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CLIMATE CHANGE ADAPTATION STRATEGIES IN AGRICULTURE: CASE STUDY: AZERBAIJAN AGRICULTURE AND CLIMATE CHANGE

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ABSTRACT

Climate change is an alarming challenge that put at risk the very basis of our existence. The alteration in temperature, precipitation patterns, as well as other extreme weather events have cascading effects on agriculture. Therefore, climate change adaptation strategies in agriculture are the essential tool for ensuring food security and a sustainable future. This paper aims to appeal the importance of climate change problem and the urgency of implementing adaptation strategies from a specific country case example. In line with the intensively growing climate change adaptation discussions, the idea of the paper is to examine the relationship between climate change and agriculture, explaining the costs and benefits of the current and prospective adaptation practices in Azerbaijan, from a farmer to governmental point of view.

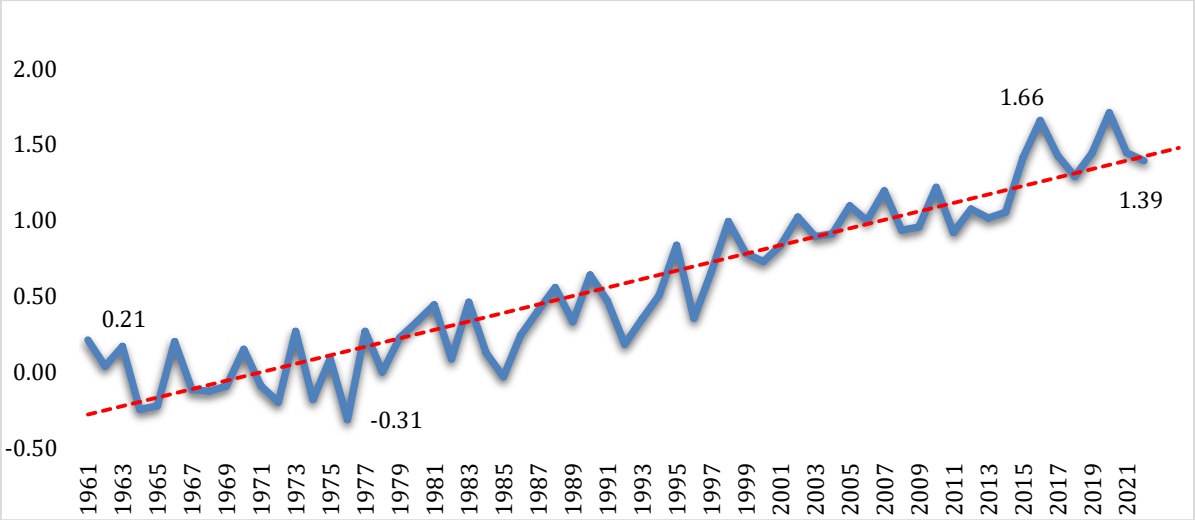
Keywords: climate change, agriculture, adaptation strategies, bibliometric review, case study

INTRODUCTION

What is the implication of climate change from a global perspective?

"Change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer […]" is how the Intergovernmental Panel on Climate Change (IPPC) defines climate change. (Pörtner et al., 2022). Climate change can be caused by internal natural processes or external forcings, such as changes in the solar cycle, volcanic eruptions, and persistent anthropogenic changes in atmospheric composition or land use. (Bashmakov et al., 2022). In 2022, the global annual mean land temperature (*Figure 1*) will be a 1.4°C anomaly, which is 6.6 times the observed temperature in 1961. The past eight years, 2015 to 2022, have been the eight warmest since records began in 1961. Furthermore, future increases can be expected based on the trend line drawn from the world average (FAO, 2023).

