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Climate change adaptation education as a tool for biodiversity conservation and sustainable agricultural systems

Salih Gökkür[1*]

Republic of Türkiye Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies (TAGEM), Aegean Agricultural Research Institute, İzmir, Türkiye

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Abstract

Adaptation to climate change is a set of measures that need to be implemented to protect biodiversity and especially natural ecosystems and to ensure that greenhouse gases in the atmosphere remain at normal levels. In societies where individual awareness of climate change and nature cannot be achieved, the applicability and impact of adaptation strategies remain limited. Practical training that includes climate- and environmentally friendly behaviors positively impacts climate change awareness. Increasing awareness of the impacts of climate change can lead to success in adapting to it. With this study, it is aimed to contribute to the studies on adaptation to climate change. This article aims to offer suggestions on what can be done to reduce the negative effects of changes in climate parameters that alter the life cycle of all living things on biodiversity and human life. Raising public awareness is crucial for combating the effects of climate change. To prevent the negative impacts of climate change, which is becoming increasingly evident worldwide, countries must make joint decisions and act together. Furthermore, to reduce the negative effects of global warming resulting from climate change and to enable them to take the necessary precautions, comprehensive education programs must be developed and implemented for all individuals.

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Introduction

Climate change refers to long-term changes resulting from the disruption of the natural balance of climate systems worldwide due to human activities. Climate change is associated with an increase in the concentration of greenhouse gases in the atmosphere and the resulting rise in average global temperatures (Kurnaz, 2023). Global climate change is one of the most important environmental and social problems affecting the planet and living things. The presence of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), diazot monoxide (N_2O) and ozone (O_3) in the atmosphere causes the atmosphere to retain more rays from the Sun. This effect causes more heat to rise in the atmosphere and the Earth to warm up more (IPCC, 2023; Akgün and Önder, 2025).

2024 was the warmest year on record for global temperatures dating back to 1850. The global average temperature for 2024 was 15.10°C. This was 0.12°C higher than the previous highest annual value in 2023. Besides 2024 was the first year in which the global average temperature was 1.5°C above pre-industrial levels. Keeping the global average temperature at 1.5°C was the threshold set by the Paris Agreement to significantly reduce the risks and impacts of climate change. Multiple global records were broken for greenhouse gas levels and both air temperature and sea surface

1 Corresponding Author: Agricultural Engineer, MSc., Republic of Türkiye Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies (TAGEM), Aegean Agricultural Research Institute, İzmir, Türkiye, E-mail: salih.gokkur@tarimorman.gov.tr, ORCID No: 0000-0002-0217-0420

temperature, contributing to extreme events such as floods, heat waves and wildfires (Copernicus, 2025). Scientists state that the Earth's temperature has increased enough in the last 50 years to affect human life. If no action is taken, they predict that the Earth's temperature will increase by approximately 2°C by the end of the 21st century. In addition to the increasing warming of the Earth's climate, it is estimated that the average surface temperature of the Earth will increase by 1.4-5.8°C between 1990 and 2100 (Turan, 2014; Kırpık et al., 2022). If global warming is kept below 2°C, only less than 2% of ecological communities worldwide and more than 20% of their component species are expected to experience sudden losses due to climate change. However, this risk increases rapidly as the level of warming increases, threatening 15% of species in the event of a 4°C warming. In addition, it has been determined that these risk levels are similar between protected and unprotected areas (Trisos et al., 2020; Şimşek and Kurtuluş, 2025). These findings indicate that sudden and severe biodiversity losses caused by climate change pose an imminent threat (Şimşek and Kurtuluş, 2025).

