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# Impact of Climate Change on Irrigated Agriculture in steppe Zones of Uzbekistan

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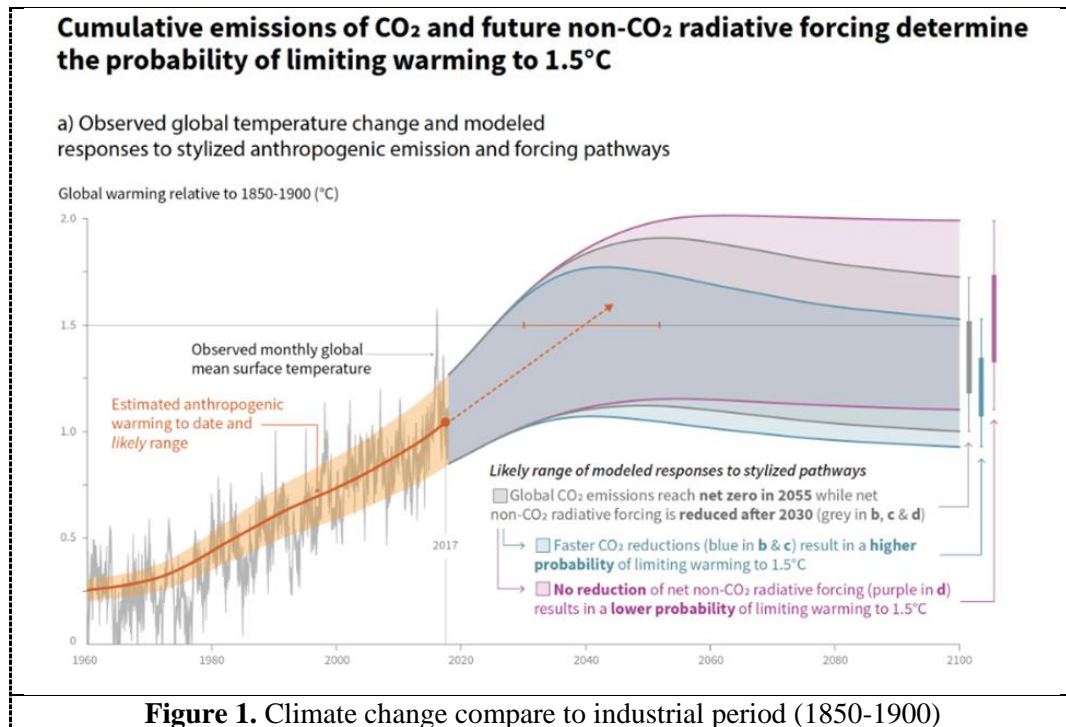
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**Abstract.** The study has been conducted in the newly developed by lift irrigation areas of Karshi steppe (Uzbekistan). The research questions included an assessment of the climate change impact on agricultural production. The studies allowed to examine main factors affecting the behavior of agricultural producers in the face of climate change, as well as their current practices and skills for adapting to the effects of climate change. As research results show, the impact of climate change on irrigated agriculture in the study areas has become especially tangible over the last decade. In this regard, situations arise with crop losses and reduced quality of agricultural products. According to research outcomes the agricultural producers have general information and general knowledge about climate change and its impact on agriculture. The most important consequences caused by the climate change impact on irrigated agricultural production include - increasing in water scarcity, growing in numbers of agricultural pests and plant diseases, declining in crop yields, instability and unpleasant weather surprises, the need to spend more labor and resources to get a satisfactory crop yield, salinization of land and water resources contamination, increase in the frequency and intensity of extreme weather events such as droughts and frosts, and others.

## 1. Introduction

Global climate change over the past decades has taken a strong place among the main environmental and economic problems facing the world community [1,3,4,6,7,9,12,15,17,19,21,22,24]. Climate change poses an immediate and irreversible threat to mankind, society, and the planet. Recognizing that many countries have ratified the Paris Agreement in December 2015, the main purpose of this is to continue efforts to curb global climate change. It is estimated that global warming due to human activity increased by 1.0 °C compared to the industrial period (1850–1900). If current rates continue to grow, global warming is likely to rise to 1.5 °C between 2030 and 2052[13, 15, 24].