Figure 1. World mean annual temperature change between 1961 and 2022



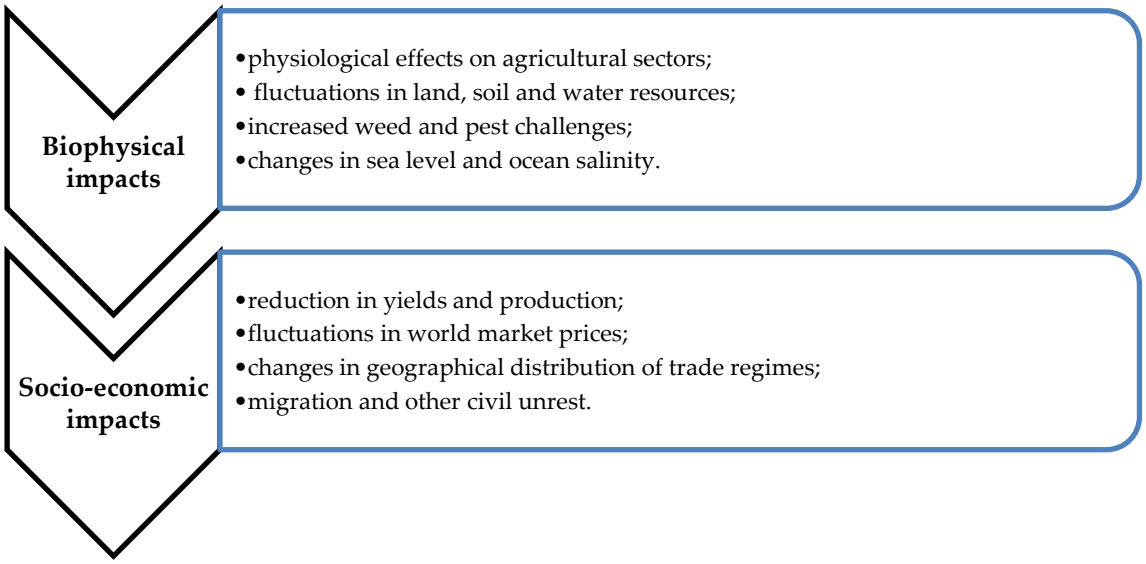
Source: *Author's calculation based on the FAOstat database*

Climate change has more alarming effects on agricultural production across various regions of the world than on any other aspect of global economic and social life (FAO, 2016). According to the studies, the relationship between agriculture and climate change can be twofold. On one side, agriculture is highly vulnerable to changing climatic conditions, as due to temperature anomalies soil fertility, crop or livestock productivity, scarcity can increase, and on the other side, agriculture production is one of the major reasons for having high global greenhouse gas emissions. Climate change impact can be divided into two groups (*Table 1*).

Although the overall impact of climate change is uncertain, according to researchers, it is mainly crop yields and yields that vary due to extreme weather events (Yohannes, 2015). On the livestock side, heat stress can affect animals by increasing vulnerability to disease or reducing fertility and milk production, as well as drought challenges can threaten pasture and feed supplies for animals. In fisheries and aquaculture, climate change barriers exacerbate overfishing and water pollution pressures. Concerning the end of the food system

value chain, problems like an excess of animal protein, food waste, and the amount of greenhouse gases produced by the consumption of food can be mentioned as additional factors to take into account when addressing climate change. Climate change affects global, regional, and local food security. Still, its effects, as well as adaptation and mitigation policy outcomes, can differ across countries' time zones, socio-economic statuses, and credibility of the solutions that have been proposed to tackle it.

Table 1. Impact of climate change



Source: *FAO (2007)*

1. LITERATURE REVIEW

What is climate change adaptation in an agricultural context?