The concept of biodiversity refers to a broad field of study and research within the science of biology. In this context, it refers to the diversity of living beings regardless of their origin. It includes terrestrial, marine, oceanic and other aquatic ecosystems, ecosystem communities, intraspecific, interspecific and inter-ecosystem diversity (United Nations, 1992; Kurt, 2017). Prioritizing biodiversity and using ecosystem services that enable people to adapt to the negative effects of climate change can be described as a nature-based solution (Kara and Yereli, 2022). WWF (2020) defines nature-based solutions as ecosystem conservation, management and/or restoration interventions that can reduce the long-term impacts of climate change, manage expected climate risks to nature, have co-benefits for people and biodiversity, and provide measurable positive climate adaptation and/or mitigation (Kaçmaz, 2021). Flooding is the event of areas that would not normally be flooded being submerged due to above-normal flow and level rise in a river. It is an adverse event that occurs depending on the geological conditions, topographical features and existing hydrological and climatic conditions of the regions. Floods are one of the most common types of disasters, usually occurring as a result of excessive runoff from dry lands. Extreme heavy rainfall, rapid melting of snow cover, tsunamis in coastal areas and storms originating from tropical cyclones are among the causes of floods. (Republic of Türkiye Ministry of Forestry and Water Affairs, General Directorate of Water Management, 2017; Süzgenli, 2024). Construction should be avoided in areas with a high risk of flooding. The risk of flooding can be reduced by preserving and increasing green spaces. Afforestation can be carried out, especially on sloping hillsides (Süzgenli, 2024). Ecological benefits provided by nature-based solutions include regulating water flow and cycle, preventing drought, water scarcity, floods and inundations, improving water, soil and air quality, biological treatment, preventing soil loss, reducing disaster risk, protecting and supporting biodiversity, capturing and storing carbon, providing disease and pest control, restoring degraded areas and reducing noise. Nature-based solutions in coastal ecosystems and coastal areas provide protection of coastal ecosystems, reducing coastal floods and inundations, preventing coastal erosion, sequestering and storing carbon, protecting biodiversity and creating recreational opportunities (Coşkun Hepcan, 2022).

Agricultural production is directly affected by changes in climate parameters such as temperature, rainfall and humidity; in other words, by climate change. The increase in summer and winter temperatures in some parts of the world due to climate change will lead to decreases in agricultural production because plants cannot adequately meet their chilling requirements. Breeding programs should be increased to develop drought-resistant varieties with low chilling requirements. In some fruit species, under conditions of extreme cold, defoliation, browning of shoots, freezing of trunks, bark cracking and tree desiccation may occur. Depending on the severity of the cold, this can result in the death of the tree. The increase in temperatures in some northern regions of the world will positively impact agricultural production by creating suitable climatic conditions for the cultivation of new species and varieties. Decreased rainfall will negatively impact yields, leading to a drop in agricultural income. Since flower bud formation in fruits begins the previous year, reduced rainfall affects the yield and quality of the following year. Hail damage, depending on the phenological stage of the affected plant, can cause flower and fruit drop, loss of fruit quality and diseases due to wounds on the plant. Excessive rainfall can cause cracking in some fruit types, diseases in the root zones of plants due to rising groundwater levels and yield reductions due to flower drop (Gökkür, 2019).

Figure 1. Excessive rainfall can result in peel cracking in pomegranate fruit (Original photograph by Gökkür, 2023)

Excessive humidity during the pollination period of some fruit trees prevents pollination by sticking the pollen grains together. Hot and drying winds during this period dry out the stigma, reducing pollination and fruit formation. In some fruit species, the effect of heat decreases in high humidity, but a suitable environment for some diseases is created. Insufficient relative humidity and dry conditions negatively affect flowering and the development of flowers into fruit (Ayaz and Varol, 2015; Gökkür, 2019). It is observed that diseases and pests, which are increasing in many plant species due to climate change, negatively affect the yield and quality of agricultural production (Gökkür, 2019).

The impacts of climate change on agriculture can impact food security and international trade. Because agriculture is an economic activity that not only provides food but also significantly impacts economic balances. For example, reduced production can lead to increased product prices, higher consumer prices, increased imports and decreased exports. Moreover animal production is directly or indirectly affected by climate change. Rising temperatures can disrupt the balance between heat production and utilization in animals. This can lead to decreased pregnancy rates, increased abortions, increased mortality, decreased feed intake, decreased feed conversion, changes in live weight and decreased milk and meat production. Changes in animal production also impact costs (Dellal and McCarl, 2007; Dellal, 2018; Dellal et al., 2020). Moreover the production and distribution of energy are affected by factors such as the depletion of water resources due to climate change. Water-dependent renewable energy sources, such as hydroelectric power plants, are directly impacted by falling water levels. Furthermore, high temperatures increase energy demand and can strain electricity infrastructure (Columbia Climate School, 2022; Keskinden, 2024).