While climate change is a global problem, but its impact is felt differently in different regions. This means that the process of adaptation is often dependent on local conditions and that is why people from different regions adjust differently. Increasing the current temperature from 1 °C to 1.5 °C or higher in relation to the industrial period increases the need for adaptation as well. Therefore, temperature stabilization at 1.5 °C compared to the industrial period will be easier than adapting to 2.0 °C [13, 15, 24].

Global warming, unlike other environmental problems, is causing more concern to specialists. This is mainly due to the lack of knowledge and awareness of climate change and the slow pace of the hazardous process.

Central Asia is one of the regions most affected by climate change and long-term global climate change. The main feature of its climate is drought. In many respects this is due to the natural humidity in the area. Particularly acute is the issue of the impact of climate change on water resources and agriculture in the Central Asian region, which requires a more detailed study. Climate, fresh water, biophysical and socio-economic systems are complexly interconnected. Therefore, a change in any of these systems can cause a change in the other. Anthropogenic climate change poses great additional difficulties for countries that are already facing the problem of sustainable use of freshwater resources. Freshwater in Uzbekistan is associated with water shortages (prolonged droughts) and its pollution. Each of these problems can be exacerbated by climate change. Freshwater factors play a fundamental role among key regional vulnerabilities [2, 11, 15, 21].

Problems associated with climate change and the hydrological regime of water bodies harm the pace of economic development, provision of vital needs, and rational natural resources management. Today, the countries of Central Asia are faced with the need to find ways to solve the minimization and, if possible, prevent water problems and, above all, mitigate the water deficit. Long-term observations in the region show that global warming is occurring in the Central Asian region in the form of trends in some components of the hydrological cycle: there is an increase in the evaporation layer, a decrease in snow accumulation and a decrease in glaciation in mountainous areas. There is an increase in the variability of hydrometeorological series [3, 6, 12, 19].

For Uzbekistan, located in the lower parts of the main rivers of the Aral Sea basin and experiencing all the hardships of an increasing shortage of water resources, problems associated with changes in

water availability due to climate change play a key role in the economic development of the country. According to the results of the climate change assessment based on daily observations from 1951 to 2019, the average warming rate of maximum temperatures since 1951 was 0.22 degrees, minimum - 0.36. In the zone of the Aral Sea, very high rates of increase in maximum temperatures were noted. The highest rates of warming were recorded in autumn. The rates of the warming observed in Uzbekistan are more than two times higher than the world average. A significant reduction in the repeatability of low temperatures was noted. The number of days with high temperatures (above 40 degrees) more than doubled in the Aral Sea region, by 32-70 percent in the rest of the territory, and by 10-12 in the foothills.

According to the results of the scenarios, until 2030, the Central Asian region will have approximately the same volumes of water as today. However, in the case of an extreme scenario, a significant decrease in runoff is possible. For example, individual models when doubling the concentration of *CO2* show that the flow of the Amudarya can decrease by more than a third, and the Syrdarya by one fifth [2, 6, 11].

The research results showed that in the considered range of changes in climatic parameters based on regional climatic scenarios for the region for the next 20-30 years, one should not expect a significant change in water resources. However, with climate warming, there will be a decrease in average water runoff over the growing season. Possible changes in the runoff of this period were estimated within the limits of natural variability: from + 3 ... 10 to 2 ... 7%. Changes in the annual runoff of the main rivers of Central Asia - the Amudarya and Syrdarya upon the implementation of various climate change scenarios (at the time of doubling the concentration of carbon dioxide in the atmosphere) implies a reduction in water resources [1, 2, 6].