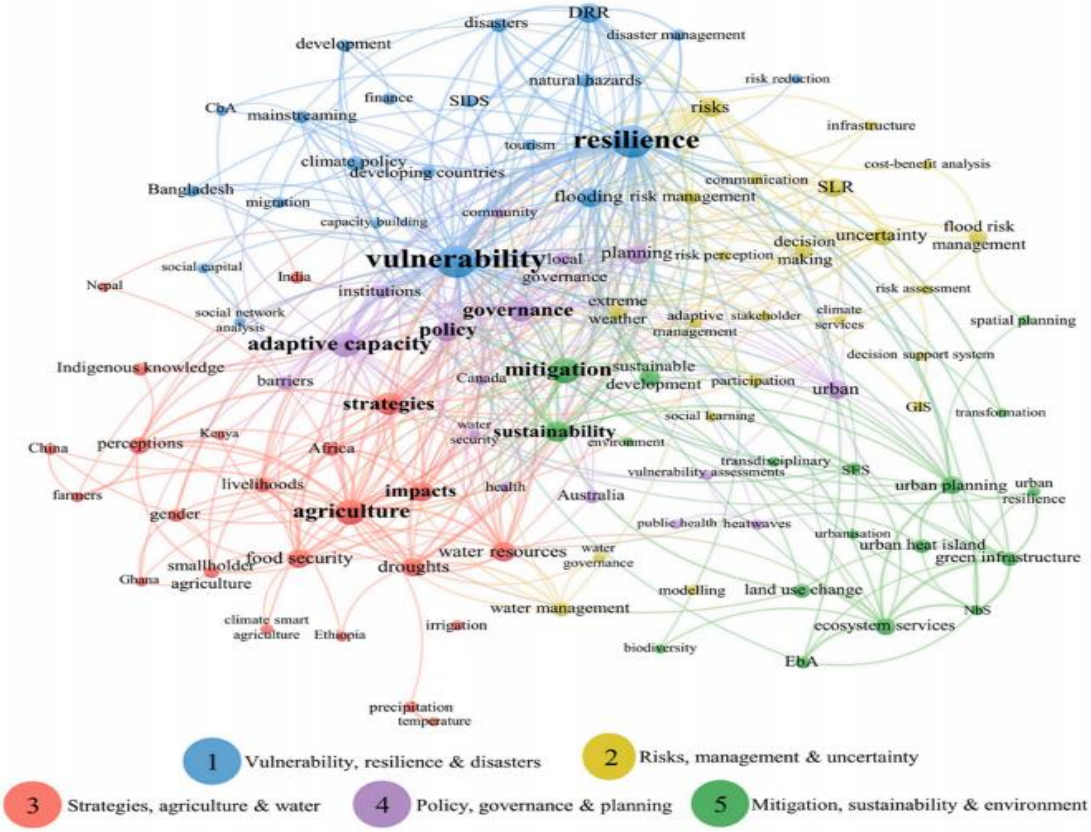
The IPPC defines climate change adaptation as *"the adjustment of natural and human systems in response to actual or expected climatic stimuli and their effects, has various strands: reducing the sensitivity of systems affected by climate change, increasing their resilience to climate-related uncertainty and instability, exploiting beneficial new opportunities, and coping with adverse consequences. […]"* (Pörtner et al., 2022).

The vast amount of literature on the results of climate change adaptation has existed and is still expanding. The most recent comprehensive survey of the research on climate change adaptation was presented by Nalau et al. (2021). They highlighted the extent of the topic of climate change adaptation by using a multidimensional bibliometric review. They examined nearly 11 thousand pieces of literature that covered the years 1978 to 2020 and focused on the human aspects of climate change adaptation publications. After the map was produced with the keywords, five significant themes, according to the study, became more obvious.

The international databases Scopus and Web of Science Core Collection were searched for material on adaptation to climate change using a query formulation strategy that was implemented in this research. Another bibliometric review was conducted using VOS-viewer to visualize and map the literatures from Scopus databases in order to discover prominent research themes, and their relationships with related sub-topics. Key study areas were

climate change, adaptation, vulnerability, and drought; related sub-topics included global warming, adaption strategies, gender, and irrigation and so on.

