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Assessing Stakeholders' Perception and Adaptation Strategies against Impacts of Climate Change on Agricultural Production (Wheat): A Case Study of Kabul, Afghanistan

Ocena sposobu postrzegania przez interesariuszy skutków zmian klimatycznych dla produkcji rolnej (pszenicy) oraz stosowanych przez nich strategii adaptacyjnych: studium przypadku Kabulu, Afganistan

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Abstract: Climate change has serious environmental, economic, and social impacts on the agricultural community in Afghanistan. A combination of many factors, including low socioeconomic situation, poor infrastructure, extreme poverty, rapid population growth, and low adaptive capacity, exerts the agricultural community at extreme vulnerability. Utilizing adaptation strategies by farmers and policymakers plays an important role in minimizing the impacts of climate change. It is important to know how stakeholders perceive the impact of climate change that influences their livelihoods, and the way they use adaptation strategies. This study assessed stakeholders' perceptions of climate change and vulnerability based on information that was collected from literature and the stakeholders themselves through surveys and interviews. Therefore, the study is primarily focused on Stakeholders' perception of climate change, effective variables, the impact of climate change on wheat production, and adaptation strategies. Findings revealed that stakeholders had concerns about the negative impact of climate change on crop production. Among the farmers, 90.4% and 72.8% believed that drought and temperature trends had already increased, and only 27.3 % of them thought that rainfall had decreased. The belief of a decrease in crop production due to climatic challenges was recorded by 90.9% and 80% of farmers and agricultural organization workers, respectively. Farmers reported a decrease in crop production of over 46%, and they utilized alternative and tolerant varieties as a means of adapting to the changes and of limiting crop reduction. Agricultural organization workers recommended some strategies including cultivation of adaptive seeds, crop rotation, water resource management, jungle protection, tree planting, increasing public awareness, agriculture machinery, and greenhouse creation, but 33.4 % of them did not provide any suggestions. Stakeholders' perception and adaptation practices could be improved by the support of organized cooperatives, policy making, training programs, and development of relevant strategies.

Keywords: climate change, stakeholders' perception, wheat production, adaptation strategies, Afghanistan

Streszczenie: Zmiany klimatyczne wywierają znaczący wpływ na społeczność rolniczą w Afganistanie w wymiarze środowiskowym, gospodarczym i społecznym. Połączenie wielu czynników, takich jak niski status społeczno-ekonomiczny, słaba infrastruktura, skrajne ubóstwo, szybki wzrost populacji oraz ograniczona zdolność adaptacyjna, sprawia, że rolnicy należą do grup szczególnie narażonych na zagrożenia. Zastosowanie strategii adaptacyjnych zarówno przez samych rolników, jak i decydentów, odgrywa zatem kluczową rolę w ograniczaniu skutków zmian klimatycznych. Istotne znaczenie ma poznanie sposobu, w jaki interesariusze postrzegają zmiany klimatyczne oraz ich wpływ na źródła utrzymania, a także zrozumienie stosowanych przez nich strategii adaptacyjnych. Niniejsze badanie prezentuje stanowisko interesariuszy wobec zmian klimatycznych i związanych z nimi zagrożeń na podstawie danych z literatury przedmiotu oraz informacji pozyskanych bezpośrednio od respondentów za pomocą ankiet i wywiadów. Analiza koncentruje się na percepcji zmian klimatycznych, czynnikach warunkujących te procesy, ich wpływie na produkcję pszenicy oraz na stosowanych strategiach adaptacyjnych. Wyniki badań wskazują, że interesariusze wyrażają obawy związane z negatywnym oddziaływaniem zmian klimatycznych na produkcję roślinną. Wśród rolników 90,4% oraz 72,8% uznało, że nasiliły się odpowiednio zjawiska suszy i wzrostu temperatury, podczas gdy jedynie 27,3% respondentów było zdania, że zmniejszyła się ilość opadów. Przekonanie o spadku produkcji rolnej spowodowanym zmianami klimatycznymi wyraziło 90,9% rolników oraz 80% pracowników organizacji rolniczych. Według szacunków rolników produkcja roślinna zmniejszyła się o ponad 46%; w odpowiedzi na te straty stosowano alternatywne, bardziej odporne odmiany roślin. Pracownicy organizacji rolniczych rekomendowali szereg działań adaptacyjnych, takich jak uprawa roślin odpornych na zmiany klimatu, płodozmian, racjonalne gospodarowanie zasobami wodnymi, ochrona lasów, sadzenie drzew, podnoszenie świadomości społecznej, wykorzystanie maszyn rolniczych czy budowa szklarni. Jednocześnie, 33,4% z nich nie zaproponowało żadnych rozwiązań. Wnioski z badań wskazują, że postrzeganie zmian klimatycznych oraz praktyki adaptacyjne interesariuszy mogłyby zostać istotnie wzmocnione poprzez wsparcie spółdzielni, odpowiednie rozwiązania polityczne, programy szkoleniowe oraz opracowanie adekwatnych i spójnych strategii adaptacyjnych.

