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The Impacts of Climate Change on Agriculture in Afghanistan: A Review

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ABSTRACT

Climate change is a global threat to agriculture and agricultural products worldwide. Since the Green Revolution, greenhouse gas emissions in the atmosphere have increased rapidly, such as CO_2, N_2O, and CH_4, which have caused global warming. Furthermore, due to global warming, the temperature has risen rapidly in most parts of the world in recent years. Agriculture in Afghanistan has been negatively affected by climate change factors in recent decades. Such as drought, changes in the time and quantity of precipitation, and temperature caused losses in agricultural products. The impacts of climate change on Afghanistan's agriculture sector and agricultural products have not yet been widely investigated in previous literature. Thus, this review aims to describe the most vulnerable factors of climate change in Afghanistan. This review also focuses on adapting practices that reduce the negative effects of climate change on agriculture. The combination of all the information mentioned above may be useful to policymakers and governmental and nongovernmental organizations to state a reasonable plan to reduce the negative effects of climate change on agriculture and agriculture products that the plants face in the future under climate change conditions in Afghanistan.

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Introduction

South Asian countries, including Afghanistan, are among the most affected by climate change (Omerkhil et al., 2020). Afghanistan is where more than 2/3 of its people live in rural areas, and eighty percent of their income comes from agricultural production (World Bank, 2021). Agriculture is the most vital part of Afghanistan's economy, as nearly 80% of the country's population is engaged in this sector (World Bank, 2014). In Afghanistan, climate change is related to various adverse effects of climate change factors, including increasing temperatures (Mehrad, 2020). Afghanistan is classified as one of the nations with the most climate-sensitive agricultural production. From 2011-2016, the country faced high exposure

to climate extremes regarding inter-seasonal variability, frequency, and intensity (FAO, 2018).

Furthermore, temperature has risen significantly in Afghanistan, between 0.6 and 1.8°C since 1950 (Shokory et al., 2023). Moreover, the temperature is projected to rise exponentially (Mehrad, 2020). Crops require particular climate conditions, and climate changes can significantly negatively affect crops (Khalily, 2022). For instance, wheat crops in Afghanistan are impacted by temperature patterns (Khalily, 2022). Temperature had a significant negative impact, implying that a mean temperature increase of 1 ◦C decreased wheat and barley yields by 271 and 221 kg/ha, respectively (Sarwary et al., 2023).

On the other hand, current precipitation is meaningfully lower in the southwest and northwest of Afghanistan and pointedly more at some grid places in the northeast and southeast of the country (Aich & Khoshbeen, 2016; Qutbudin et al., 2019). Due to the lack of rainfall, rain-fed crops (wheat and barley) production has reduced significantly, about 40% less than in 2000 (SAARC, 2010). Furthermore, water shortages have devastated Afghanistan's agriculture and pastures and led to water scarcity for human consumption (Mayar, 2021). For instance, data revealed that mean annual precipitation has remarkably decreased in western Afghanistan (Aliyar & Esmailnejad, 2022). However, according to a report by the World Food Program and UN Environment Program (2016), Afghanistan is already facing severe climate-change-related flooding caused by heavy rainfall over a short period and rapid melting of snow and ice in highland areas during the spring.

At the same time, agriculture in Afghanistan, which provides a livelihood to nearly 80 percent of the population, has been the sector most affected by the drought (Mohammad et al.,2018). Impacts include insufficient food, loss of assets, drought-induced migration, reduced planting areas, and distressed livestock selling (Mohammad et al.,2018). While the country suffers greatly from institutional failures and poor capacity in the water resources management sector (Akhtar et al., 2017). Due to the drought in 2021 and the 25 percent deficiency in national wheat production.

South Asian countries, including Afghanistan, are the most affected by climate change (Omerkhil et al., 2020). Furthermore, Afghanistan, like other developing countries, is highly vulnerable to the severe impacts of climate change (Mehrad, 2020). In Afghanistan, climate change is related to various adverse effects of climate change factors, including increasing temperature (Mehrad, 2020). Agriculture is the most vital part of Afghanistan's economy, as nearly 80% of the country's population is engaged in this sector (World Bank, 2014). Afghanistan is a country where more than 2/3 of its people live in rural areas, and eighty percent of their fed on agricultural production (World Bank, 2021). This is even though only (%12.1) of Afghanistan's soil is agricultural land, (%5) of which is cultivated (irrigated) and (%7) is rainfed (Goodh & Sedra, 2010).