Irrigated agriculture plays a key role in ensuring economic and social sustainability in Uzbekistan. About 50% of the population of Uzbekistan live in rural areas and 27% of the employed population work here. Despite the steady tendency to reduce the share of agriculture in the GDP of Uzbekistan, it remains an important sector and, according to the results of 2019, amounted to about 26% [20]. Agriculture, as an important sector of the economy, provides the needs of the population for food and processing industry for raw materials. 90% of food in the country is produced by the agricultural industry. Therefore, timely assessment of the impact of climate change on agriculture, timely and effective development of adaptation measures is an urgent problem for the socio-economic development of agricultural production in Uzbekistan.

This study was conducted in Karshi, Mubarek, and Nishon districts of the Kashkadarya region. The goal of the study was to assess the impact of climate change on irrigated agriculture and to provide a descriptive portrayal and baseline data of the agricultural producers in the selected regions of irrigated agriculture (irrigated by lift irrigation) in Karshi steppe in regard to their knowledge, attitudes, and practices related to Climate change and its impact on agricultural production conditions.

## 2. Methods

The study was conducted in 3 (Karshi, Nishon, and Muborek) districts located in the region. A specifically designed questionnaire was used to solicit and measure selected farmers' knowledge about climate change, business management, attitudes, and practices. The survey instrument was field-tested for ease of use, scoring complexity, and ease of understanding by the farmers. In total, 66 interviews were conducted with respondents - representatives of agricultural producers - farms and dekhkan farms, household plots, as well as other related organizations.

An important objective of the study was to collect and analyses of the special information on the behavior of agricultural producers in the context of climate change and its impact on agricultural production, as well as their current practice and their skills in adapting to the effects of climate change and the development of reasonable recommendations.

The questionnaire that was designed to study the basic knowledge of agricultural producers on climate change in the context of climate change, their impact on agricultural production, as well as the skills of agricultural producers to adapt to climate change included following chapters:

- Determining the characteristics of each respondent's farm and his/her business;
- Respondent's overall awareness of climate change by assessing the availability of the required information;
- Assessment of respondents' awareness and knowledge of the impact of climate change on agriculture;
- Evaluate the respondent's behavior and skills to mitigate the negative effects of climate change;
- Specific questions to study the respondents' opinions, needs and suggestions for improving the effectiveness of climate change adaptation

Respondents representing agricultural producers were selected among Farmers Council members. At the same time, the conditions for the location of respondents in relation to water sources were considered when selecting respondents. The data was obtained through direct field surveys with agricultural producers. The study team members were provided with instructions on how to conduct surveys, including guidance on specific issues, materials, and guidance. Quantitative analysis of the data obtained during the survey was processed using the statistical software - SPSS.

#### Research area

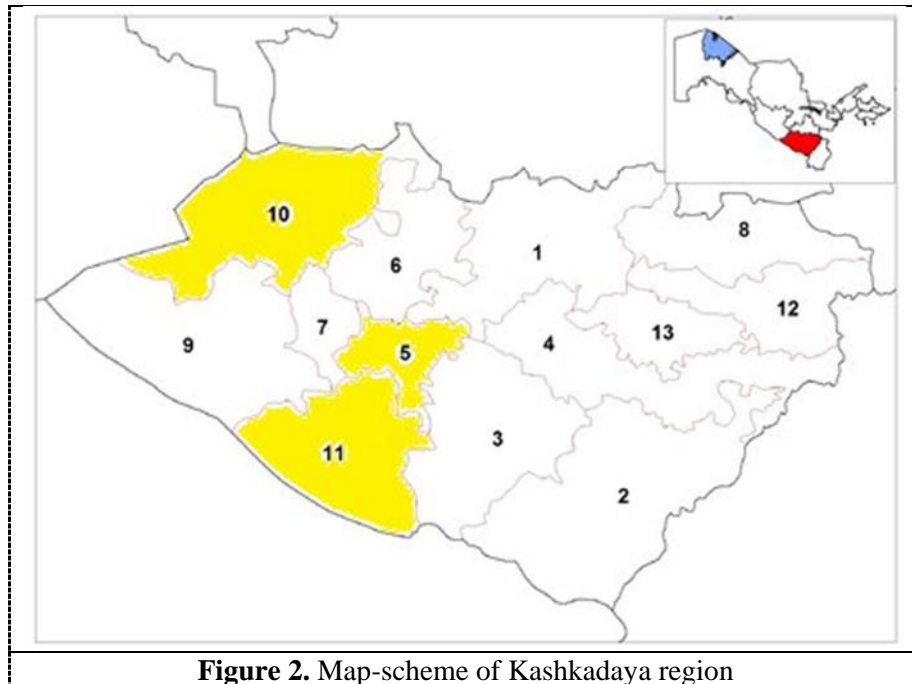
Three districts of the Kashkadarya region were selected based on specific natural and economic conditions, specialization, geographical location, and water supply. The selected regions include Karshi, Mubarek, and Nishan districts.