Słowa kluczowe: zmiany klimatyczne, percepcja interesariuszy, produkcja pszenicy, strategie adaptacyjne, Afganistan

Introduction

The impacts of climate change on livelihoods and food security are a major concern in Afghanistan. A combination of the country's low level of socioeconomic development with rising levels of insecurity, and natural/climatic disasters exert extreme pressure on people in susceptible conditions (IFRC 2022). Climate change including extreme temperatures, floods, droughts, earthquakes, and decreases in rainfall with a lack of adaptive capacity has proved to be one of the biggest humanitarian challenges of the country, and this country was recorded one of the most vulnerable countries to climate change (Aich et al. 2017; UNDP 2017). It is noted that more than two-thirds of the population was affected by droughts during 2018-2019 (FAO 2019). Furthermore, 13.5 million people are facing crisis meaning worse levels of food security (FAO 2019). Climatic disasters directly affect agricultural and livestock production, food security, access to water resources, and migration, and indirectly impact households, the economy, socioeconomic status, health, educational outcomes, the degradation of natural resources, as well as GDP. In Afghanistan, 10.5 million people out of the 17 million in 22 provinces were severely affected by droughts during the last decade. Moreover, due to repeated drought duration, the country lost 334 million dollars per year, and 13.5 million people were affected and suffered a worse level of food security in 2018 (FAO 2019). Moreover, an increase in mean temperatures have negative impacts on crop production (Arunrat et al. 2021). It is reported that an increase in temperature by 1.5 centigrade by 2050 will extremely affect agriculture, water resources, ecosystems, food security, health, and energy production (FAO 2019). It is illustrated that rising temperature has a negative effect on wheat production, while rising precipitation and atmospheric CO_2 concentration have a positive effect on crop production (**Error! Reference source not found.**Aruneat et al. 2021).

An increase of 1.5°C in temperature was reported by 2018 (WBG 2020), and a decrease of 5-10% in rainfall is expected between 2006 and 2050 in Afghanistan (NEPA 2018). An increase in temperature, droughts, and a decrease in rainfall led to reduced wheat production by up to 50% (FAO 2019). Wheat is one of the most vital crops from the aspect of food security in Afghanistan. Based on the Ministry of Agriculture, Irrigation, and Livestock (MAIL), Afghanistan would need to produce about 7 million metric tons of wheat by 2022 to achieve self-sufficiency (Sharma et al. 2015), but the production of wheat fails to fulfill internal demand of about 2 million tons due to many factors such as climatic crises, vulnerability, lack of investment or adaptation strategies. In the last decades, only minimum investment in agricultural growth and development was conducted, whereas, investment in the agriculture sectors, developing infrastructure, and building irrigation systems are key factors that can improve agricultural production and economic systems.

Developing mitigation and adaptation strategies plays a vital role in reducing the impact of climate change as well as vulnerability of agricultural products by implementing adaptation practices and undertalking resilient agricultural activities to ensure food security and sustainable agricultural production (Habib-u-Rahman et al. 2022). Mitigation strategies are actions conducted to reduce the magnitude of anthropogenic impact on climate (Lawler et al. 2013). Adaptation strategies are measures that aid human and natural systems in adapting to climate changes (Lawler et al. 2013).To create a sustainable production system, it is necessary to use adaptation strategies which are the best way to minimize climatic damage to agricultural production (IPCC 2019). Adaptive capacity is the ability to adjust to potential damage, utilize opportunities, or act to reduce the impacts of climate change (IPCC 2014). Three items, such as the efficacy of adaptation (a belief that an adaptive method could protect from risks), self-efficacy (technical skill), and cost of adaptation (the ability to withstand the cost) are important to the adaptive capacity and stakeholders' perception of climate change (Habib-u-Rahman et al. 2022). The perception was defined as the way that the resource-poor stakeholders understand climatic events (Hasan and Kumar 2019).

Numerous studies have attempted to determine stakeholders' perceptions of climate change and adaptation practices that reduce the impacts of climate change on wheat production (Sarwary et al. 2021; Yadav et al. 2022). Dinar et al (2012) reported several adaptation strategies in Africa such as differention of crops, crop rotation, changing the sowing dates, while Akinnagbe and Irohibe (2015) listed some effective strategies in cropping system including planting of drought resistant varieties, crop diversification, change in cropping calender, mixed cropping, irrigation management system, soil conservation, tree planting and agroforesty. Other studies presented many adaptation practices such as sowing date determination, identifying adaptive seeds and varieties, crop rotation, agroforestry, soil conservation, covering cropping system, and water resource management (Dhaka et al. 2010; Dinra et al. 2012; Ali et al. 2016; Habib-u-Rahman et al. 2022; Yadav et al. 2022). Furthermore, other strategies like laser leveling, fertilizer management, mulching as well as pest and disease management are also used to counteract the effects of climatic challenges (Dhaka et al. 2010; Habib-u-Rahman et al. 2022; Samiri et al. 2019; Yanagi 2024). In addition, the use of modelling is a method that can simulate crop and climatic variables for different periods. These models play a significant role in better understanding the impact of climate change on crop production and adaptation strategies (Habib-U et al. 2022; Ahmed and Hassan 2011; Yadav et al. 2022; Ali et al. 2016).

