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Ways of taking preventive measures to eliminate the negative effects of climate factors on agriculture

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Abstract
Climate change poses significant challenges to global agriculture, affecting food security and livelihoods. Increasing greenhouse gas emissions have caused changes in temperature, precipitation patterns, and frequency of extreme weather events, affecting crop and agricultural productivity. Adapting to these changes requires a multifaceted approach that considers both the immediate and long-term impacts of climate change on agriculture. This includes implementing sustainable land management practices, promoting the use of climate-resilient crop varieties, and improving water management techniques. This study also aims to explore various strategies and measures that can be implemented to eliminate or reduce the negative impacts of climate change on agriculture. The research seeks to provide practical solutions to increase the resilience of agricultural systems to climate change by examining adaptation and mitigation strategies.

Keywords: *strategies, climate change, agriculture, solutions, climate-resistant*

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I. INTRODUCTION AND LITERATURE REVIEW

Agriculture is the backbone of the global food supply, providing essential resources for human survival and economic stability. However, the sector faces significant challenges due to the increasing impact of climate change. Climate factors, including rising temperatures, altered precipitation patterns, and more frequent and severe weather events, pose serious threats to agricultural productivity and sustainability. As such, taking preventive measures to eliminate the negative effects of climate factors on agriculture has become a critical priority at the global level.

The importance of implementing preventive measures in agriculture cannot be overstated. Climate change directly affects crop yields, livestock health, and soil fertility, leading to reduced food security and higher risks of famine, especially in vulnerable regions. For instance, prolonged droughts can lead to water scarcity, adversely impacting crop growth and reducing agricultural outputs. Similarly, excessive rainfall and flooding can destroy crops, erode soils, and disrupt planting seasons. These changes threaten the livelihoods of millions of farmers worldwide and have far-reaching implications for global food markets and prices.

Preventive measures, such as adopting climate-resilient crop varieties, improving water management practices, and implementing sustainable land management techniques, are essential to mitigate these impacts. For example, drought-resistant crops can withstand prolonged dry periods, ensuring stable yields even in adverse weather conditions. Efficient irrigation systems, such as drip irrigation, optimize water usage and minimize wastage, crucial in areas facing water scarcity. Additionally, practices like conservation agriculture and agroforestry enhance soil health, increase biodiversity, and improve resilience to extreme weather events.

1.1 Problem Statement

Azerbaijan, like many other countries, is facing the adverse effects of climate change on its agricultural sector. The country experiences a variety of climatic conditions, from semi-arid regions to mountainous areas, making it particularly vulnerable to changes in climate patterns. In recent years, Azerbaijan has seen an increase in the frequency and intensity of droughts, which have severely affected crop yields and water resources. Flooding and extreme weather events have also posed significant challenges to the agricultural industry.

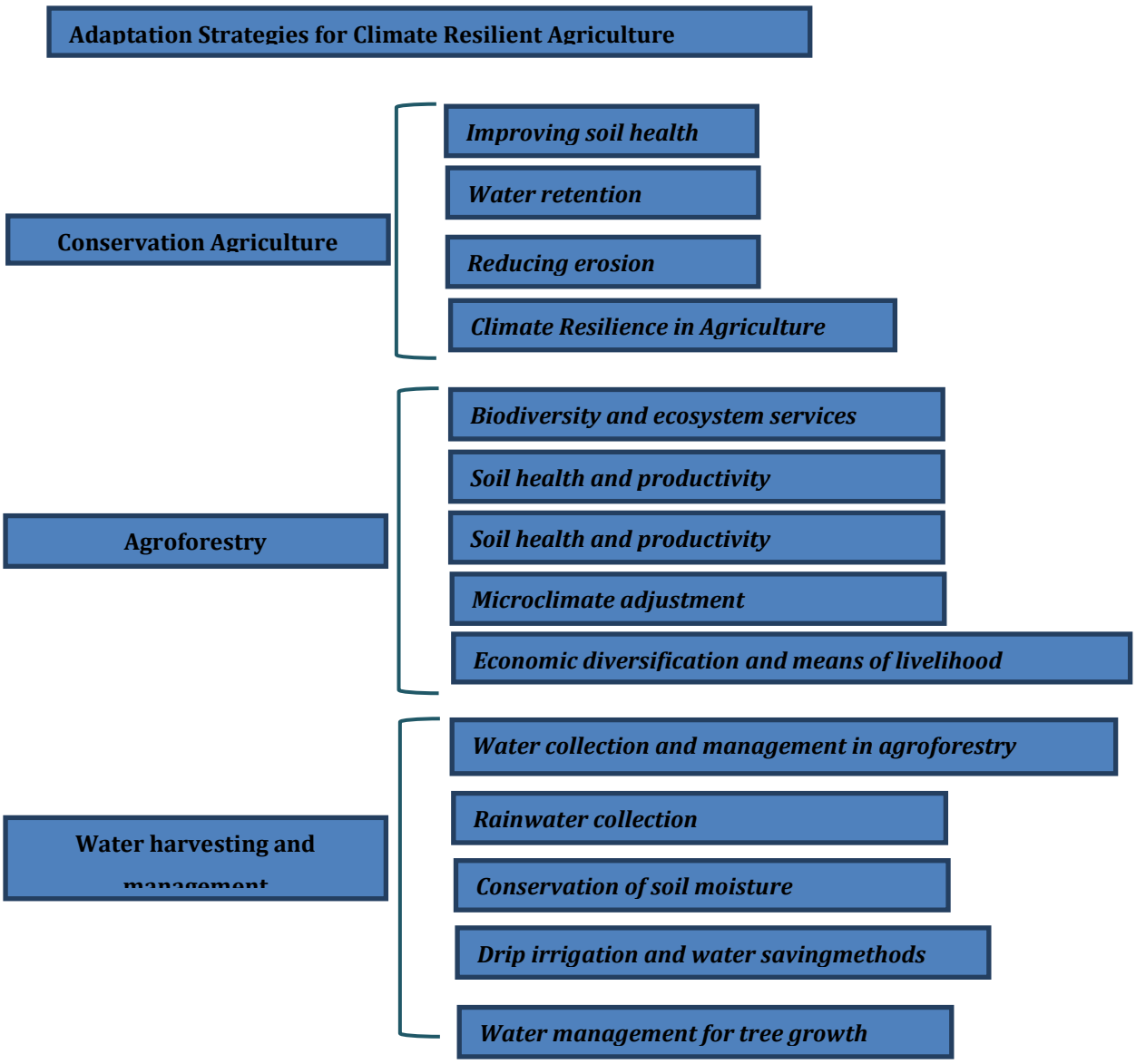
To combat these issues, Azerbaijan has been actively working on implementing preventive measures to enhance climate resilience in agriculture. Initiatives such as the development of drought-resistant crop varieties, improved irrigation infrastructure, and the promotion of sustainable land management practices are underway. The government, in collaboration with international organizations, is also focusing on enhancing farmer education and access to modern agricultural technologies. These efforts aim to ensure that Azerbaijan's agricultural sector can adapt to the changing climate and continue to contribute to the country's food security and economic development.