**Table 1.** Main specialization and additional specializations of farms participated in the survey

№	Districts	Farms with main specialization	Farms with additional specializations
1	Karshi	Cotton -wheat - 21; Orchards - 1	Dehkan farms - 2; Orchards - 1; Livestock - 4; Other - 3
2	Mubarek	Cotton -wheat - 22; Orchards - 1	Livestock - 5; Household yeard -1; Other - 3
3	Nishan	Cotton -wheat - 15; Orchards - 2; Livestock - 3; Other - 1	Cotton -wheat - 3; Dehkan farms - 5; Orchards - 2; Livestock - 2; Other -4

Kashkadarya is one of Uzbekistan's major producers of wheat, cotton, and other agricultural products. This can be seen in the following figures. For example, the region produces 12.4% of cotton and 12.8% of the grain in the country.

The Kashkadarya region consists of 13 administrative districts: 1. Chirchik District. 2. Dehkanabad district. 3. Guzgor district. 4. Kamashi district. 5. Karshi district. 6. Koson district. 7. Kasbi district. 8. District of Kitob. 9. Mirishkor district. 10. Muborak district. 11. Nishon district. 12. Shakhrisabz district. 13. Yakkabog districts.



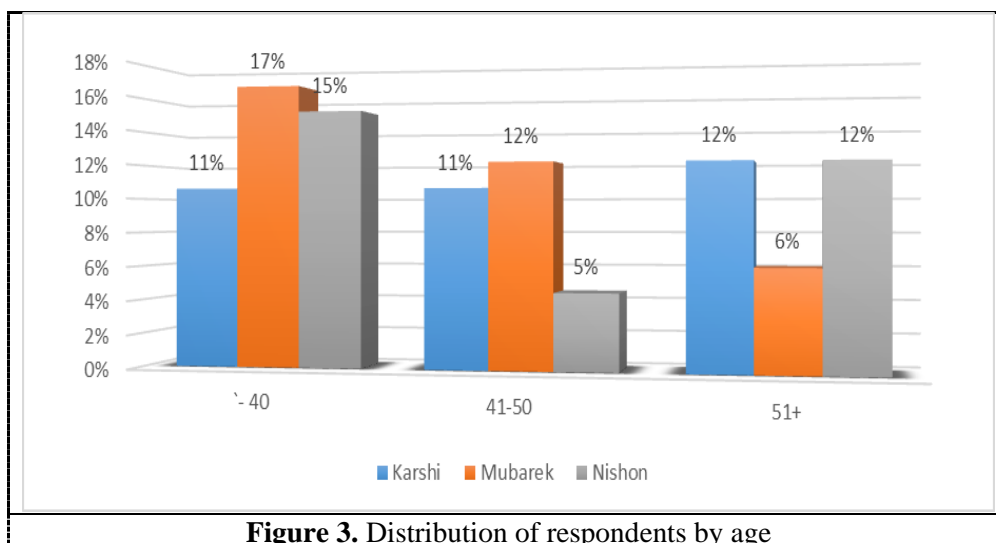
**Figure 2.** Map-scheme of Kashkadaya region

### 3. Results and Discussions

The average age of respondents was 44 years. This indicator varies slightly by district: The average age of respondents accordingly in Nishon district was 45 years, in Karshi district - 46, and Mubarek district - 42 years. The percentage of respondents by age was as follows: 43% of all respondents were younger than 40 years, 27% - from 41 to 50 years, 30% - over 51 years.