This study determined the impacts of climate change on agricultural production through stakeholders' perception evaluation. The main question is how stakeholders perceive climate change, and how they would adapt, or use strategies to reduce the climatic vulnerability on crop production. We asked agricultural stakeholders how they response against climate change in the study area. Next, we were interested how the agricultural communities respond, or adapt to climate change affecting agricultural production. We defined farmers as primary stakeholders and agricultural organization workers as secondary stakeholders. This study was conducted through surveys and interviews with individuals who have experience in wheat cultivation. The main concepts, including stakeholders' perception of climate change, effective parameters, reduction of crop production, and indigenous knowledge of stakeholders related to mitigation and adaptation strategies, were evaluated.

1. Materials and Methods

1.1. Study area

This study was conducted in Kabul (34°33'19.258" N, 69°12'26.95" E), located in the central zone of Afghanistan. It covers a total area of approximately 4,655.25 km², with an elevation of 1,958.5 metres above mean sea level (Fig. 1). The average annual temperature is 12.44 °C, and the annual total precipitation is 362 mm. The driest month is June, with about 1 mm of precipitation. Most rainfall takes place in March, with an average of 88 mm. July, with an average temperature of 23.2 °C, is the warmest month of the year. The lowest average temperature of the whole year is -2.9 °C, which occurs in January. Cereal crops cover a large cultivation area, and wheat is the most important plant covering 61.30% of the total cropped area (Raoufi et al. 2024). Wheat is cultivated in October and November and harvested in June (UNDP 2017). This study was conducted in the centeral region of Afghanistan and it was based on the existing data and interviews with organizations' workers. Many organizations such as the Ministry of Agriculture, Irrigation and Livestock that deal with climate change issues and agricultural production are located in Kabul.

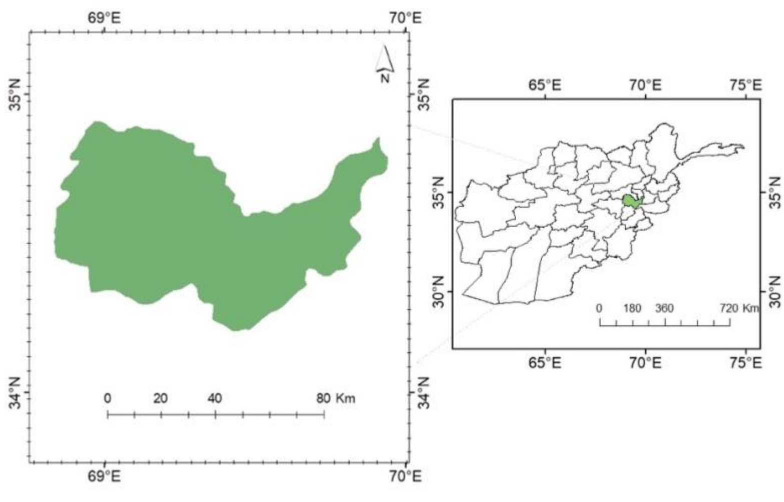

Figure 1. Location of the study area, Kabul, central Afghanistan

1.2. Surveys and interviews

Data were collected from farmers and agricultural workers, governmental reports, and scientific literature. They were collected from the agricultural community (stakeholders) through face-to-face interviews and surveys. Stakeholders have been categorized into two groups, namely, Primary stakeholders and secondary stakeholders. Primary stakeholders are farmers who have experience in wheat cultivation, while secondary stakeholders are agricultural organization workers. These two groups play an important role in crop production. Farmers are directly engaged in crop cultivation in the field and sometimes they adapt their methods according to their indigenous knowledge in response to climate change. In turn, the experts, i.e., secondary stakeholders, have knowledge and they make policies to reduce the impacts of climate change. The secondary stakeholders were selected as those who are responsible for policymaking and planning against climate changes in the Ministry of Agriculture, Irrigation and Livestock, including the agricultural research institute, natural resource management. To match the number of experts (50 people) from the governmental office, we selected the same number of farmers randomly from the four sites of Kabul. Consequently, this study covered 50 primary stakeholders and 50 secondary stakeholders, giving a total of 100 samples (N= 100). Climate change perception was coded as a binary variable (“yes” or “no”), and later choice options were coded using the Likert scale. The respondents were asked to define their perception of climate change and the impact of the climate change on their livelihoods. They were then asked to provide information about variability and climatic parameters that have a higher impact on crop production using questionnaires. The questionnaires contained several items, including stakeholders’ perception of climate change, type of impacts, effective parameters, irrigation resources, level of effective parameters, date of cultivation, precipitation months, drought periods, and adaptation strategies. We asked the primary stakeholders about organizational cooperation, training programs, and governmental cooperatives as well. Moreover, secondary stakeholders were asked about training programs and organization policies that deal with climate change. In this study, 5 points in Likert scale: (No change =0, change 1, effective change =2, extreme change =3, very extreme change =4) has been used to measure levels of climate change according to stakeholders’ responses.

