). Adaptation to climate change in Afghanistan: Evidence on the impact of external interventions. *Economic Analysis and Policy*, *64*, 64–82. https://doi.org/10.1016/j.eap.2019.07.010

Jun, Z., Li, D., & Huang, R. (2023). A review of Climate-Smart Agriculture: Recent advancements, challenges, and future directions. *Sustainability*, *15*(4), 3404. https://doi.org/10.3390/su15043404

Lal, R. (2004). Soil carbon sequestration to mitigate climate change. *Geoderma*, *123*(1–2), 1–22. https://doi.org/10.1016/j.geoderma.2004.01.032

Lal, R., Suleimenov, M., Stewart, B. A., Hansen, D., & Doraiswamy, P. C. (2007). Climate change and terrestrial carbon sequestration in Central Asia. In *CRC Press eBooks*. https://doi.org/10.1201/9780203932698

Maisiri, N., Senzanje, A., Rockström, J., & Twomlow, S. (2005). On farm evaluation of the effect of low cost drip irrigation on water and crop productivity compared to conventional surface irrigation system. *Physics and Chemistry of the Earth, Parts a/B/C*, *30*(11–16), 783–791. https://doi.org/10.1016/j.pce.2005.08.021

Mushwani, H., Ahmad, M. M., Sahak, K., & Hairan, M. H. (2023). The Current State of Early Warning System in South Asia: A Case Study of Afghanistan. *SSRN*. https://doi.org/10.2139/ssrn.4596891

Omerkhil, N., Kumar, P., Mallick, M., Meru, L. B., Chand, T., Rawat, P. S., & Pandey, R. (2020). Micro-level adaptation strategies by smallholders to adapt climate change in the least developed countries (LDCs): Insights from Afghanistan. *Ecological Indicators*, *118*, 106781. https://doi.org/10.1016/j.ecolind.2020.106781

Shams, H. K. (2016). *Study on Effective utilization of irrigation water in Afghanistan*. CiNii Dissertations. https://ci.nii.ac.jp/naid/500001081151?l=en

Shobair, S. S. (2015). 1 The effects of calamities on water resources and consumption in Afghanistan. *www.academia.edu*. https://www.academia.edu/71855040/1_The_effects_of_calamities_on_water_resources_and_consumption_in_Afghanistan

The impacts of agricultural trade and support policy reform on climate change adaptation and environmental performance. (2022). *OECD Food, Agriculture and Fisheries Working Papers*. https://doi.org/10.1787/520dd70d-en

Three new drought-adapted ICARDA/ARIA wheat varieties released in Afghanistan - Afghanistan. (2020, December 16). ReliefWeb. https://reliefweb.int/report/afghanistan/three-new-drought-adapted-icardaaria-wheat-varieties-released-afghanistan

Tumwesigye, W., Aschalew, A., Wambi, W., Atwongyire, D., Nagawa, G. M., & Ndizihiwe, D. (2019). Climate Smart Agriculture for Improving Crop Production and Biodiversity Conservation: Opportunities and Challenges in the 21st Century - A Narrative Review. *Journal of Water Resources and Ocean Science*, *8*(5), 56. https://doi.org/10.11648/j.wros.20190805.11

Wakweya, R. B. (2023). Challenges and prospects of adopting climate-smart agricultural practices and technologies: Implications for food security. *Journal of Agriculture and Food Research*, *14*, 100698. https://doi.org/10.1016/j.jafr.2023.100698

Wani, S. P., & Garg, K. K. (2009). Watershed Management Concept and Principles. *ResearchGate*. https://www.researchgate.net/publication/266351616

World Bank Open Data. (n.d.). World Bank Open Data. https://data.worldbank.org/indicator/EN.ATM.GHGT.KT.CE?locations=AF

Xoconostle-Cázares, B., Ramírez-Ortega, F. A., Flores-Elenes, L., & Ruiz-Medrano, R. (2010). Drought tolerance in crop plants. *American Journal of Plant Physiology*, *5*(5), 241–256. https://doi.org/10.3923/ajpp.2010.241.256

Zizinga, A., Mwanjalolo, J. M., Tietjen, B., Bedadi, B., Gabiri, G., & Luswata, K. C. (2022). Impacts of climate smart agriculture practices on soil water conservation and maize productivity in rainfed cropping systems of Uganda. *Frontiers in Sustainable Food Systems*, *6*. https://doi.org/10.3389/fsufs.2022.889830

Zougmoré, R. B., Thomas, T. S., Ericksen, P. J., Said, M. Y., & Jalloh, A. (2016). Toward climate-smart agriculture in west africa: A review of climate change impacts, adaptation strategies and policy developments for the livestock, fishery and crop production sectors. *Agriculture & Food Security*, *5*(1). https://doi.org/10.1186/s40066-016-0075-3