1.2 Research Objectives

In this research work, we will talk about the measures taken to prevent or adapt to climate change in the world. They can be grouped as follows (Figure 1).

Figure 1

Cluster Adaptation Strategies for Climate Resilient Agriculture



Source: Author's development.

Adaptation Strategies for Climate Resilient Agriculture

Since adaptation of agriculture to climate change is crucial for ensuring food security and sustainable development, this section examines various adaptation strategies that can help make agriculture more resilient to the effects of climate change.

Sustainable Land Management Practices:

1. Conservation Agriculture: Conservation agriculture involves minimizing soil disturbance, maintaining permanent soil cover and practicing crop rotation. These practices help improve soil health, increase water retention and reduce erosion, making agriculture more resilient to climate change (Derpsch et al., 2010).

1.1. Improving soil health

Conservation agriculture focuses on improving soil health, a critical aspect of sustainable farming. This practice aims to improve soil structure, increase soil organic matter and reduce soil erosion, ultimately benefiting crop growth and agricultural sustainability.

Minimizing soil disturbance: One of the main principles of agricultural conservation is to minimize soil disturbance. Conventional tillage can disrupt soil structure and reduce organic matter. Conservation agriculture helps maintain soil structure and microbial activity, improving soil health (Hobbs et al., 2008).

Soil cover maintenance: Conservation agriculture emphasizes the importance of permanent soil cover maintenance. This can be achieved by using crop residues, cover crops or mulches. Ground cover helps protect soil from erosion, reduces evaporation, and provides organic matter essential for soil health (Derpsch et al., 2014).

Increasing soil organic matter: Conservation agriculture practices such as crop rotation and use of cover crops help increase soil organic matter content. Organic matter improves soil structure, increases water retention and provides nutrients for plant growth. It also promotes microbial activity, which is important for nutrient cycling and soil health (Poeplau & Don, 2015).

1.2. Water retention

Conservation agriculture plays an important role in improving water retention in agricultural soils, contributing to better crop yields and overall farm sustainability. By implementing conservation agricultural practices, farmers can improve their ability to capture, store, and use water efficiently, especially in regions prone to drought and erratic rainfall patterns.

Soil cover and reduced evaporation: One of the primary mechanisms by which conservation agriculture improves water retention is through the maintenance of permanent soil cover. Crop residues, cover crops or mulches left on the soil surface help reduce evaporation, keeping more water in the soil for plant uptake (Pittelkow et al., 2015).

Improved infiltration: By reducing soil compaction and maintaining organic matter content, conservation agriculture increases soil permeability. This leads to an increase in the rate of water percolation, which allows rainwater to penetrate the soil and be stored for plant use instead of running off the surface (Lal, 2015).

1.3. Reducing erosion

Conservation agriculture helps reduce soil erosion by protecting the soil surface from raindrops and reducing surface runoff. This is achieved by covering the soil with crop residues or cover crops that act as a physical barrier against erosion (FAO, 2017).

Erosion Reduction in Conservation Agriculture: Erosion reduction is an important aspect of conservation agriculture, which aims to protect soil from degradation and loss. By implementing erosion reduction practices, farmers can maintain soil fertility, improve water quality, and increase overall farm sustainability.

Soil cover and surface protection: One of the main strategies to reduce erosion in conservation agriculture is the maintenance of permanent soil cover. This can be achieved by using crop residues, cover crops or mulches that protect the soil surface from raindrops and reduce surface runoff (Derpsch et al., 2014).

1.4. Climate Resilience in Agriculture

Climate resilience in agriculture refers to the ability of agricultural systems to withstand and recover from climate-related stresses and shocks, such as drought, flooding and extreme temperatures. Building climate resilience is critical to ensuring food security, sustaining rural livelihoods and promoting sustainable agricultural development in the face of climate change.