2. Results

2.1. Stakeholders’ perception of climate change and vulnerability

More than 90% of farmers reported that their farm and crop production were affected by climate change. Farmers perceived climate change as an increase in temperature and droughts, a decrease in rainfall, and crop yield reduction.

Table 1. Farmers’ perception and effective parameters based on their responses.

	Yes/No Ques.	Parameters	Response (%)
Farmers’ perception of climate change	No	No, or I don’t know	-
	Yes (90.9 %)	Reduced rainfall	27.3
		Extreme temperatures	72.8
		Flood	18.18
		Drought	90.4
		Reduced production	86.4

Changes in climatic parameters such as drought (90.4%), crop yield reduction (86.4%), increase in temperature (72.8%), decrease in rainfall (27.3%), and flood (18%) as perceived by farmers

(Table 2). The results showed that drought, crop yield reduction, and extreme temperatures are the topmost perceived cause parameters of climate change. About 50.9% of farmers stated that climate change is at the stage of effective change, 20.9% of them said it is at the stage of change, 4.5% believed that climate change is in the stage of low change and another 4.5% of them believed that there has been no change in climate (Table 2).

Table 2. Change in variables according to the farmers' perception in (%)

	Parameters	No change	Low Change	Change	Effective change	SD
Change in Parameters	Rainfall reduction		4.5	22.8	36.4	16.01
	Extreme temperature	4.5		22.8	68.18	32.79
	Floods			18.18	27.27	6.43
	Droughts			18.18	59	28.86
	Yield reduction			22.8	63.7	28.92
	Ave. (%)	4.5	4.5	20.9	50.9	21.88

Most of the farmers have reported that climate change affects wheat production negatively. According to the baseline, crop production decreased by 46.4 % (Table 3).

Table 3. Reduction in wheat production in recent years according to the farmers' report

	Wheat yield (Kg/ 80 m^2 of cultivation area)
Reference period	18.4
Change period	9.6
Difference	8.7
Change (%)	46.4

Strategies that are used by farmers during climate change are listed in Table 4. 68% of farmers during the stress condition used alternative varieties, whereas 13.6 % of them utilized resistant varieties (Table 4).

Table 4. Farmers using strategies under stress conditions

	Response	Methods
Farmers' perception	68.18	Alternative varieties
	13.6	Resistant and tolerant varieties

2.2. Secondary stakeholders' perception of climate change and vulnerability

Table 5 presents the perception of agricultural organization workers of climate changes, capacity-building programs, and the impact of climate change on the country's production resources. 20% of secondary stakeholders claimed that climate change has a positive impact on wheat production in a rainfed condition, while more than 66% of them believed that climate change has a negative impact on wheat production (Table 5). 66.7% of secondary stakeholders announced that they did not get any capacity-building programs during their work in their organization. Moreover, 80% of responders believed that food production systems were affected by droughts, precipitation shortage, increases in temperature, and floods (Table 5).

Table 5. Secondary stakeholder responses relative to the impact of climate change on crop yields, capacity building, and reduction of the country's food production under climate change

	Type of effect	Response (%)	Parameters
Impact of climate change on wheat yields	Positive	20	Increase in rainfed wheat yield
	Negative	66.7	Increase in diseases, pests, floods, ETc, yield reduction
Capacity building programs	No	66.7	No capacity-building program has been implemented
	Yes	-	Research in dry lands, introduce new varieties and technologies
Impact of climate change on food production	No	20	No comments
	Yes	80	Rainfall reduction, increase in temperature, floods and droughts

About 24% of respondents reported that climatic variables are experiencing extreme changes, and 50% of them stated that their perception was mainly influenced by drought, 26.7% by extreme temperature, and 20% by yield reduction (Table 6).

Table 6. Parameters change by stages according to secondary stakeholders (%).