Adaptation means the emergence of a situation that is different from the norm and the ability to adapt to the new situation. Climate change is the unusually frequent changes in climate parameters. In fact, as the definition suggests, climate change calls for adaptation. Because climate change impacts biodiversity, land and marine ecosystems, water resources, the energy sector, agriculture, fisheries, the food sector, the manufacturing industry, transportation, tourism and public health, adaptation activities must be determined separately for each sector or area. Adaptation also means managing risks effectively.

Mitigation and adaptation strategies are widely used in combating climate change. The mitigation strategy is based on directly reducing carbon emissions, which are the main source of climate change; It includes practices such as capturing and storing carbon, reducing energy demand, reducing vehicle demand by providing recreation opportunities in the city and its immediate vicinity and enabling food production in the city and its immediate vicinity (BUSECAP, 2017). Moreover the creation of green areas increases the recreation and tourism potential of regions. It contributes to increasing the level of knowledge and awareness of urban residents and visitors on climate change and biodiversity. Creating blue-green infrastructure components specific to local conditions, including nature-based or hybrid solutions such as rain gardens, green walls, roof gardens, rain ditches, urban orchards, urban parks, gardens, green corridors, stream corridors, flood parks, etc. in urban micro-watersheds increases the climate resilience of urban systems. Designing a system that resembles the functioning of the natural system in micro-watersheds reduces the risk of water and high temperature-related disasters (Coşkun Hepcan, 2022).

Adaptation to climate change has a structure that varies and diversifies according to urban and local conditions and sectors. In order to adapt to the effects of climate change, it is necessary to conduct “impact analysis” studies in the first stage on sectors that may be negatively affected by climate change, such as water resources, agriculture and food security, public health, natural ecosystems and biodiversity, coastal regions. A "vulnerability/risk assessment" should be conducted regarding the potential water shortages, droughts, desertification, increased disasters, decreased agricultural production, deterioration in food security and public health, degradation of terrestrial and marine ecosystems, negative impacts on energy, tourism and fisheries and threats to coastal areas due to sea level rise. Adaptation action planning must be integrated into sectoral development plans at the national, regional and local levels (Talu, 2021).

Although experts have been studying global warming, biodiversity loss, epidemics or infectious diseases and economic and social impacts for years, societal measures to prevent warming remain insufficient. Changes in economic growth, markets, international trade and economic policies resulting from climate change have different consequences for economies depending on their level of development. It is known that less developed countries will be more affected by climate change than other countries and their development and economic growth rates are negatively impacted. It is predicted that if global warming cannot be prevented, societal adaptation will be difficult (Özüşen, 2023).

Objectives

Climate change constitutes one of the greatest challenges facing humanity in the last century (Swim et al., 2011; Özbay and Alcı, 2021). Short-term and long-term effects of climate change may be accompanied by trauma, anxiety, fear, worry and depression (Cianconi et al., 2020; Doherty and Clayton, 2011; Clayton et al., 2017; van der Linden, 2017; Özbay and Alcı, 2021).

Climate change education is related to environmental education, sustainable development education and disaster risk reduction education (Barak, 2018). In order for students to develop behaviors that will help combat climate change, it is primarily necessary to increase their contributions to solving environmental problems. According to Mochizuki and Bryan (2015), climate change education addresses content-based information such as climate, deforestation, habitat loss, water cycle, soil erosion, air pollution and other content-based information, while also addressing environmental concerns such as reducing carbon consumption, promoting low-carbon development, reducing deforestation through sustainable forest management and improving water and waste management, in order to raise students' awareness (Barak, 2018).

Early childhood is considered a critical stage for the permanent establishment of any behavior. Educating children about ecological sustainability, ecosystems, biodiversity and climate change appears to be the most effective way to solve environmental problems (Celiloğlu, 2023). When the literature is considered, it is a fact that young children are the future individuals who will realize the plans and solutions for climate change. They should be given opportunities to realize this change. It's safe to say that if children are provided with the necessary educational environments, they can take positive action against climate change, starting with their immediate surroundings (Duran, 2023). Communicating scientific knowledge to a wide audience, minimizing the impacts of global climate change through cooperation among all segments of society and creating hope that it is not too late to take action are key tasks for future decision-makers in combating global climate change (Yüce Yörük and Varer Akpınar, 2023).