Figure 2. Priority research themes grouping around climate change and agriculture



Source: *Nalau and Verral (2021)*

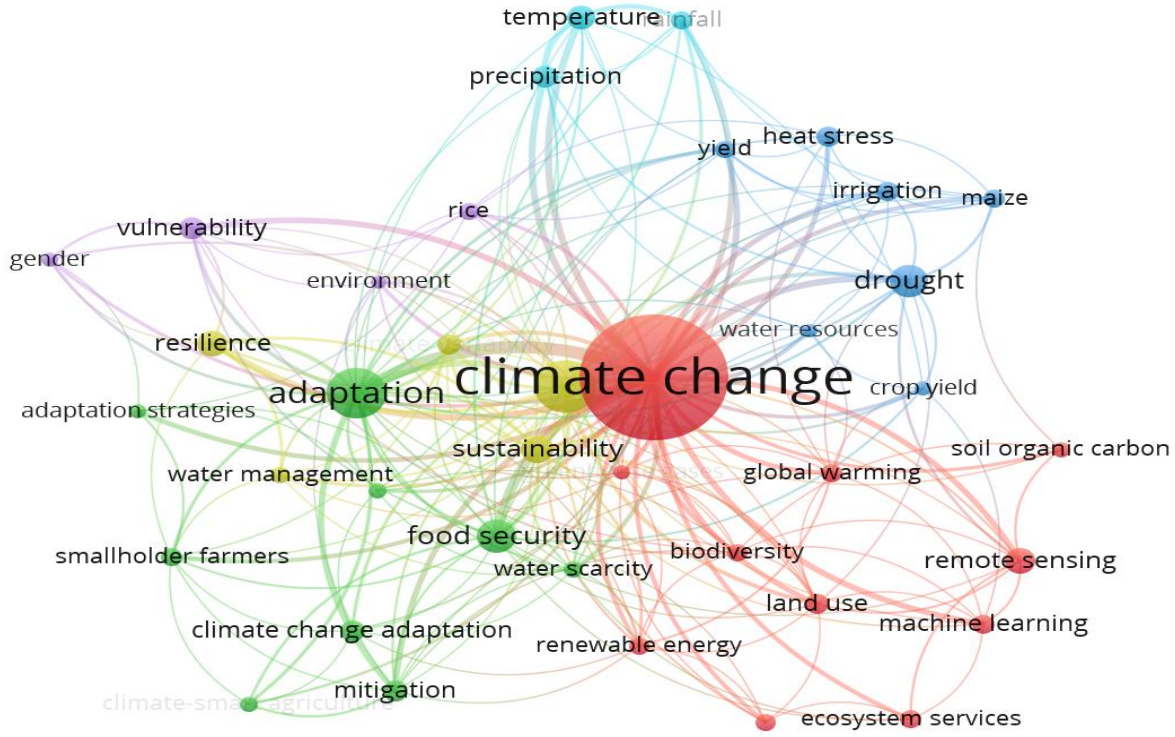
Despite the growing scientific interest in adaptation research there are still several gaps surrounding this idea. Because of the conceptual diversity, adaptation is difficult to monitor and set up a concrete measurement system. Adaptation actions propose local solutions for chosen microenvironments employing locally accessible capacities, which in the global context cannot be considered as a sustainable option. While mitigation has a well-established set of measurement indicators that can be applied for all levels of countries in the same way. Moreover, while research on adaptation known as a bottom-up strategy (e.g., studying how private individuals or sectors might adjust to a particular location or country), research on mitigation known as a top-down approach (e.g., focusing on technological and economic reforms) (Klein et al., 2015).

The IPCC Assessment Report (Lee et al, 2023) states that adaptation can no longer be ignored. In the most unstable regions of the planet, vulnerability is growing while mitigation progresses very slowly. Addressing this, IPCC Assessment Report (Lee et al, 2023) emphasizes that people must start making changes in their lives because the current mitigation and adaptation measures and policies are insufficient.