	Parameters	0	1	2	3	4	SD
Change in Parameter	Rainfall reduction	3.4	-	20	13.4	0	8.36
	Extreme temperature	3.4	26.7	13.4	26.7	3.4	10.62
	Floods	13.4	6.7	13.4	10	30	9.27
	Droughts	6.7	3.4	10	50	13.4	17.20
	Yield reduction	3.4	16.7	30	20	3.4	11.21
	Ave.	6.1	13.4	17.4	24.0	10.0	7.01
0= no change, 1= low change, 2= change, 3= effective change, 4= extreme change							

The adaptation strategies that were suggested by secondary stakeholders are listed in Table 7. 33.4% of the stakeholders selected "No suggestion" as regards reduction of climate impacts, while more than 60% of them proposed the following methods: adaptive/resistant/tolerant seeds, water resource management, jungle protection, tree planting, public awareness, agriculture machinery, and greenhouse creation (Table 7).

Table 7. Adaptation strategies suggested by secondary stakeholders (%)

	Response (%)	Adaptation strategies
Strategies suggested by stakeholders	33.4	No suggestion
	6.7	Adaptive seed
	6.7	Water resource management
	10	Jungle protection
	16.7	Tree planting
	16.7	Public awareness

	Response (%)	Adaptation strategies
	Other	Agricultural machinery
		Greenhouse creation

2.3. Mitigation and Adaptation strategies

A literature survey was conducted to find the main adaptation strategies that can reduce the impact of climate change on crop production. Moreover, some strategies that were suggested by stakeholders were also listed in Appendix 1 (Table 1 and Table 2), but were also indicated in the References section.

3. Discussion

3.1. Stakeholders' perception of climate change and vulnerability

This study evaluated stakeholders' perceptions of the influence of climate events on their food production, or livelihood. The respondents had different perceptions of climate change impacts on their livelihoods, both positive and negative. 20% of secondary stakeholders believed that the impact of climate change is positive on wheat production (Table 5). The country's agricultural production could be positively impacted by climate change via an increase in atmospheric CO_2 and longer season (WBG 2020). Moreover, 90.9% of primary stakeholders and 66.6% of secondary stakeholders reported the negative impacts of climate change on crop production. Increases in temperature, droughts, and decreases in precipitation were reported as the main factors of climate change that reduced crop production. An increase in temperature of 1.5°C was reported in the period of 1900 -2017, whereas a decrease in rainfall patterns was reported as lowered by less than 10% in the period of 1951- 2010 (WBG 2020). Droughts affected 70% of the total population in the period of 1980-2008, with a decline of 43% in cereal crop production in 2004, and a decline of 8-9% in wheat production in 2004 and 2011 (FAO 2019). The studies showed that Afghanistan faces significant drought issues, which directly impacts the livelihoods and the economy (WBG 2020).

Farmers reported that their crop production was reduced by about 47% during the last decade (Table 3). Crop production was reduced during droughts in the period of 2017 – 2018 by up to 50% (WBG 2020). The studies noted that crop yields in the irrigated area could be reduced by 30% in years of water scarcity, and these effects have a major impact on livelihoods (WBG 2020). The negative impacts of temperature increase on wheat production were reported on a global scale by the studies of Hanif et al. (2010), Ahmed and Schmitz (2011), Ashfaq et al. (2011), Shakoor et al. (2011), Zeb et al. (2013), Haris et al. (2013), Zhang et al. (2021), Shafiq et al. (2021), and Gul et al. (2022). Reductions in crop yields due to the increase in temperature were also reported by Pongratz et al. (2012), Ali et al. (2017), Shakoor et al. (2018), Saei et al. (2019), Xie et al. (2019), and Liu et al. (2020). Global wheat yields would decrease by 6.0 ± 2.9% with a one-degree rise in global temperature (Zhao et al. 2017). For every 1°C increase in temperature, global wheat yields are predicted to decline by 4.1–6.4% (Morgounove et al., 2018); 0.02% (Zhang et al. 2021); and 0.89% (Shafiq et al. 2021). Reduction in rainfall was also reported by NEPA (2018) and Sharma et al. (2015) (about 100 millimeters). NEPA (2018) reported that the mean precipitation in March-May decreased by 5–10% in the central region of Afghanistan, whereas it increased in October–December between 2006 and 2050. A reduction in precipitation for the growing months can greatly influence crop growth and production. Crop Evapotranspiration (ETc), Crop Water Requirements (CWR), and irrigation requirements may increase due to precipitation reduction in the growing months.

3.2. Useful strategies to minimize the impact of climate change on crop production

The results showed that farmers used some strategies to minimize the impacts of climate change, such as introduction of alternative and tolerant varieties. These are the two most useful strategies that were employed by farmers based on their indigenous knowledge. Local people have more sensitivity due to their closest contact with the environment and resources, and they have to improve local information (IPCC 2007). Over time, the information was accumulated in some communities to improve crisis management (Amoseh et al. 2023). Many studies over the years acknowledged that climate crises might shape farming community perceptions through the occurrence of extreme events (Banerjee et al. 2014). Indigenous knowledge plays a significant role in utilizing adaptation strategies in local farming (Amoseh et al. 2023).