The World Conservation Strategy is a strategy created in 1980 by the International Union for Conservation of Nature, the United Nations Environment Programme and the World Wildlife Fund (WWF). This strategy aims to provide a framework for the conservation and sustainable management of the natural environment on a global scale. The World Conservation Strategy is designed to promote international cooperation and action on environmental protection and sustainable resource management and has developed an ecological approach and strategies primarily focused on the protection of the physical environment (Bozlağan, 2005; Aytaç, 2023).

The strategies outlined within this framework are grouped around four main objectives (Bozlağan, 2005; Aytaç, 2023):

Biodiversity conservation: The strategy emphasizes the importance of conserving biodiversity and proposes various conservation measures to prevent habitat and species loss (Bozlağan, 2005; Aytaç, 2023). Pollinating insects play a crucial role in the functioning of ecosystems, the maintenance of biodiversity and agricultural production. Various practices in industrial agriculture and the excessive use of chemicals are reducing the densities of pollinating insects and bringing many species to the brink of extinction. To protect biodiversity threatened by climate change, it is necessary to create suitable habitats for pollinators in the design of cities and the planning of industrial areas, and to reduce the use of chemical pesticides in agriculture (Demir Özden and Ünver, 2023).

Sustainable management of natural resources: The sustainable use and management of natural resources is a key component of the strategy. This promotes sustainable practices in sectors such as forestry, water management, fisheries and agriculture (Bozlağan, 2005; Aytaç, 2023).

Control of environmental pollution: The strategy proposes controlling pollution and minimizing environmental impacts. It includes measures against water, air and soil pollution (Bozlağan, 2005; Aytaç, 2023). Some agricultural producers who throw pesticide containers into irrigation canals are causing pollution of water and soil resources. To prevent this type of environmental pollution, regulations should be prepared and implemented that include deterrent measures such as the cancellation of agricultural subsidies (Gökkür, personal communication, November 20, 2025).

Sustainable development: The World Conservation Strategy aims to strike a balance between environmental conservation and development. It emphasizes the environmental and social dimensions of sustainable development (Bozlağan, 2005; Aytaç, 2023). In order to achieve sustainable development, attention must be given to the protection of nature in every activity undertaken.

The aim of climate change education is to inform communities about the impacts of climate change, its causes and ways to combat it. Besides the main objectives of climate change adaptation training are to increase the capacity of societies to cope with climate change, to raise knowledge and awareness on this issue, and to determine the activities that will be least affected by the negative effects of climate change. Achieving success in combating climate change requires the development and implementation of adaptation and mitigation strategies. Training programs aimed at combating climate change should be designed using a lifelong learning approach, encompassing all age groups from children to adults. These programs should be tailored to individuals' ages and knowledge levels, aiming to enhance their awareness and understanding.

Teaching Methods on Climate Change

The key actors in delivering climate change education to the public are academics, teachers and trainers. To raise awareness about climate change in society, individuals of all age groups need to receive training at different levels. Educational programs in the field of climate change should include understandable and regularly updated educational materials suitable for all age groups. This approach will increase the effectiveness of adaptation processes to the negative impacts of climate change.

Teachers play a key role in climate change education. Therefore, teachers need to constantly update their knowledge of climate change in light of new scientific developments and recent reports. In particular, teachers need to improve their knowledge of solutions to combat climate change (within the scope of mitigation and adaptation) and develop their pedagogical content knowledge on how to incorporate these solutions into their lessons. For this reason, more emphasis should be placed on solutions to combat climate change in teacher training (Parmak and Karaarslan Semiz, 2024).

Siron, et al. (2021), in their study aiming to identify the perspectives of teachers and pre-service teachers to promote climate change awareness in early childhood education, found that there was no significant difference between teachers and pre-service teachers in terms of climate change awareness. Participants indicated how they would develop children's awareness using media, learning resources, methods, indoor and outdoor play activities and how they would evaluate the learning process to implement climate change awareness in early childhood education (Duran, 2023).

Before explaining the causes and consequences of climate change and answering their questions, children should be taught how nature and ecosystems work and how everything in nature is interconnected, limited and harmonious. We should encourage children to notice and be curious about the natural processes that make life possible. The information and words given should be chosen according to the children's personality traits. For example, it would not be helpful to talk about negative scenarios with an introverted child who may experience anxiety. Be aware of children's developmental stages and consider their emotional and social development characteristics (Anonymous, 2025).