Considering the above issues, the questions arise: *what can be the applicable adaptation that can serve as a sustainable solution in this complex world?* In the wide sense, agriculture's adaptation

can be anticipatory (ex-ante) or reactive (ex-post), can target the short or the long term, and may occur at one or many of the multiple levels within the complex system comprising agriculture, the natural environment, food production and delivery, and rural communities. However, in broad sense adaptation policies can be divided into three parts:

Figure 3. Priority research themes grouping around climate change adaptation policy and agriculture



Source: *Author's own collaboration based on the 100 most commonly used keywords (climate change, adaptation, agriculture, vulnerability). The connection represents a group of keywords that have been used together in at least five publications, with the line thickness (minimum seven or more publications) proportional to the strength of co-occurrence. The size of the circle represents the frequency of the term.*

On-farm adaptation strategies (*farmer's response to shifting precipitation patterns*): crop shifting, using different harvest and planting/sowing dates, and other small adjustments to farm operations. These strategies can successfully adapt to new conditions and support farmers in avoiding initial shocks in the short term.

Private sector adaptation strategies: addressing information gaps through insurance, investing in more extensive infrastructure projects or technologies, or promoting more sustainable practices along the value chain.

Governmental adaptation strategies: adaptive measures emphasized in regulatory frameworks, providing information and research, or capacity building to improve human capital.

Overall, these kinds of strategies (e.g., insurance plans, early warning systems) are recognized as essential for long-term adaptation solutions (FAO, 2016).

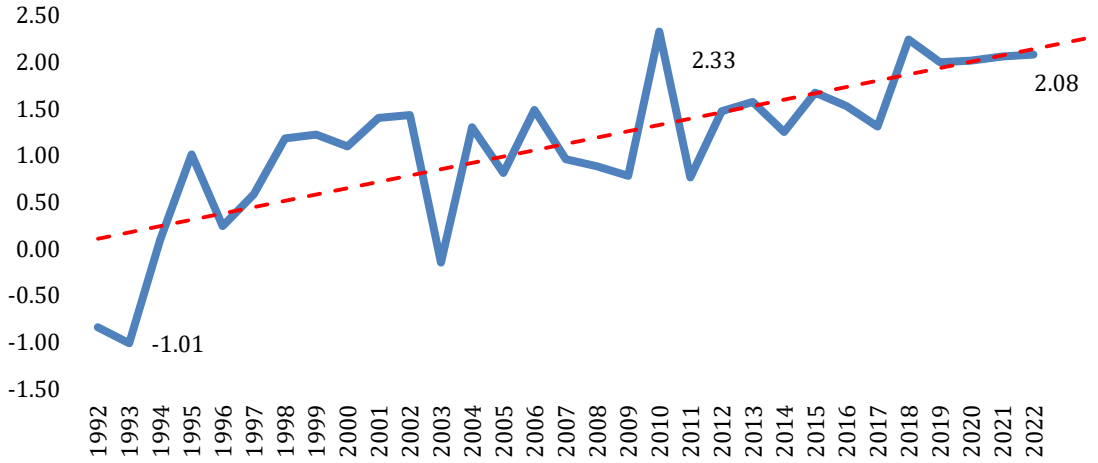
2. CASE STUDY: AZERBAIJAN AGRICULTURE AND CLIMATE CHANGE

How to ensure that adaptation strategies are implemented in an efficient, productive and sustainable way? What is the role of government in providing an appropriate institutional and policy framework? Given that adaptation entails specific responses to varying circumstances, how can policies provide the right signals and incentives for successful production in agriculture? In order to give answers to these types of questions, with the case study method, I will present the current and prospective situation of climate change and agriculture relationship, as well as ongoing and possible adaptation strategies in Azerbaijan.

For the last 30 years, the average annual temperature in Azerbaijan changed from -1.0 to 2.1°C (*Figure 2)*. Temperatures in Azerbaijan are projected to rise at a faster rate than the global average, with potential warming of 4.7°C by the 2090s over the 1986–2005 baseline, under the highest emission pathway (World Bank and Asian Development Bank, 2021).