Adaptation and mitigation strategies have better efficiency when they are integrated, but by itself, a single strategy is not sufficient (IPCC 2014). These strategies are complementary and should be used as such to help solve climatic challenges (IPCC 2014). Concerning the stakeholders' responses and literature, there are some useful strategies widely used against climate-related issues.

3.2.1. Mitigation

Mitigation strategies prevent the emissions of greenhouse gases. Greenhouse gas emissions are the main driving force of global warming, produced by several sectors including agriculture, industries, mining, and even households. Agriculture produces greenhouse gases as well, and this sector can be seriously affected by climate changes. Reduction in GHG and production of more food seem to be challenging, but it is necessary to reduce the emission of gases such as N_2O, CH_4, and CO_2. Application of chemical fertilizers can increase emissions of N_2O, whereas CH_4 is emitted by livestock and rice cultivation fields (Habib-u-Rahman et al. 2022) as well. Many other factors such as managing the acidity of the soil, conservation of soil erosion, minimizing tillage, and implementing crop rotation, lead to increased levels of carbon in the soil (Table 8). An increase in the duration of grazing can store some amount of carbon in the soil as well. The varieties of plants and animals that produce minimum GHG emissions can help to reduce GHG effects (Habib-u-Rahman et al. 2022).

3.2.2. Adaptation

The process of adapting involves responding to changes in natural or human systems due to current or projected climate changes or their consequences, which is an ongoing process that reduces harm or exploits opportunities (Amoseh et al. 2023). The risks of climate change could be reduced by implementing integrated adaptation methods. There are many methods to improve agricultural systems for adaptability, such as crop management practices, crop rotation, and crop diversity (Table 9).

3.2.2.1. Climate adaptation wheat varieties

According to this study, 13.6% of farmers and 6.7% of agricultural organization workers suggested adaptive varieties. The breeding of climate-adaptive wheat varieties aims to enhance wheat's ability to thrive, develop, and maintain high yields and quality characteristics under new climatic conditions. Planting these varieties is a good adaptive strategy to ensure the stability and sustainability of wheat production under climate conditions (Yadav et al. 2022). Studies illustrated that using adaptive varieties could reduce biotic and non-biotic stress and improve production quality (Ali et al. 2017). Some adaptive wheat varieties may increase their adaptive ability in stress conditions (Yanagi 2024). These wheat varieties are expected to display good stress tolerance and climatic adaptability under high temperatures, drought, salinity and water-deficit conditions. Moreover, they should show resistance against pests and diseases because climate change may lead to the emergence of new pests and diseases as well. An increase in wheat production of good quality and quantity could be achieved through breeding and genetic development (Ali et al. 2017).

3.2.2.2. Agricultural practices

This study showed that farm management could reduce the impact of climate change on wheat production. Secondary stakeholders said that farm management can improve crop growth and development, water use efficiency, and farm practices. Crop rotation, cultivation methods, nutrition management, soil management, and irrigation techniques are agronomic management methods that are very important for adapting to stress conditions and increase sustainability of agricultural systems. These approaches lead to increased crop production by improving cultivating systems. In the case of climate change, farmers used flexible and adaptive systems to reduce climatic impacts. These can be done by tillage depths, changing the date of planting, providing water, and improving soil practices during planting (Ali et al. 2016; Yadav et al. 2022). Sowing date management is a good strategy to reduce the impact of climatic stress on wheat production. Late cultivation may face heat stress at the time of flowering or grain filling, leading to a reduced weight of grains (Samiri et al. 2019, Yadav et al. 2022). Naresh et al. (2014) reported that early sowing is essential to avoid terminal heat stress and the adoption of conservation agriculture provides the avenue for advancing the sowing of wheat by 15-20 days.

3.2.2.3. Water resource management

Watering of crops may be provided by irrigation and precipitation during the growing season. Water management plays a vital role in reducing the impact of climate change on plants. Stakeholders (6.7%) suggested water resources management as an adaptation approach against the climate change crisis. This method has been reported by many studies worldwide. Irrigation techniques are a better option for mitigating the impact of drought on crop development (Yadav et al. 2022). Soil and water conservation can be achieved by irrigation systems such as sprinkler systems that decrease vapor pressure deficit. Water conservation in soil and reduced canopy temperature may be supported by optimizing the transpiration process with a drip irrigation system. Besides, mulching is an effective method to maintain the soil moisture and temperature at the optimal level and hence improve biomass production, particularly under rainfed conditions. On the surface soil, mulching helps to maintain soil moisture, resist fluctuations of soil temperature, and improve soil aeration that increases seedling appearance and root growth. Moreover, soil moisture can help plants minimize canopy temperature by transpiration cooling and avoiding heat stress (Yadav et al. 2022). Adjusting effective water usage may increase water use efficiency. Water management can be achieved by water-saving irrigation techniques, optimizing irrigation systems, and collecting rainwater for plant use in the growing periods.