The agriculture sector in Afghanistan has been affected by climate change factors for several decades. One of the main factors is the increasing CO_2 in the atmosphere, which has

caused global warming and a rise in temperature in Afghanistan. In the previous studies, the effects of climate change on Agriculture were not well described. Thus, it is necessary to investigate and highlight the most important and vulnerable climate change factors affecting Afghanistan's agriculture. Therefore, it is essential to investigate and highlight the most important and vulnerable climate change factors affecting Agriculture in the country. Policymakers and governmental and nongovernmental agencies can use this information to prepare a reasonable plan to mitigate the adverse effects of climate change on agriculture in Afghanistan in the future.

Effects of Temperature Rise on Agriculture in Afghanistan

Crops require particular climate conditions, and climate changes can significantly negatively affect crop yields (Khalily, 2022). The most important food crops for the country's people are wheat, corn, and rice (Khalily, 2022). Studies show that wheat crops in Afghanistan are impacted by temperature patterns (Khalily, 2022). Moreover, it is projected that during the period 2021–2050, the mean yield of wheat may decrease by 21 to 28%, the rice yield may decrease by 4.92 or 6.10%, and the barley yield may decrease by 387 or 535 kg/ha (Sarwary et al., 2023). Temperature had a significant negative impact, implying that a mean temperature increase of 1 ◦C decreased wheat and barley yields by 271 and 221 kg/ha, respectively (Sarwary et al., 2023). It is reported that most farmers are affected by climate change, such as loss of employment, labor scarcity, pest and disease outbreaks, and a decline in groundwater level (Sarwary et al., 2021).

Substantial warming is expected all over the country, with the most severe temperature increase in the north (the Northern plains), the Hindu Kush, and the Central Highlands (Mehrad, 2020). Over the previous 10 years, a relative rise in both mean maximum and mean minimum temperature and a relative drop in yearly precipitation has been reported (Rahimi & Nazarian, 2022). Afghanistan's mean temperatures will continue to rise between 1.5°C and 3°C until the 2050s and between 2.2°C and 6.3°C by the 2100s. The minimum suggestion is a 1.5°C increase until the 2050s and 2.5°C by the 2100s in Afghanistan (Mehrad, 2020). Similarly, increases in mean minimum and mean maximum temperatures of up to 4.5 and 5°C, respectively, are anticipated (Sharma et al., 2015). According to the World Bank Group (2021), Afghanistan might warm by 1.4 to 5.4°C by the 2080s and 2090s, relative to the baseline of 1986-2005, which is greater than the global average (Jawadi et al., 2019; Shroder and Ahmadzai, 2016). Projections suggest that by 2100, the average temperature in Afghanistan will increase by 2-6 degrees Celsius, and the country will have generally drier conditions (Aich & Khoshbeen 2016).

The important climate adaptation strategies are changing cropping patterns, drilling new bore wells, and farm diversification, which are extensively practiced by farmers (Sarwary et al., 2021). Therefore, acquiring a thorough comprehension of the implications of climate change on the cultivation of key cereal crops is of the utmost importance (Sarwary et al., 2023). Organizing capacity-building programs on crop-specific climate-smart agricultural practices such as moisture conservation, biomass mulching, alternate wetting and drying

irrigation methods, introducing drought-tolerant varieties, direct seeding, water harvesting, and recycling for supplemental irrigation for farmers through trained personnel from extension and line departments for sustainable agriculture in Afghanistan is one of the viable options to practice climate change adaptation (Sarwary et al., 2021).

Effect of Precipitation Reduction on Agriculture in Afghanistan

In 2017 alone, climate shocks (floods and droughts) negatively affected the food security status of 7.8 million Afghans (FAO, 2018). At the same time, widespread suffering, death, and displacement resulting from the flooding engendered by precipitation events, whose severity has increased by 10–25% in the past 30 years (WFP, 2016).