The main negative effects of climate change on lands in Azerbaijan are heat stress, and other extreme events like flooding, or drought. The most sensitive sectors are human health (e.g., respiratory or heart diseases), agriculture (e.g., decreased crop yields, soil degradation and loss of arable land, fluctuation in production level), water resources (e.g., reduced freshwater supplies, increased risk of flash floods), as well as forestry (e.g., increasing vulnerability to wildfire or insect outbreaks) and tourism (increased costs from damages and losses to the ski resorts or beaches). Furthermore, it is widely known that climate change impacts can be disproportionately divided among different income levels of population. For instance, low-income population, especially in rural areas whose income directly connected to the agriculture sector, is more vulnerable to the extreme events like droughts.

Figure 4. Annual temperature in Azerbaijan from 1992 to 2022



Source: *Author's calculation based on the FAOstat database*

Even though agriculture is an important sector of the Azerbaijan economy, (about 55.2% of the land area suitable for agriculture and over 36.3% of employment level in agriculture sector by the end of 2021), productivity in agriculture is lower compare to other sectors (5.6% of GDP in 2021) (State Statistical Committee, 2022).

Like in other countries, also in Azerbaijan climate change can have direct and indirect effects to the agriculture sector. From direct effects point of view, variations in carbon gas

emissions, and temperatures, and from indirect effects point of view, can include impacts on water resource scarcity, changes in soil components, as well as reduction of arable areas due land degradation and desertification.

According to the Fourth National Communication to the UN framework convention on climate change (Humbatova et al, 2021), the Ministry of Ecology and Natural Resources assesses the likely impact of climate change on several agricultural subsectors:

- ✓ The ***cotton subsector***, which area under this crop has sharply decreased in recent decades, is expected to benefit from higher temperatures and a longer growing season, while this benefit can be offset by water scarcity that is likely to affect the irrigation of cotton fields (WB and ADB, 2021). For more productivity, it was suggested to expand its planting area and to take timely and proper reclamation measures.
- ✓ As a result of global warming, ***winter wheat*** vegetation period is expected to be shortened, which can lead to a faster grain harvesting.
- ✓ Rising temperatures are projected to lead to significant changes in the altitudes at which ***vineyards*** may be planted (from altitudes of 800–900 m, to much higher altitudes of 1400–1700) in Azerbaijan by the end of the 21st century. However, there is a shortage of suitable land at such altitudes (World Bank and Asian Development Bank, 2021). Furthermore, as the rainfall is expected to decrease in summer, in its turn, this situation can increase the need for additional irrigation of vineyards.

OECD has emphasized five dimensions that should be considered by public and private actors when designing their risk management strategies in agriculture: 1) the time frame, taking early warning actions and planning for the long-term; 2) building a trade-off between policy objectives and actor; 3) collaborative processes, including various stakeholders; 4) investments in strengthening human capital and supporting adapted practices (Baldwin and Gray, 2020).

The ability of farmers to use hydrometeorological and pertinent geospatial data to support good farm-level decision making, research-oriented innovations in agronomic practices in response to forecast climate changes, and highly developed water infrastructure that meets the needs of the farming community are just a few examples of the characteristics that define high levels of adaptation strategies in the agricultural sector in each country (Ahouissoussi et al, 2014).

In general, assessing the adaptive capacity of Azerbaijan's agricultural sector is challenging for following reasons:

Adaptive capacity reflects a wide range of socioeconomic, policy, and institutional factors, from farm, regional, and national levels, as well as determining the variations in current climatic exposure, social structures, institutional capacity, education level, and access to infrastructure. Moreover, for sustainable adaptation strategies financial resources are one of the key factors. Until 1995, there were no policy or legal documents related to climate change issues, as well as adaptation strategies in the country. In 1995, Azerbaijan's parliament ratified the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol in 2000, as well as the Doha addendum in 2015, for the 2nd period of fulfilling obligations. Undertook obligations such as preparing and regularly updating the cadastre of gas emissions that create a heating effect, and preparing national data, and these obligations were systematically fulfilled.