Crop diversification and rotation: Crop diversification and rotation can help improve climate resilience by reducing the risk of crop failure due to climate-related stresses. Planting different crops with different growth periods and climatic requirements can help ensure that at least some crops thrive under existing conditions (Lipper et al., 2014).

Sustainable land management practices: Adoption of sustainable land management practices, such as conservation agriculture, agroforestry and soil conservation measures, can improve soil health, water retention and overall farm resilience to climate change (FAO, 2017).

2. Agroforestry: Agroforestry involves the integration of trees and shrubs into agricultural landscapes. Trees provide shade, improve soil fertility and increase biodiversity, making agroforestry systems more resilient to climate change (Nair et al., 2009).

2.1. Biodiversity and ecosystem services. Agroforestry systems that integrate trees and shrubs into agricultural landscapes play an important role in promoting biodiversity and providing a range of ecosystem services. These

systems contribute to biodiversity conservation and sustainable management of natural resources, increasing the resilience of agricultural landscapes to climate change and other environmental pressures.

Habitat creation and species diversity: Agroforestry systems provide habitat for a wide variety of plant and animal species, increasing biodiversity compared to conventional monoculture systems. The presence of trees and shrubs in agroforestry systems creates diverse microhabitats that support different species, including pollinators, birds, and beneficial insects (Montagnini, 2016).

Pollination and pest control: Different plant species in agroforestry systems attract pollinators such as bees, butterflies and birds, which are important for crop pollination. In addition, these systems support natural enemies of pests, such as predatory insects and birds, which help to naturally control pest populations and reduce the need for chemical pesticides (Gurr et al., 2017).

2.2. Soil health and productivity. Trees in agroforestry systems add organic matter to the soil through leaf and root exudates, improving soil structure and productivity. This increases the soil's ability to retain water and nutrients, making agroforestry systems more resilient to drought and nutrient stress (Jose, 2009).

Soil health and productivity in agroforestry: Agroforestry systems that integrate trees and shrubs into agricultural landscapes play an important role in improving soil health and fertility. These systems promote sustainable land management practices that improve soil structure, increase organic matter content, and improve nutrient cycling, ultimately benefiting crop growth and agricultural productivity.

Accumulation of organic matter: One of the main advantages of agroforestry is the accumulation of organic matter in the soil. Trees and shrubs in agroforestry systems contribute to the soil organic matter pool through leaf litter, root exudates, and decaying plant material. This organic matter improves soil structure, water retention and nutrient availability, leading to healthier soils and crop yields (Montagnini, 2006).

Nutrient cycling and availability: In agroforestry systems, trees and shrubs play an important role in nutrient cycling because they can access nutrients from deeper soil layers and make them available to crops through litter decomposition and root cycling. This cycling of nutrients helps maintain soil fertility and reduces the need for external inputs such as synthetic fertilizers (Nair et al., 2009).

2.3. Microclimate adjustment. The presence of trees in agroforestry systems can modify the microclimate, provide shade and reduce extreme temperatures. This microclimate adjustment can help plants withstand heat stress and reduce water evaporation from the soil, increasing water use efficiency (Scherr and Garrity, 2013).

Microclimate regulation in agroforestry: Agroforestry systems that integrate trees and shrubs into agricultural landscapes play a crucial role in microclimate regulation. These systems modify local climate conditions to create a favorable environment for crops, livestock and beneficial organisms. Microclimate regulation in agroforestry is achieved through various mechanisms, including shading, wind protection and moisture conservation, which contribute to increasing agricultural productivity and ecosystem resilience.

Shading and temperature regulation: One of the main methods of microclimate regulation of agroforestry systems is shading. Trees and shrubs provide shade, reduce sunlight intensity, and reduce temperatures in an agricultural landscape. This shading effect can help reduce heat stress in crop and livestock production, especially during hot periods, improving overall agricultural productivity (Nair et al., 2009).

Wind protection: In agroforestry systems, trees and shrubs serve as natural windbreaks, reducing the impact of wind on crops and soil. Winds prevent soil erosion, protect crops from wind damage, and create protected microclimates that are more favorable for plant growth and development. This wind protection can improve crop yields and increase agricultural sustainability (Montagnini, 2016).

Moisture retention and water availability: Agroforestry systems can enhance soil moisture retention and reduce water stress in crops. Trees and shrubs intercept and help retain rainfall, reduce runoff and increase infiltration. This increased moisture availability can increase crop water use efficiency and reduce the risk of drought stress, especially in arid and semi-arid regions (Jose, 2009).

2***.4. Economic diversification and means of livelihood***. Agroforestry provides additional sources of income to farmers from tree products such as fruits, nuts, trees and medicinal plants. This economic diversification can help farmers cope with climate-related income changes and reduce their vulnerability to climate change (Garrity et al., 2010).

Economic diversification and livelihoods in agroforestry: Agroforestry systems that integrate trees and shrubs into agricultural landscapes offer opportunities for economic diversification and increased livelihood opportunities. These systems provide farmers with multiple sources of income and products, contributing to financial stability and sustainability.

Wood products and non-timber forest products (NTFPS): Agroforestry systems provide farmers with a variety of wood products and non-timber forest products (NTFPs) that can be harvested for sale or personal use. These products include fruits, nuts, herbs, resins, fibers and others. The collection and sale of these products can provide additional income to farmers, especially during the off-season for the crops (Franzel et al., 2004).