The youngest respondent was 24 years old and the oldest respondent - 63 years old. Five women participated in the study.

Of the 66 respondents surveyed, 22 were from Karshi district, 23 from Mubarek district, and 21 from Nishon.



**Figure 3.** Distribution of respondents by age

Distribution of the surveyed respondents by their education accordingly is as follows: with higher education – 21.2%, secondary special education - 37.9% and secondary education - 40.9%. Most of the respondents have experience and knowledge in agriculture and have relevant agronomists, economists, accounting, and other specialties. There are some farmers with non-agricultural education such as teachers, lawyers, and engineers (78.8%), but the vast majority have extensive experience in agriculture.

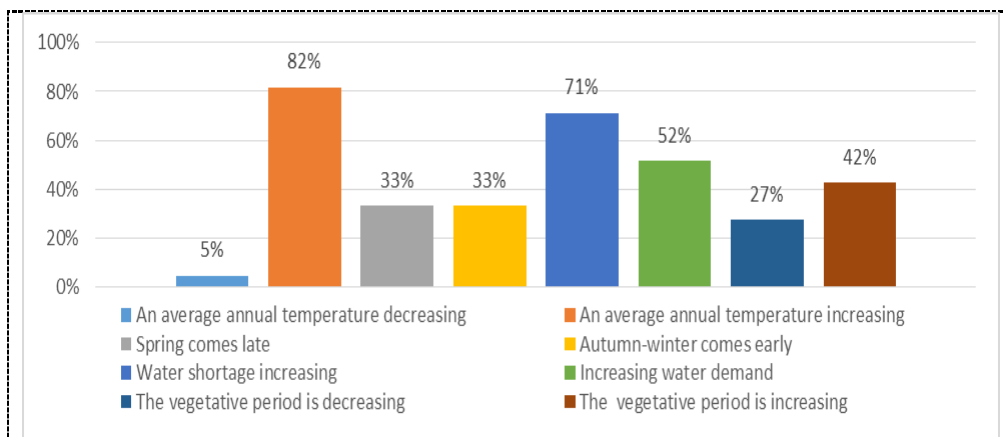
**Characteristics of the farms**

In the surveyed areas, the bulk of the farms involved (88%) - are specialized in cotton and wheat production, and 12% of them specialized in horticulture and livestock production. It should be noted that 45% of the respondents are engaged in the cultivation of the main crops as well as other agricultural products (livestock, horticulture, etc.). The area of farms varies. Cotton and wheat farms range from 20 to 284 hectares, and in orchard farms from 12 to 59 hectares. The total area covered by the survey was 6242.8 hectares.

**Climate Change Awareness**

The results of the surveys show that more than 89% of the respondents are aware of climate change issues. This indicator is 77.3% in Karshi and 91.3% in Mubarek. All respondents in Nishan District are 100% aware of climate change, but many of them are insufficiently aware of climate change problems.