Succeeding years, the importance of preparing necessary policy measures were gaining more attention and from institutional context point of view, country adapted several national programs on socio-economic development of regions, soil protection, land and water management, improving the environmental situation in the country, as well as state program on the use of Alternative and Renewable Energy Sources. In 2016, Azerbaijan has signed and ratified the Paris Climate Agreement. In its Nationally Determined Contributions (2017), the country has outlined climate change mitigation actions in its energy, oil and gas, residential and commercial, transportation, agricultural, and waste sectors, as well as set a goal of maintaining a 35% reduction in greenhouse gas emissions by 2030 compared to the base year (1990). Until now, four national communications to the United Nations framework convention on climate change has been introduced, showing the present situation in all the sectors of the economy in line with the climate change, as well as its mitigation policies, and possible adaptation strategies.

Last but not the least, the policy document "Azerbaijan 2030: National Priorities for Socio-Economic Development", approved in 2021, sets out an ambitious roadmap for long-term development with five key priorities, where one of them is achieving a cleaner environment and greener growth. National priorities for socio-economic development aligned with the goals of the United Nations 2030 Agenda for Sustainable Development and for the implementation of these priorities in 2022, the "Social and Economic Development Strategy of the Republic of Azerbaijan in 2022-2026" was approved. Concepts of a "green energy zone" will be applied by expanding the use of ecologically clean and economically efficient renewable energy sources, where main targets are related to mitigation policies against the climate change in the energy field.

From managerial level point of view, several policies and programs implemented in the country: analysing current and prospect situation of temperature change - *Agrometeorological observations* – conducted in 19 hydrometeorological, 11 agrometeorological stations and 7 stations of the regions important for agriculture of the territory of the country. These observations are made on meteorological indicators such as average, maximum and minimum air temperatures, temperatures of the soil surface and different depths, soil moisture, daily and decadal amount of precipitation, wind speed, relative humidity, and snow conditions; *Agrarian Insurance Fund* – provide insurance services for producers of agricultural products (cereals, vegetables, livestock) by promoting sustainable business development and always fulfil their obligations; *Agricultural subsidies* - to regulate the production costs of agricultural products, increase the profits of farmers, stabilize the prices of food products and encourage the production of food products as needed;

Assisting the farmers with necessary information and finance for their in the productivity level and other circumstances regarding climate change and agriculture*: Electronic Agricultural Information System* - to provide services in the field of agriculture and to provide automation of information creation, collection, processing, storage and search for this purpose. An electronic system reflecting information on ownership rights, spatial location, and current planting structure of farmland and so on.

As we can see, although some adaptation related strategies exist, but there is still huge lack of adequate information that related to solving the climate change and agriculture challenges (e.g., strengthening scientific and technical capacities, collaboration among researchers and

farm advisory services, as well as the provision of clear messages and instruments to policy makers and stakeholders). Considering myriad literatures, adaptation strategies can be grouped in three levels: farm level, management level and institutional level. The agriculture sector's vulnerability to climate change in Azerbaijan stems from high reliance on subsistence farming, with low productivity, high rates of soil degradation and limited land availability (USAID, 2017). The solution to Azerbaijan's agricultural problems and the way to achieve the sector's goals is to ensure the sustainable development of agriculture, with applicable adaptation policies in the country context as stated in Table 2.