3.2.2.4. Planting of trees

Tree planting is an impotant method of reducing pollution and the impact of climate change. Secondary stakeholders (16.7%) suggested tree planting as adaptation method in the study area by expanding green rings and green areas in the city. This method should be implemented by transplanting and seedlings in cropping systems (Akinnagbe et al. 2015).

3.2.2.5. Awareness and Perception

There is a positive relationship between awareness of climate change impacts and implementation of adaptation and mitigation strategies. In this study, 16.7% of secondary stakeholders rcommended the role of this approach in adaptation against climate change. Awareness plays an important role in determining and applying effective methods of adaptation strategies (Juana et al. 2013). Arbuckle et al. (2013) claimed that mitigation action requires awareness of climate change and human activities. Risk perception corresponds to the belief of possible adverse consequences for valued objects. Perception of the risks can affect engagement and the support of policies that address the issues (Hyland et al. 2015).

3.2.2.6. Crop rotation system

Crop rotation is a sample technique used easily in the farmers' fields. Farmers should select the varieties that show more adaptability to climatic conditions. This method has more advantages, including increased fertilizing of soil, strong soil structure, and decreased pests and diseases (Yadav et al. 2022). Pala et al. (2007) assessed some methods of crop rotation such as alfalfa-wheat, cowpea-wheat, and fallow-wheat. They reported that cowpea-wheat produces more yields than fallow-wheat (Saimiri et al. 2019, 227). Bonder et al. (2007) reported that ETc could be reduced by mulching crops. Using legumes in crop rotation systems leads to increased fertilization, nitrogen fixation, soil organic materials, and control of pests, diseases, and weeds (Saimiri et al. 2019, 228).

3.2.2.7. Nutrient Management

Efficient nutrient management is a method to reduce the impact of heat stress on wheat production (Yadav et al. 2022). The crop's yield was maintained by optimizing nitrogen supply to increase stomatal conductance, chlorophyll contents, and photosynthetic rate at elevated temperatures. Fertilizer management, amount, time, and type of fertilizer have an impact on plant growth and development.

Application of potassium (K) in the form of orthophosphate helps to activate the various physiological and metabolic processes, including photosynthesis, respiration, and tissue water potentiality, that assists in extreme temperature by increasing stress tolerance. Silicon used at the heading stage reduces the negative impact of heat stress due to antioxidant improvement (Yadav et al. 2022). Increased heat tolerance can be achieved through the application of calcium, which improves the photosynthesis rate, activates antioxidant enzymes, and increases the amino acid content. Magnesium and Sulfur deficiency lead to increased susceptibility in wheat crops. Optimum supply fertilization of crops can reduce the impact of heat stress on crop production (Yadav et al. 2022).

3.2.2.8. Pest and disease management strategies

Pests and diseases may increase in stressful conditions. Chemical pesticides are a serious environmental challenge. Chemical control is a big challenge in developing countries. The impacts of non-selective pesticides may damage all biotic elements in ecosystems. Biological management reduces the impact of non-biotic stress on the ecosystem. Moreover, integrated pest management can provide safe control of pests and diseases in the field. Using new technologies, new tools, and equipment in agricultural practice plays a very important role.

3.2.2.9. Modeling

Wheat is the most important cereal in the country, and it is the most vulnerable crop to climatic stresses. Therefore, it is necessary to understand the potential impact of climate change on wheat yields and production. There are many models to simulate climatic trends, crop growth and development, and crop production under stress conditions during the planting period. Modeling techniques are applied widely in agriculture to project future yield conditions (Ali et al. 2016). The models can evaluate damages in crop production because of the interaction between different environmental and agronomical factors. It is possible to identify and manage threat factors for the production process under climatic scenarios (Ali et al. 2016).

Conclusion

This study revealed that the agricultural community in the study area has been severely affected by climatic events such as drought, extreme temperatures, reduced rainfall, and floods. Stakeholders' perceptions indicated that farmers have been significantly impacted by climate change, with more than 90% reporting decreased crop yields due to climatic stresses. According to primary stakeholders, wheat production alone has declined by up to 47%. In response, several adaptation strategies were identified to mitigate these impacts and enhance agricultural productivity. Stakeholders emphasized that effective adaptation and strategic environmental and agricultural planning could reduce climate change impacts, conserve agroecosystems, and maintain ecological balance. Such planning may also enhance ecosystem stability and strengthen links between agricultural and natural systems.

While farmers commonly recognized two adaptation options (resistant and alternative varieties), this study highlighted additional strategies—such as crop rotation, improved agronomic practices, water and field management, soil conservation, policy development, public awareness, nutrition management, and water-use efficiency—that may improve agricultural resilience in Afghanistan. However, the mechanisms for effectively implementing these strategies remain underexplored and require further research. Furthermore, this research was conducted in a relatively small agricultural community. Future studies should embrace other regions and other crop systems to provide a more comprehensive understanding of adaptation practices in Afghanistan.