Analyzing precipitation trends in Afghanistan from 1950 to 2019 indicates that heavy precipitation mostly occurs in the spring and winter (Mehrad, 2020). January, February, and March have the highest rainfall, while September and July have the lowest (Mehrad, 2020). At the same time, in the spring, precipitation significantly decreased by 32%, but it remained unchanged in the winter (Mehrad, 2020). An analysis by Aich and Khoshbeen (2016) suggests a significant change in the climate of the country since the 1950s: the average annual temperature has increased by about 1.8 degrees Celsius; the average yearly precipitation has decreased (with higher variation across seasons and space); and extreme weather events have become more frequent. However, Savage et al. (2009) reported a 0.6-degree Celsius warming and a 0.2-mm decrease in average monthly precipitation since 1960. Since 1950, rainfall has substantially fallen in Afghanistan, which is likely to continue in the future (Mehrad, 2020).

Precipitation is significantly less in the southwest and northwest and substantially more in some parts of the northeast and southeast of the country (Aich & Khoshbeen, 2016). Reducing rainfall in the northern regions has affected the water supply for rice cultivation, and therefore, the continuation of this trend will reduce rice production in Afghanistan (SAARC, 2010). Due to the lack of rainfall, rain-fed crops (wheat and barley) production has decreased significantly, about 40% less than in 2000 (SAARC, 2010). Most importantly, these shocks are responsible for a food quantity-quality trade-off (D'Souza & Jolliffe, 2012), leading Afghanistan to experience severe micronutrient deficiency, as reflected in the 2002 scurvy epidemic (Cheung et al., 2003), and in large portions of the population (especially women of reproductive age) suffering from anemia and iron and vitamin A deficiency (Cheung et al., 2003; Levitt et al., 2010; Mihora et al., 2004); spring rainfall would be significantly reduced (Aich & Khoshbeen, 2016). Precipitation during March, April, and May is estimated to decrease by 10-40 mm (Aich &Khoshbeen 2016). According to forecasts and reports, some areas of Afghanistan will suffer an 8.5 percent decrease in average mean rainfall (Sharma et al., 2015). Most of the country's southern, eastern, and central territories have low precipitation and, therefore, suffer from severe droughts (RCRC, 2020). For Afghanistan, where the annual water supply relies largely on winter precipitation in the mountains that accumulates as glaciers, snow, and ice, this has resulted in one of the worst droughts of the past two decades (Mayar, 2021).

Meltwater from the mountains' glaciers, snow, and ice, which act as natural stores, feeds irrigable land, rivers, and reservoirs (Mayar, 2021). Water shortages have devastated Afghanistan's agriculture and pastures and led to water scarcity for human consumption (Mayar, 2021). For instance, in 2021, rainfed wheat has reduced in the country's northern regions; the country's hydroelectric dams are performing at far below usual levels; many drinking water wells have gone dry in Kabul due to dwindling groundwater levels; and children have to queue for hours at deeper wells, often far from their homes (Mayar, 2021). Pamir and Wakhan glaciers, which are the source of northern Afghanistan rivers, experienced a shrinkage level of up to 18% by 2019 and are expected to be shrunk by about 15.9% in 2050 and 27.3% in 2100, respectively (Mehrad, 2020). Under the available optimistic scenario, there will be a precipitation increase of about 30-40 mm in the southern and north-eastern (Hindu Kush) regions (Mehrad, 2020).

Analysis of mean annual precipitation showed a significant decreasing trend in six provinces in the north, while an increasing trend of 9.2 mm per decade has been observed in three provinces (Aliyar & Esmailnejad, 2022). In the south, a notable reduction of the precipitation trend has been experienced in Helmand, Kandahar, and Nimruz provinces, but Ghazni and Uruzgan show a positive trend (Aliyar & Esmailnejad, 2022). Data revealed that mean annual precipitation has remarkably decreased in western Afghanistan (Aliyar & Esmailnejad, 2022).

The winter has become drier in the past five decades due to high evaporation, which is expected to continue (Mehrad, 2020). According to the study period, the mean annual rainfall in the central regions indicates a rise of 37.5 mm per decade in Kabul, while in Wardak, the precipitation increases up to 9.21 mm per year (Aliyar & Esmailnejad, 2022). These regions are directly influenced by the moist air masses of the Indian monsoon getting trapped at the high mountain slopes, which can lead to increased rain (Aliyar & Esmailnejad, 2022). Data reveals an upward trend of precipitation in the eastern part of Afghanistan (Aliyar & Esmailnejad, 2022). Nearly all grid sites in the nation's northwest and southwest experienced a significant temperature increase. Qutbudin et al. (2019) reported that the geographical distributions of the changes in precipitation and rainfall were reduced dramatically at a few sites in the southwest and northwest.