Agroforestry value chains: Agroforestry systems can contribute to the development of value chains for wood products and NTFPs. Value chains cover all stages of agricultural production, processing, marketing and

distribution, enabling farmers to add value to their products and access higher value markets (Scherr and Garrity, 2013).

3. Water harvesting and management: Applying water harvesting techniques such as building small dams or ponds can help capture and store rainwater for agricultural use. Efficient water management practices such as drip irrigation can also help reduce water wastage and improve crop yields (Rockström et al., 2007).

3.1. Water collection and management in agroforestry. Water harvesting and management play an important role in ensuring efficient use of water resources in agroforestry systems and increasing agricultural productivity. Agroforestry practices can help capture, store and manage water, especially in arid and semi-arid regions, improving soil moisture levels and crop water availability.

Contour gardens and terraces: Contour beds and terraces are soil conservation measures that help to retain water. They are built along soil contour lines to reduce runoff and promote water infiltration, thus increasing soil moisture and reducing erosion (FAO, 2015).

Drip Irrigation and Water Saving Techniques: Drip irrigation is a water saving technique that delivers water directly to the roots of plants, minimizing water wastage. This technique can be integrated into agroforestry systems to ensure efficient water use and optimize crop growth (Hobbs et al., 2008).

3.2. Rainwater collection. One of the key strategies in agroforestry is rainwater harvesting, which involves capturing and storing rainwater for agricultural use. Techniques such as building small dams, ponds, or check dams can help collect rainwater, which can then be used for irrigation, livestock watering, and other agricultural activities (Rockström et al., 2010).

Rainwater harvesting is a practice that involves collecting and storing rainwater for later use. It is an ancient technique used for centuries to provide water for drinking, irrigation and other purposes. Rainwater harvesting can be implemented at various scales, from small, household-level systems to large, community-level systems.

3.3. Conservation of soil moisture. Soil moisture conservation refers to practices and techniques aimed at maintaining or improving the amount of water stored in the soil. Conservation of soil moisture is very important for plant growth, especially in arid and semi-arid regions where water is limited.

3.4. Drip irrigation and water saving methods. Agroforestry systems can also benefit from water-saving irrigation methods such as drip irrigation. Drip irrigation delivers water directly to plant roots, minimizing water wastage and increasing water use efficiency. Other water conservation practices such as mulching and soil conservation measures can also help reduce water loss (Hobbs et al., 2008).

3.5. Water management for tree growth:

Proper water management is essential for tree growth and health in agroforestry systems. Trees need enough water to grow, especially during the planting stage. By efficiently managing water resources, farmers can ensure the long-term sustainability of their agroforestry systems and maximize tree growth and productivity (Nair et al., 2009).

Water management for tree growth is critical to ensuring healthy and productive trees, especially in areas where water is limited or prone to drought. Proper water management practices can help trees withstand dry periods, improving growth rate and overall tree health.

Water requirements for trees:

Trees have different water requirements depending on factors such as species, age, size and environmental conditions. Young trees and newly planted trees require more frequent watering to establish their root systems, while mature trees may require additional watering only during dry periods.

Types of climate-resistant products (Figure 2):

1. Drought Tolerant Plants:

Planting drought-tolerant crop varieties can help reduce the impact of water scarcity on agriculture. These species can tolerate dry conditions and maintain productivity during drought (Gupta et al., 2019).

Characteristics of drought tolerant plants:

- Deep root systems: Drought tolerant plants often have deep root systems that allow them to access water from deeper soil layers (Gowda et al., 2011).
- Small Leaf Size: Plants with small leaves are better able to retain water by reducing transpiration (Blum, 2005).
- Reduction of water loss: Drought-tolerant plants may have mechanisms to reduce water loss through transpiration, such as waxy leaf sheaths or the ability to close leaf stomata during dry periods (Chaves et al., 2003).

2. Heat Resistant Plants:

Heat-resistant plant varieties can withstand high temperatures, reducing the risk of heat stress and crop failure. These species are particularly important in regions experiencing increased temperatures due to climate change (Lobell et al., 2011).

Heat-resistant plants are species that can withstand high temperatures, which are becoming increasingly important due to climate change. These products are crucial for ensuring food security in regions where high temperatures are a limiting factor for crop production.

Features of heat-resistant plants:

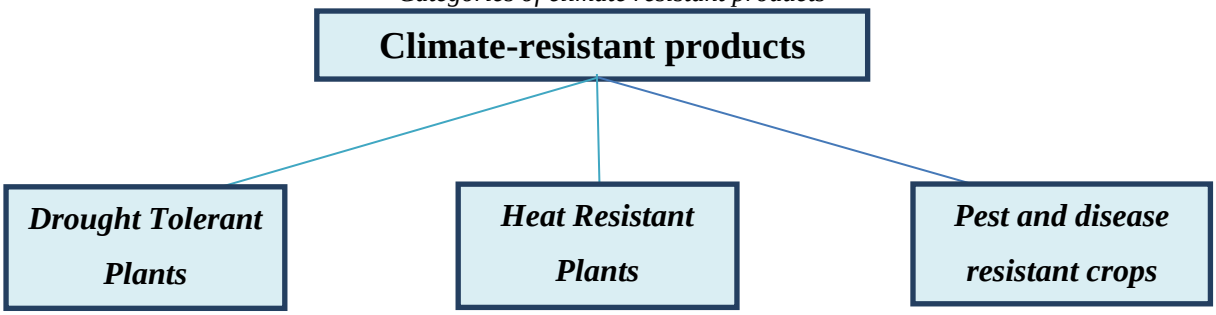
- Heat shock proteins: Heat tolerant crops often produce heat shock proteins that help protect plant cells from heat stress (Wang et al., 2004).
- Increased photosynthetic efficiency: Some heat-tolerant plants have adaptations that improve photosynthetic efficiency at high temperatures and allow them to maintain their growth and productivity (Prasad et al., 2008).
- Early flowering: Plants that flower early in the season may be more heat tolerant because they can avoid the hottest part of the year (Slafer et al., 2005).