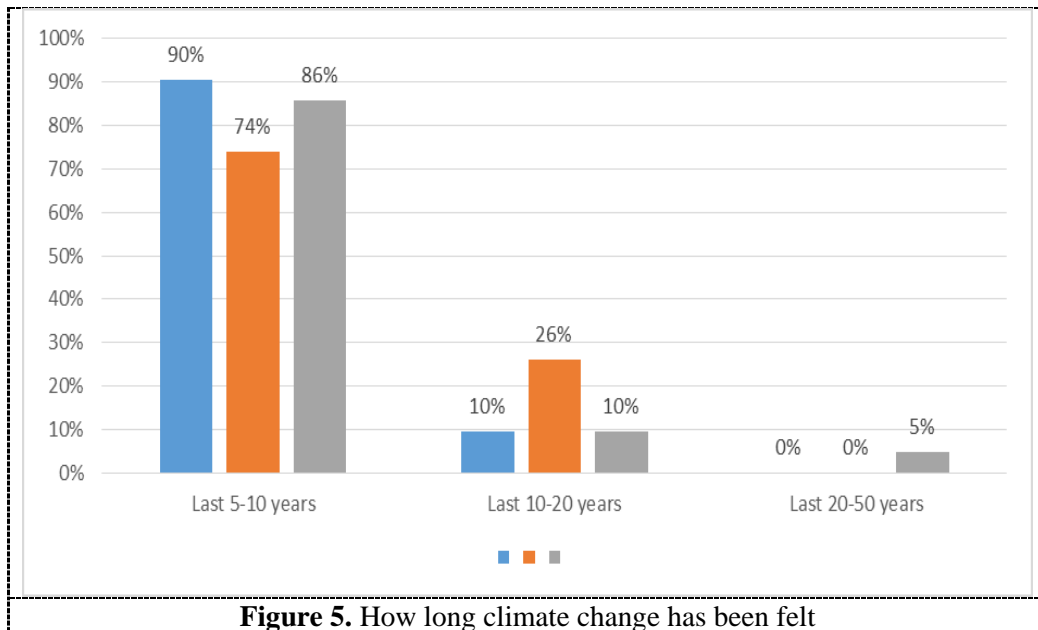
Respondents indicated the signs, effects, and consequences of climate change, mainly due to the average annual temperature increase (82%), increased water shortages (71%), increased water demand (52%), prolongation of the growing season (42%), and late spring (42%). 33%), the early arrival of autumn (33%), and others.



**Figure 4. Signs of climate change**

Contrary to the general tendency, Mubarek District has the highest water deficit (78%), and the average annual temperature increase (74%). In Karshi, the longer growing season (64%) is more important than increasing water demand (45%).

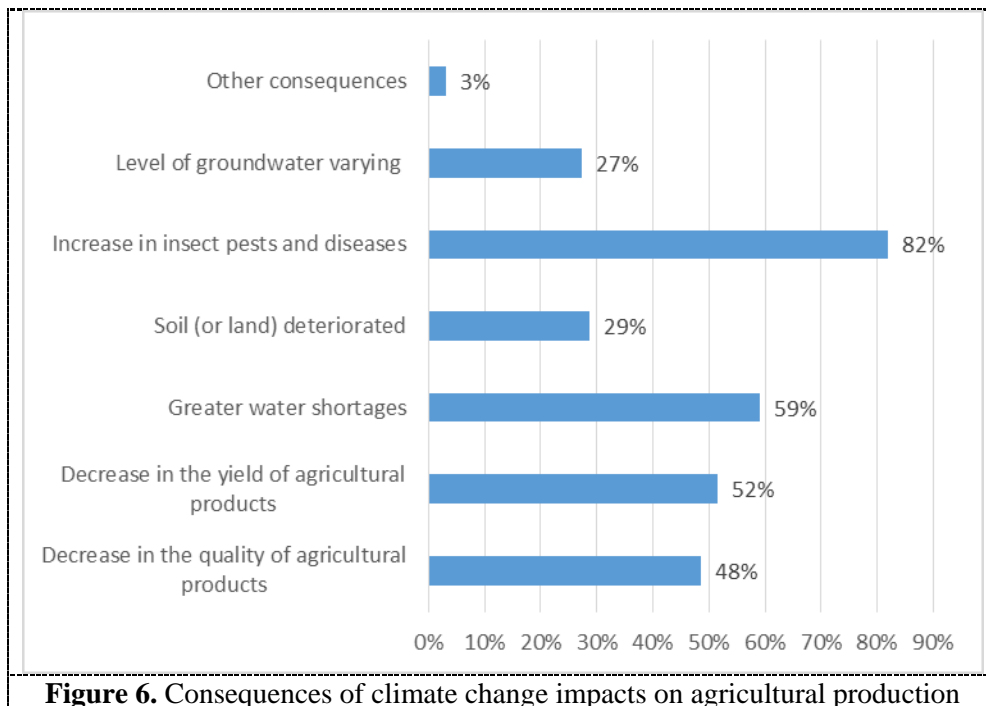
Responding to the question of how long climate change has been felt, many of the respondents (83.1%) said that the last 5-10 years. The fact that many of the respondents (61%) have more than 15 years of work experience in agriculture shows that climate change is clearly visible in recent years. Therefore, subsequent questions in this study are based on the same views of the respondents.