Table 2. Adaptation strategies

Strategy name	Types	Pros	Cons
Farm level[1]	-Change crop variety - switching from one crop variety to drought-tolerant crops in response to climatic stresses and changes; -Using mixed cropping; -Change in cropping calendar; -Apply water-saving technologies in irrigation; -Improve storage systems for agricultural products.	-Higher or stable crop yields; -Diversification of agricultural production; -Lowering greenhouse gas emissions; -Efficient water usage; -Reduction of food spoilage or pest infestation.	-Lack of access to timely weather information, water resources, credit facilities; -Poor soil fertility; -High price of seeds; -Limited flexibility.
Management level	-Early warning electronic systems, especially for drought, floods, and landslides; -Establishment of a reliable information system of water and land resources use; -Analysis of climate risks and assessment of climate impacts using crop–weather interactions; -Developed hydrometeorological information, particularly for short-term temperature and precipitation forecasts; -Farmer training and improved access to effective and efficient extension systems.	-Increase farmer awareness; -Reducing the risk of damage and, achieving product protection; -Supporting better farm-level decision-making such as irrigation scheduling, developing, and an early warning for upcoming extreme events; -Forecasting pest and disease for optimal chemical use.	- Finance consuming; -Unpredictable weather; -Excessive cost of farm input.
Institutional level	-Comprehensive adaptation strategies; -Developing agricultural support policies, especially with water scarcity problem; -Changes in agricultural market prices – Market price support; -Support farmers from R&D and innovation point of view; -Agri-environmental payments; -Land retirement policies; -Taxing the environmentally harmful inputs.	-Environmental sustainability. -Changes in production volume; -Increase in the use of environmentally friendly inputs; -Build climate-resilient livelihoods; -Reducing environmental pressures.	If not well-managed the policies: -Biodiversity lost; -Increases in invasive species; -Water scarcity -Soil degradation and etc.

Source: *Author's own research*

[1] The ability of farmers to recognise climate change is an essential prerequisite for adaptation (Masud M.M. et al., 2017). For understanding and developing the prosper adaptation strategies in the farm level, it needs well-organized and developed qualitative and quantitative methodological analysis, considering regional, farm size, type of product and other specifications.

Even though Azerbaijan's National Communications address a wide range of sectors in relation to projected climate change impacts and related adaptation measures, in 2017, the country has embarked on the preparation and implementation of a National Adaptation Plan (NAP) and is expected be in place by 2024. The aim of NAP will be to coordinate the key organisations and activities, strengthening institutional, technical, and financial capacities – in support of the country's efforts to ensure that medium-to long-term climate adaptation needs for three areas: water, agriculture, and coastal areas (UNDP, 2021).

By fostering circumstances for more sustainable management of water resources and the use of adaptable solutions in the nation's agriculture, projects with effective adaption types from the Table above can help to offset the harmful consequences of climate change. The introduction of new tools and practices, particularly through data collection and analysing, as well as awareness-raising training program for farmers, decision-makers, and other local communities to improve their strength and capacity to adapt to climate change, can help to build institutional, technical, and financial capacities.

CONCLUSION

As judgments are unavoidably influenced by personal values, emotions, social experiences, perception of risks and other behavioral factors, adaptation studies need to focus more on the anthropocene side of climate change. Optimizing management practices should be a top priority in farm-level adaptation efforts to reduce the effects of extreme climate events and increase opportunities in the future. For national and local organizations that support agriculture to plan their activities and provide timely services to the intended beneficiaries, they need information on risks (farmers).

Considering Azerbaijan case a number of areas need the urgent attention (e.g., meteorological, or agricultural community) to effectively address climate barriers in achieving sustainable food production. Additional priorities include developing a network for climate monitoring and data collection in rural areas, characterizing natural resources through methodical data management and archiving, providing information to research institutions, extension organizations, and farmers based on their needs, ensuring the use of modern information products (inputs, credit, market, and financial considerations should be considered for information goods), and forecasts from regional climate models.

To maintain government commitment, it is essential to integrate climate information services into early warning systems for food security, humanitarian assistance, agricultural policies and food security programs. To offer demand-based information and feedback to national meteorological and hydrological services, agronomic research and extension institutions, sustained communication channels must be established. Gaining community trust requires creating a network of local farmers and spreading awareness. All facets of CRM require the presence of a variety of intersecting components, including capacity building, awareness, gender equality, and collaboration. Remember that if adaptation and mitigation methods (and their correct execution) are not put in place, the effects of climate change will continue to worsen.

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