3. Pest and disease resistant crops: Planting pest and disease resistant crop varieties can help reduce the impact of climate change on agriculture. These species can withstand the attacks of pests and diseases, reducing the need for chemical pesticides (Savary et al., 2012).

Pest- and disease-resistant crops are varieties that have been developed to withstand attacks from pests and diseases, reducing the need for chemical pesticides. These crops play a crucial role in sustainable agriculture by reducing the environmental impact of pest and disease control measures.

Figure 2

Categories of climate resistant products



Source: Author's development.

1.3 Research Methodology and Data Analysis

Global warming in Azerbaijan is a significant environmental challenge with diverse impacts on the country's ecosystems, economy, and society. Like many regions worldwide, Azerbaijan has experienced observable changes in its climate over the past century, including increases in temperature, changes in precipitation patterns, and more frequent extreme weather events.

Overall, global warming poses significant challenges to Azerbaijan, requiring concerted efforts at the national and international levels to reduce greenhouse gas emissions and build resilience to climate change impacts.

Measures taken in Azerbaijan regarding climate change are as follows:

Green Credit Mechanism (2010): This mechanism offers loans to individuals and projects that act in accordance with climate change in sectors of the economy. "Green projects" are the main focus for 2024 within the framework of the preferential credit mechanism of the Entrepreneurship Development Fund (EDF). These projects aim to reduce greenhouse gas emissions in production, develop technologies or promote the use of clean energy. Examples include energy efficiency, renewable energy, waste management, recycling, water conservation, sustainable transport, agriculture and circular economy initiatives.

Entrepreneurs can get concessional loans from SIF for these projects. The private capital investment requirement for "green projects" in the liberated territories and the Nakhchivan Autonomous Republic was reduced from 50% to 30%, and the obligation of joint financing with banks was waived.

The fund provides 10 million manat concessional loans for green projects with 5% interest for up to 10 years. Entrepreneurs in the liberated territories can also take loans from banks and non-bank credit organizations, and business loans of up to 5 million manats with a guarantee of up to 90% of the Fund. The state subsidizes 10% of the annual interest rate of these loans for up to 36 months.

E. Hamidov, Deputy Chairman of the Board of Directors of the Fund, emphasized the importance of turning ideas into concrete plans and comprehensive conceptualization of projects before investment. He noted the need to assess risks, identify opportunities and measure profitability, all of which should be included in the business plan. Extensive market research, understanding of environmental requirements, and ensuring environmental and financial sustainability are essential. Cooperation with environmental organizations and experts can increase the impact and success of the project.

After finalizing the business plan, entrepreneurs should formulate a strategy for managing personal capital and attracting foreign investment. For "green projects" requiring long-term debt, bond issuance and bank loans may be considered. Fund loans offer low interest rates and long grace periods, making them more cost-effective than other business loans. Although the payback period of "green projects" may be longer, it is important to evaluate each project separately. The growing global focus on sustainability is expected to create more opportunities and favorable economic conditions for such projects in the long run. ("Azərbaycanda yaşıl layihələr üçün güzəştli kreditlərin verilməsinə başlanılır," 2024).

Use of Renewable Energy Sources: Azerbaijan implements projects to increase the use of renewable energy sources such as air, solar, and wind energy in areas with strong days. Appropriate laws and normative legal acts have been adopted in order to develop the field of renewable energy in our country, to improve the legislation and institutional environment in this field. In recent years, the works carried out in the field have been continued and the Law No. 339-VIQ dated May 31, 2021 of the Republic of Azerbaijan "On the use of renewable energy sources in the production of electricity", which makes a special contribution to the development of renewable energy, was approved.

In paragraph 5 of the document "Azerbaijan 2030: National Priorities for socio-economic development" approved by the Decree of the President of the Republic of Azerbaijan dated February 2, 2021 ("Clean environment" and "Green growth country") in the direction of climate change and combating it , as well as the issues of application of renewable energy based on the principles of green energy space in all areas of the economy in our country have been reflected. Thus, in accordance with the country's socio-economic development priorities, more attention is being paid to the use of renewable energy sources and the expansion of the application of "green" technologies in the current and future period. Within the framework of the works carried out in this field, camera studies were continued across the country in the direction of identifying and prioritizing areas with the potential of renewable energy sources. National Priorities are also of particular importance in the direction of the implementation of the obligations arising from the UN's "Transformation of our world: Agenda for sustainable development until 2030".(Ministry of Energy of Azerbaijan, 2024).