**Figure 5.** How long climate change has been felt

**Impact of climate change on agricultural production**

97% of respondents indicated that climate change harmed agricultural productivity and accordingly 92% of them - on the quality of agricultural products. 81.8% of the respondents from the three regions covered by the survey have shown that the most important problem was the increase in pests and plant diseases. The water shortages (59.1%), decrease of agricultural productivity (51.7%) deterioration of agricultural products (48.5%), deterioration of soil (28.8 %), changes in groundwater table (27.3%) and others (3.0%) are shown as next major problems associated with climate change impact on agricultural production.



**Figure 6.** Consequences of climate change impacts on agricultural production



Overall, 71% of respondents said that pests and diseases had increased, with 47.5% of respondents experiencing an increase in water shortages and 34.4% of respondents said that crop yields were decreasing in their farms.

In Karshi district, as opposed to the general trend, the decline in the quality of products (42.9%) and the decline in crop yields (38.1%) are more affected by the increase in water shortages (33.3%). Also, in Nishan district it seems there is a greater impact of crop and vegetable degradation (36.8%), higher air temperatures (31.6%), the rise of ground water (31.6%) than crop yield decline (15%).

It also was noted that due to 31.1% increase in groundwater level, 31.1% above normal air temperature, 26.2% crop and vegetable degradation, 21.3% decline in agricultural production, 19.7% decline in farm income and 8.2% stated that production of some types of crops were not successful.

The implications noted by farmers reflect the assessment given in the Second National Communication of the Republic of Uzbekistan[12] and many predictions made by the number of researchers [1,2,8,15,20,21,22,23,24].

Based on the above data, the research team summarized the respondents' views on the impact of climate change on agricultural production in Karshi, Mubarek, and Nishon districts.

**Table 2.** Specifics of Climate Change Impact on Agricultural Production

<b>Group</b>	<b>Specifics of the Impact</b>
Decrease in Agricultural Production	Garmsel sheds cotton flowers. The melon failed to produce.
	Garmsel is hurting the agricultural products
	Garmsel's frequency increased
	Due to the increase in temperature, pests have increased.
	Due to climate change, annual revenue has declined
	Climate change affects the vegetation period of the plant, the crop is still ripe and forced to open.
	Hot air flow has increased and has a great impact on productivity
	The heat increased.
	As the temperature increased, the water decreased
	At times, temperatures can be extremely severe and have a severe adverse effect on the plant.
	The heat of the chile is increased. There was no water.
	discarding of cotton flowers
	Fruit yield decreased
	Decline in my economy. The breed of the Bukhara-6 sort has shrunk.
	As a result of climate change, the yield and quality of many species of plants have declined
	Agricultural products are becoming more expensive
	Cultivation of fodder plants. productivity decreased due to salinization
Cotton thirst for 3-4 days	
Cotton production has been delayed	
Irrigation of cotton lasts 3-4 days	
The harvest is declining	
Yield is decreasing, Water is scarce, Labor is demanding, Cost increases	
The harvest is delayed, the yield is falling, and it is wasted	
Productivity decreased, there was no water. Affected cotton fiber	
Insect pests and diseases	The pest has increased
	Income has decreased due to the increase in pests
	Destruction of useful insects. Plenty of worms on corn. Aphids trips to the clover