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Appendix 1:
Supporting Data for *Assessing Stakeholders' Perception and Adaptation Strategies against Impacts of Climate Change on Agricultural Production (Wheat): A Case Study of Kabul, Afghan*istan

Table 1. Mitigation strategies according to the stakeholders and literature.

Methods	Function	Resource
Tree planting	CO_2 capture	(Dhaka et al. 2010; IPCC 2014; Akinnagbe and Irohibe, 20215; Sarwary et al. 2020; Usman et al. 2020; Habib-u-Rahman et al. 2022; Amoseh et al. 2023)
Reduced GHG Emission	Avoid warming	
Biochar and organic amendments	Increase soil stability	
Reduce N_2O	Reduce acidity	
Biodiversity	Increase resilience and stability	
Land use management	Reduce land risks	
Soil conservation	Decrease soil erosion, acidity, increase nutrients	
Water harvesting techniques	Water management	(Dhaka et al. 2010; IPCC 2014; Sarwary et al. 2020; Usman et al. 2020; Habib-u-Rahman et al. 2022; Amoseh et al. 2023)
Fertilizer management	Reduce N_2O, avoid economic damages	
Promotion of energy crops		
Agricultural waste management	Increase organic materials in soil, avoid pests and disease epidemic	
Release crop residues on soil	Increase soil humus, water maintenance, and carbon	
Promotion of carbon sequestration	Increase soil's carbon, and water	

Table 2. Adaptation strategies according to the stakeholders and literature.

Methods	Function	Resource
Automatic weather stations	Primary data for risk analysis	(Dhaka et al. 2010; Dinar et al., 2012; Naresh et al. 2014; Habib-u-Rahman et al. 2022, Yadav et al. 2022)
Early warning systems	Avoid impact crises	
Sowing date management	Reduce stress on the flowering process, increase WUE,	
Cover cropping	Nitrogen fixation increases water maintenance in soil, protects soil erosion	(Samiri et al. 2019; Habib-u-Rahman et al. 2022; Amoseh et al. 2023)
Fertilizer management	Increase resistance, activate stomata, increase chlorophyll contents and	(Dhaka et al. 2010; Usman et al. 2020; Yadav et al. 2022; Habib-u-

Methods	Function	Resource
	photosynthetic rate, increase WUE	Rahman et al. 2022; Amoseh et al. 2023; Yanagi 2024)
Soil conservation	Increase soil nutrition	
Water conservation	Reduce ETc, improve growth and development of root and seedling	(Dhaka et al. 2010; Dinar et al., 2012; Akinnagbe and Irohibe, 20215 Usman et al. 2020; Yadav et al. 2022: Habib-u-Rahman et al. 2022)
Development of climatic resilient varieties	Adapt to stress	
Collection of seeds and gen banks	Identify new adaptive varieties	
Heat and drought seed tolerance	Automatic adaptive system	
Development of new policies	Flexible to new challenges	Habib-u-Rahman et al. 2022; Usman et al. 2020
Alteration in grazing time	Increase soil carbon	
Use of organic fertilizers	Improve water maintaining	
Soil health monitoring	Avoid pest attacks and acidity	(Dhaka et al. 2010; Samiri et al. 2019; Usman et al. 2020; Habib-u-Rahman et al. 2022)
Inter-cropping of legumes	Increase soil humus, nitrogen fixation, increase soil fertilizing, increase WUE, pest control	
Lazier land leveling	Increase water use efficiency, manage line cultivation, reduce ETc,	(Dhaka et al. 2010; Akinnagbe and Irohibe, 20215; Usman et al. 2020; Yadav et al. 2022: Habib-u-Rahman et al. 2022)
Rotation cropping system	Reduce pest attacks, increase crop nutrition, nitrogen fixation	
Green manuring	Improve WUE, nutrition, and water maintaining	(Dhaka et al., 2010; Yadav et al. 2022: Habib-u-Rahman et al. 2022)
Mulches and residue management	Increase soil moisture, carbon,	
Optimum planting density	Decrease ETc,	(Ahmed and Hassan 2011; Junjua et al. 2013; Akinnagbe and Irohibe, 20215; Hyland et al. 2015; Ali et al. 2016; Ado et al. 2018; Yadav et al. 2022: Habib-u-Rahman et al. 2022)
Modeling	Project threat and crop yields, simulation crop yields and risks	
Awareness of farmers	Use of strategies	
Data sets management		
Institutional/governmental support		(Usman et al. 2020)
Indigenous knowledge		(Usman et al. 2020 Habib-u-Rahman et al. 2022; Amoseh et al. 2023; Yanagi, 2024)
Soil microbes	Improve degradation process to crop nutrition	
Pests and disease management	Protect ecosystems, natural enemies, soil microbes	

Methods	Function	Resource
Machinery of agriculture	Decrease human forces, increase outcomes	