Afforestation and Expansion (2019): Under this project, 4.5 million trees are planned to be planted in the country in 2020-2022. The vast territory of Azerbaijani forests is on the southern and northeastern slopes of the Greater Caucasus mountain range. These forests start from the territory of Azerbaijan and extend to the border of Dagestan. Forests cover the area in the north-east of Azerbaijan, mainly in the southwest direction from the administrative districts of Gusar, Guba, Devachi, Siyazan and Khizi. In the south-west direction from Khizi region, the forest massif gradually decreases and is replaced by a completely forestless area. On the southern macroslope of the Greater Caucasus, the forest massif is being restored in the area of Shamakhi region, and it stretches to the border of the Republic of Georgia without a break with the mountain slopes. Here, the forests mainly cover the mountainous part of Ismayilli, Gabala, Oguz, Sheki, Gakh, Zagatala and Balakan administrative regions. The forest massif stretches along the southern slope in the western direction towards the territory of Georgia without a break.

The Ministry of Ecology and Natural Resources, taking into account the state of the forest fund in the republic, prepared the draft of the "National Program for the restoration and increase of forests" and submitted it to the Cabinet of Ministers of the Republic of Azerbaijan for approval. On February 18, 2003, the great leader approved the "National Program for the restoration and increase of forests" by a special decree. (Xalq Qəzeti, 2009)

Starting from the spring season of 2003 and including 2008, local institutions have exceeded the plans and forecasts of reforestation and new afforestation works. Thus, during this period, forests were restored and new forests were planted in an area of about 60 thousand hectares. This indicator was 2 times more than in the previous 5 years. In 2003-2008, in the mountainous areas of Talysh and the Caspian coastal plain areas, relict and endemic tree species, chestnut oak, ironwood, freewood, beautiful birch, etc., were planted on 13,600 hectares. forests consisting of genera were planted and degraded forests were restored.

Reducing Natural Gas Emissions (2020): Azerbaijan plans to reduce natural gas emissions by 35 percent by 2030 compared to previous years. In the "Social and Economic Development Strategy of the Republic of Azerbaijan in 2022─2026", numerous measures are planned for the transformation of Azerbaijan into a clean environment and a "green growth country". As mentioned in the document, sustainable and sustainable use of natural resources will be ensured in our country in the coming years, an efficient waste management system will be developed to promote environmentally friendly industrialization. As a result of this,

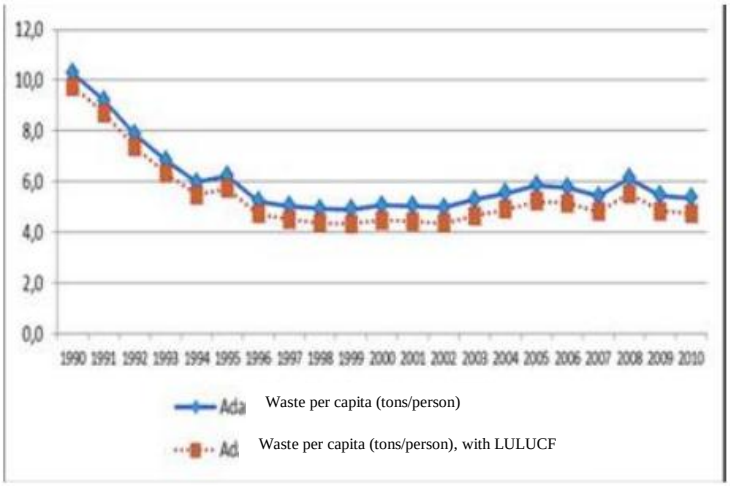
the coverage of the waste recycling process will be increased to 20 percent across the country, and 10 percent in the regions.

At the root of the problem related to climate changes is the Earth's potential to absorb carbon dioxide (CO2) and other heat-producing (greenhouse) gases (methane (CH4), nitrogen oxides, especially NO2, freons and tropospheric ozone). In the last 200 years, especially from 1950 to the present, human activity has led to an increase in the concentration of greenhouse gases. The share of carbon dioxide in the greenhouse effect is 60-64%. In recent years, more than 9 million hectares of forest cover is destroyed every year on our planet. It should be noted that the forest absorbs 20 times more carbon dioxide than a field of the same area.

According to the results of the last inventory of greenhouse gases in the Republic of Azerbaijan, greenhouse gas emissions per capita in 1990, the base year, were 10.4 tons of CO2 equivalent, while in 2010, this indicator was 5.4 tons of CO2 equivalent. This indicator is slightly higher than the global average (4.43 tons of CO2 in 2010) (Figure 3).