	The cost is increasing year by year. Material damage has increased in the fight against pests
	Disease and pests
	Insufficient winter temperatures cause insects to reproduce. In winter, pests' winter in greenhouses
	The insect species have grown
	Productivity decreased by pests
	The land is getting salinized
	Lack of water
Water supply	Water scarcity
	Water scarcity is increasing
	Problems in irrigation. No water at the right time
This is a natural phenomenon	This is a natural phenomenon. It cannot be changed

According to the survey, 83% of respondents are aware of the pest and disease management method, and 11% of the respondents know only partially.

As it was mentioned above, agricultural producers are taking steps to adapt to climate change, depending on their abilities. One of the key actions to adapt to climate change is to fight against agricultural pests and diseases that have been and will continue to grow due to climate change. Many respondents stated that they are taking special measures to control pests and plant diseases. However, there are differences of opinion about the methods of struggle: chemical methods are more effective than horticulture in horticulture, fruit, and wheat production.

Respondents consider it possible to adapt to the effects of climate change by creating drought-resistant and disease-resistant plant varieties (84.4%), the widespread use of local fertilizers (75.8%), and the use of biological control against pests and plant diseases (59.1%), the widespread introduction of modern water-saving irrigation technologies (56.1%), as well as the expansion of rainfed agriculture (10.6%).

#### 4. Conclusions

1. Agricultural producers have an overview of climate change and its impact on agriculture. Most respondents believe that they are insufficiently aware of the problem but note the signs of climate change. They directly experience and suffer from the negative effects of climate change. 97% of the respondents indicated that climate change affects agricultural productivity and 92% of respondents believe that climate change affects the quality of agricultural products.

2. The most important consequences of climate change impact on agriculture in the Kashkadarya region are:

- Increased water shortages;
- Increasing the number of agricultural pests and diseases;
- Decrease in income due to the increase in the number of insect pests;
- Destruction of useful insects;
- Decrease in crop yield and quality;
- Unstable and inclement weather;
- The need to spend more labor and other resources than usual to obtain the expected crop;
- Land salinization;
- Decrease in crop yield and quality.

3. An increase in the number of agricultural pests and plant diseases was noted by respondents as one of the most important and negative events related to climate change. Adaptation measures to mitigate the negative impacts of agricultural pests and plant diseases increase the cost of agricultural producers by spending more time and money each year and increasing production costs.

4. Based on the respondents' opinions, the specifics of the impact of climate change on agricultural production in Karshi, Mubarek, and Nishon districts were identified.

Despite the efforts to mitigate the effects of climate change, the consequences can be even more acute. The effects of climate change are already harming agriculture. 82% of respondents believe that adaptation to climate change is possible. 65% of respondents take certain measures to adapt to climate change. 83% of respondents are aware of common pest control methods, with many farmers specialized in horticulture consider that chemical methods are more effective than biological methods. Agricultural producers engaged in the cultivation of cotton and wheat believe that the biological method of combating pests and plant diseases is more effective than chemicals.

5. Respondents described the main mechanisms for improving the effectiveness of adaptation measures, including preferential loans (45% in Karshi, 43% in Mubarek and 62% in Nishan), the introduction of advanced water-saving irrigation technologies (36% in Karshi, 65% in Mubarek and 33% in Nishan).

6. Given the need for the information resources needed to adapt to climate change, the respondents noted the need for the following.

- Organization of special seminars, training, and workshops for agricultural producers to improve their knowledge and skills on adaptation to climate change
- Wider and more accurate information on climate change
- Wider information on advanced technologies in agriculture

At the same time, less than 42% of the respondents have attended seminars or training related to climate change and similar issues, and 91% of respondents believe that special seminars or training are necessary to ensure the sustainability of climate change measures. Analysis of the data obtained and the results of other similar studies will help identify areas of action to improve adaptation measures and its sustainability in the short, medium- and long-term perspectives.

## 5. Acknowledgments

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