Climate Change Causes Flooding in Afghanistan

The effect of climate change on flooding is likely to be especially severe in South Asia, where climate change appears to influence both the monsoon and tropical cyclones, the two main drivers of flooding in the region (Douglas, 2009). One country strongly affected by such flooding is Afghanistan, in which about 70% of all-natural disasters are attributable to floods (OCHA, 2014), with around 400,000 individuals displaced and 5,000 killed by flooding between 1988 and 2006 (Hagen & Teufert, 2009). According to a report by the World Food Program and UN Environment Program (2016), Afghanistan is already facing severe climate-change-related flooding caused by heavy rainfall over a short period and rapid melting of snow and ice in highland areas during the spring.

On the other hand, the northern and north-western provinces are vulnerable to seasonal floods (Safi, 2009). Nonetheless, despite extensive evidence that floods exposure reduces household calorie consumption (Del Ninno et al., 2003), neither floods nor climate change in general influence food security solely through short-term availability and food prices; floods may also be responsible for lowering household income and assets (Del Ninno et al., 2003).

Effects of Drought and Water Scarcity on agriculture in Afghanistan

Agriculture in Afghanistan, which provides a livelihood to nearly 80 percent of the population, has been the sector most affected by the drought (Mohammad., et al., 2018). Impacts include insufficient food, loss of assets, drought-induced migration, reduced planting areas, and distress selling of livestock (Mohammad et al.,2018).

While Afghanistan is semi-arid, around 80% of its water resources come from the snowmelt draining from its mountainous peaks (Akhtar et al., 2017). Based on water flow and groundwater availability, the country has five major river basins: the Kabul, Helmand, Hari Rod Murghab, Panj-Amu, and Northern basins (Akhtar et al., 2017). Except for the northern river basin, the remaining four are transboundary in nature and discharge into neighboring countries (Akhtar et al., 2017).

The country suffers significantly from institutional failures and poor capacity in the water resources management sector (Akhtar et al., 2017). Afghanistan suffers from water scarcity; the per capita availability of water is 2,500 m^3/s, which is largely unused, so it underlines the country's food security conditions (Aliyar & Esmailnejad, 2022). To meet the recommended food and water demand, the ultimate dependency comes over crop water productivity, directly linked to irrigated agriculture, which suffers from multiple management and technical deficiencies (Kreft et al., 2015).

According to the crop monitor's September 2021 Global Agricultural Monitoring (GLAM) report, the winter wheat season failed in the northern and southwestern provinces, meaning the seeds sown at the end of the previous season could not yield in the spring. The report also pointed to poor wheat-growing conditions in central Afghanistan and warned that irrigated agriculture would deliver lower-than-average yields owing to water shortages. According to estimates, Afghanistan's total wheat demand for 2020 was 6.4 million metric tons; 5 million metric tons were produced domestically, and 1.4 million metric tons were imported due to the drought in 2021 and the 25 percent deficiency in national wheat production.

Conclusion

Afghanistan, located in South Asia, is one of the countries most affected by climate change. Agriculture is the most vital part of the Afghan economy, while most people live in rural areas and depend on their agricultural products. The most important and vulnerable climate change factors affecting agriculture in Afghanistan are increasing temperatures, glacier retreats, floods, drought, unpredictable rainfall, changes in precipitation season and time, and a lack of watershed management. Most of the abovementioned factors affect agriculture negatively in the country due to reduced crop production. For instance, an increase in

temperature by 1◦C decreased wheat and barley yields by 271 and 221 kg/ha, respectively. Due to the lack of rainfall, rain-fed wheat and barley production significantly reduced by 40% from 2000 to 2010. Also, as the reduction in rainfall in the north of Afghanistan has affected the water supply for rice cultivation, which will reduce rice production in the future, to mitigate the adverse effects of climate change factors in the country, it is suggested to design and extend the climate-smart agriculture adaptative and mitigation practices and technologies such as water-smart practices, weather-smart activities, and knowledge-smart practices. It is also recommended that future research should be conducted on climate-smart agriculture practices in local areas.

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