Figure 3

Amount of greenhouse gas emissions per capita



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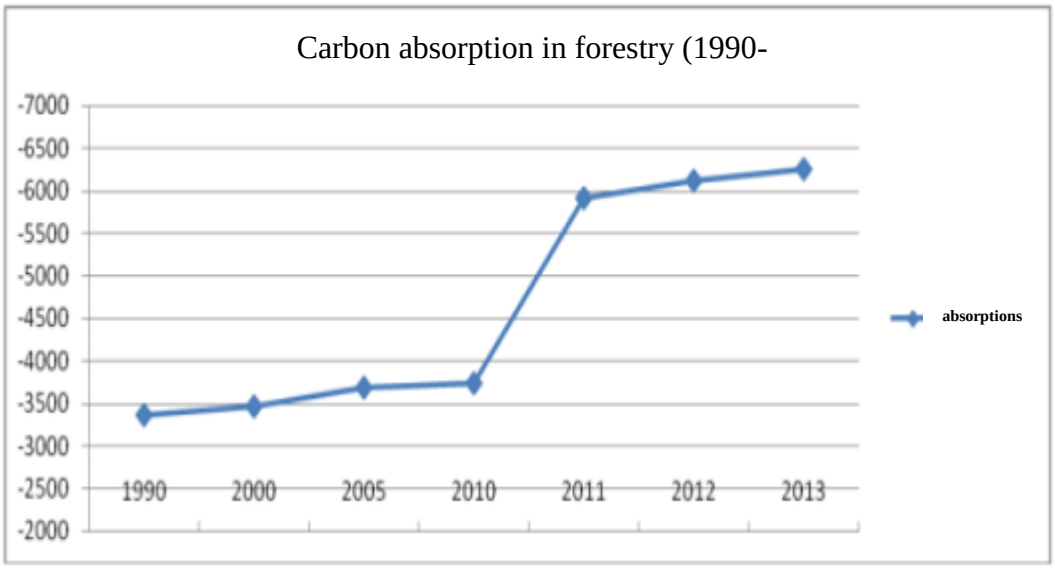
*Source:*Qəribov C. (2021)

Azerbaijan ranks 80th among 159 countries in terms of emissions of gases that create a stylistic effect. Azerbaijan's carbon emission is 47 million tons (Figure 4)

Figure 4. *Changes in GHG absorption by the forest sector in 1990-2013, thousand t, CO2 eq.*



Conclusions

The research has underscored the critical importance of implementing measures to mitigate the negative impacts of climate factors on agriculture, particularly in the context of increasing climate variability and change. Through a comprehensive analysis of various adaptation strategies, this study has highlighted the effectiveness of sustainable land management practices, agroforestry, and water harvesting techniques in enhancing agricultural resilience.

Key findings: Sustainable Land Management, Agroforestry, Water Harvesting and Management, Climate-Resilient Crop Varieties,

Implications for Azerbaijan:

Azerbaijan's proactive measures, including the introduction of concessional loans for green projects and the promotion of educational programs on climate-resilient practices, exemplify effective strategies for enhancing agricultural resilience. The country's focus on sustainable agricultural practices and renewable energy sources supports economic diversification and strengthens rural livelihoods, contributing to overall climate adaptation efforts.

In conclusion, adopting comprehensive and integrated strategies to mitigate the negative effects of climate change on agriculture is essential for ensuring food security and sustainable development. The findings of this research provide valuable insights into effective adaptation measures, while the identified areas for further research offer a roadmap for enhancing agricultural resilience in the face of ongoing and future climate challenges.

Suggestions for Future Research

Future research should focus on the following areas to build on the findings of this study:

1. Long-Term Impacts: Investigate the long-term effects of sustainable land management and agroforestry practices on soil health, water resources, and crop yields under various climate scenarios.
2. Innovative Technologies: Explore the potential of emerging technologies, such as precision agriculture and digital farming tools, to enhance the efficiency and effectiveness of climate adaptation strategies in agriculture.
3. Policy and Institutional Frameworks: Assess the role of policy and institutional frameworks in supporting the adoption of climate-resilient agricultural practices. This includes evaluating the effectiveness of financial incentives, extension services, and regulatory measures in promoting sustainable farming practices.
4. Community-Based Approaches: Examine the impact of community-based approaches to climate adaptation, including participatory planning and local knowledge integration, on the resilience of agricultural systems and rural communities.

Acknowledgements

None

Conflict of Interest

None

References

Here are the references numbered:

[1]. Al-Ain, F., et al. (2016). Water management in horticultural trees: A review. Agricultural Water Management, 171, 1-14. https://doi.org/10.1016/j.agwat.2016.03.015
[2]. Blum, A. (2005). Drought resistance, water-use efficiency, and yield potential—are they compatible, dissonant, or mutually exclusive? Australian Journal of Agricultural Research, 56(11), 1159-1168. https://doi.org/10.1071/AR05069
[3]. Chaves, M. M., et al. (2003). Understanding plant responses to drought—from genes to the whole plant. Functional Plant Biology, 30(3), 239-264. https://doi.org/10.1071/FP02076
[4]. Derpsch, R., et al. (2014). Conservation agriculture. Springer Science & Business Media. https://doi.org/10.1007/978-94-007-7796-6
[5]. FAO. (2015). Agroforestry for landscape restoration: Training and reference manual. Food and Agriculture Organization of the United Nations. https://www.fao.org/3/a-i4940e.pdf
[6]. FAO. (2017). Climate-smart agriculture sourcebook. https://www.fao.org/3/a-i7994e.pdf
[7]. Farooq, M., et al. (2017). Drought stress in grain legumes during reproduction and grain filling. Journal of Agronomy and Crop Science, 203(2), 81-102. https://doi.org/10.1111/jac.12163
[8]. Franzel, S., et al. (2004). Agroforestry for sustainable land-use fundamental research and modelling with emphasis on temperate and Mediterranean applications: Selected papers from a workshop held in Montpellier, France, 23-29 June 2002. https://doi.org/10.1007/978-1-4020-7754-1
[9]. Garrity, D. P., et al. (2010). Evergreen agriculture: A robust approach to sustainable food security in Africa. Food Security, 2(3), 197-214. https://doi.org/10.1007/s12571-010-0070-7
[10]. Gowda, V. R. P., et al. (2011). Root biology and genetic improvement for drought avoidance in rice. Field Crops Research, 122(1), 1-13. https://doi.org/10.1016/j.fcr.2011.02.004
[11]. Gurr, G. M., et al. (2017). Multi-country evidence that crop diversification promotes ecological intensification of agriculture. Nature Plants, 3(10), 17088. https://doi.org/10.1038/nplants.2017.88

[12]. Hobbs, P. R., et al. (2008). Conservation agriculture: What is it and why is it important for future sustainable food production? Journal of Agricultural Science, 146(2), 127-137. https://doi.org/10.1017/S0021859608007699
[13]. Jose, S. (2009). Agroforestry for ecosystem services and environmental benefits: An overview. Agroforestry Systems, 76(1), 1-10. https://doi.org/10.1007/s10457-009-9229-7
[14]. Lal, R. (2015). Restoring soil quality to mitigate soil degradation. Sustainability, 7(5), 5875-5895. https://doi.org/10.3390/su7055875
[15]. Lal, R. (2015). Soil conservation and climate change: soil as a source or sink for greenhouse gases? Springer. https://doi.org/10.1007/978-3-319-19058-2
[16]. Lipper, L., et al. (2014). Climate-smart agriculture for food security. Nature Climate Change, 4(12), 1068-1072. https://doi.org/10.1038/nclimate2437
[17]. Ministry of Energy of Azerbaijan. (2024, March 6). Azerbaycanda bərpa olunan enerji mənbələrindən istifadə. Retrieved from https://minenergy.gov.az/az/alternativ-ve-berpa-olunan-enerji/azerbaycanda-berpa-olunan-enerji-menbelerinden-istifade
[18]. Montagnini, F. (2006). Accumulation and fate of organic matter in tropical agroforestry systems: Biotic, climatic and management effects. Agroforestry Systems, 66(3), 217-236. https://doi.org/10.1007/s10457-005-8843-4
[19]. Montagnini, F. (2016). Agroforestry as a pathway to agricultural modernization in Latin America. Agroforestry Systems, 90(4), 657-678. https://doi.org/10.1007/s10457-016-9885-5
[20]. Montgomery, D. R. (2007). Soil erosion and agricultural sustainability. Proceedings of the National Academy of Sciences, 104(33), 13268-13272. https://doi.org/10.1073/pnas.0611508104
[21]. Nair, P. K. R., et al. (2009). Agroforestry: The future of global land use. Springer Science & Business Media. https://doi.org/10.1007/978-94-007-6226-9
[22]. Paudel, I., et al. (2016). Irrigation techniques in fruit crops: A review. International Journal of Fruit Science, 16 (3), 277-299. https://doi.org/10.1080/15538362.2016.1208352
[23]. Pittelkow, C. M., et al. (2015). Productivity limits and potentials of the principles of conservation agriculture. Nature, 517(7534), 365-368. https://doi.org/10.1038/nature13809
[24]. Poeplau, C., & Don, A. (2015). Carbon sequestration in agricultural soils via cultivation of cover crops – A meta-analysis. Agriculture, Ecosystems & Environment, 200, 33-41. https://doi.org/10.1016/j.agee.2014.10.024
[25]. Prasad, P. V. V., et al. (2008). High temperature tolerance in crops: mechanisms and genetic resources. Crop Science, 48(2), 1-12. https://doi.org/10.2135/cropsci2008.09.0555
[26]. Pruski, F. F., & Nearing, M. A. (2002). Runoff and soil erosion from field plots influenced by rainfall intensity, slope, and soil properties. Water Resources Research, 38(12), 1-10. https://doi.org/10.1029/2001WR000565
[27]. Qəribov, C. (2021). İqlim Dəyişikliyinin Meşələrə Təsirləri və Davamlı Meşə İdarəetməsi, 11-13.
[28]. Renewable News. (2024, March 31). Azerbaycanda yaşıl layihələr üçün güzəştli kreditlərin verilməsinə başlanılır. Retrieved from https://renewables.az/news/azerbaycanda-yasil-layiheler-ucun-guzestli-kreditlerin-verilmesine-baslanilir-2024-03-31-222418
[29]. Rockström, J., et al. (2007). Water for food and nature in drought-prone tropics: Vapour shift in rain-fed agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences, 363(1491), 1973-1986. https://doi.org/10.1098/rstb.2007.2171
[30]. Scherr, S. J., & Garrity, D. P. (2013). Agroforestry: Trees and agroecology for restoring land and livelihoods. In Agroecology (pp. 245-270). Springer, Dordrecht. https://doi.org/10.1007/978-94-007-6456-0_14
[31]. Slafer, G. A., et al. (2005). Genetic improvement of bread wheat yield and associated traits in Argentina. Journal of Agricultural Science, 143(4), 241-252. https://doi.org/10.1017/S0021859605005291
[32]. Stockle, C. O., et al. (2002). Climate change, water availability, and future agricultural production in the Columbia River basin. Water Resources Research, 38(9), 1-9. https://doi.org/10.1029/2001WR000507
[33]. Thornton, P. K., et al. (2018). Climate change impacts on agriculture in 2050 under a range of plausible socioeconomic and emissions scenarios. https://doi.org/10.1016/j.gfs.2017.08.001
[34]. Wani, S. P., et al. (2009). Rainwater harvesting for increasing agricultural production in the semi-arid tropics of Asia. Experimental Agriculture, 45(S1), 167-190. https://doi.org/10.1017/S001447