In terms of climate change, the necessary action is to reduce greenhouse gas emissions immediately and to near zero. Since this does not seem possible at the moment, we need to take advantage of adaptation opportunities to cope with the problems that will arise (Kurnaz, 2023).

Educational Approaches and Practices to Improve Climate Change Adaptation for Children

- The primary goal should be to get children to spend time in nature, play, wonder, observe and love nature. Children should be given opportunities to protect and love living things.
- Planting seeds, watering flowers, feeding stray animals and preparing nutritious food for birds with children contributes to raising awareness of ecological responsibility in the fight against climate change through interaction with nature.
- Observing weather, seasons and climate can provide a good foundation for children to understand and become aware of climate change. Instructors should ask them questions like, "What happens in nature in different seasons? How do trees change? What do birds, insects, butterflies and bees do?" during their lessons.

Figure 2. Nature-based observation plays a significant role in enhancing children's understanding of climate change (Original photograph by Gökkür, 2025b).

Talks should be made with children about how they feel when they encounter or have experienced extreme heat waves, hailstorms, or floods. Children should be told that it is normal to feel scared, anxious and sad after such events caused by climate change.

Raising awareness among the public, especially students, about preventing climate change is crucial for a livable world. Therefore, it is important that individuals, society and the state all have responsibilities in preventing climate change and show sensitivity in this regard (Uzun, 2021).

Key Objectives of Climate Change Adaptation Training Targeting All Age Groups

Raising Awareness of Climate Change

In recent years, increasing industrialization, the decrease in forests and green areas, the use of fossil fuels and the increase in environmental pollution have increased global warming (IPCC, 2023; Akgün and Önder, 2025). There is an important relationship between climate change education and environmental education. When the goals of these

disciplines are examined, it is seen that they have common aspects. Therefore, the use of environmental education approaches in climate change education increases the impact of climate change education (Barak, 2018; Darbaş and Yıldırım, 2024). Climate change education has been accepted as an approach that aims to develop students' climate change awareness in primary and secondary schools. Climate change education has an important place in education provided in schools, aiming to improve the education system (Oversby, 2015; Darbaş and Yıldırım, 2024). As can be seen from the conferences organized by the United Nations and the reports they have published in the last 30 years, climate change is the most important environmental issue faced by every individual (Barak, 2018). It is seen that some countries have included climate change education in their curricula upon the call of the United Nations (Barak, 2018; Darbaş and Yıldırım, 2024).

In combating climate change, people's behavioral changes in many areas from water saving to energy consumption, from waste management to reducing unnecessary consumption habits are aimed to be gained with this training and it is designed to direct individuals to search for solutions on issues such as saving energy, gaining low-carbon living habits with less consumption and protecting nature. Consequently, climate change education plays a significant role in raising people's awareness for a sustainable life. Participants should be taught the scientific basis of climate change, its impacts and the resulting problems. Most importantly, past and present perceptions of climate change should be discussed. Awareness training should explain the causes and effects of climate change and why we must act quickly to combat it.

Training content

It should be explained that climate change has diverse impacts at the local, regional and global levels, and that these impacts alter food production and living spaces. To raise awareness, the training should cover the definition of climate change, the relationship between greenhouse gases and climate change, climate parameters, causes of climate change, biodiversity loss caused by global warming, depletion of water resources, effects of climate change, disasters caused by climate change, sea level rise and its effects on coastal areas, negative impacts on food production and future scenarios related to climate change. Participants should also be informed about measures that can be taken to prevent climate change.

Developing Adaptation Strategies

Information can be shared with participants about adaptation strategies they can adopt individually and collectively in response to climate change. For adaptation, topics such as the implementation of new methods in agriculture, water management, energy efficiency and sustainable transportation can be covered in training.

Strategies should be developed to increase resilience and reduce vulnerability to climate change. Growing drought-resistant crops, construct weather-resistant constructing roads, buildings and bridges suitable for changing climate conditions are some examples of efforts that can be made to adapt to climate change (Anonymous, 2025). Furthermore, trees can be used as windbreaks to reduce wind speed around buildings. In winter, reducing wind speeds, especially cold northerly winds, can provide significant energy benefits. Green spaces help offset the formation of urban heat islands by cooling the regional microclimate through shading and evaporation, thus reducing the energy needed to cool buildings during the hot season. Planting trees (more than any other type of vegetation) is the best way to combat urban heat islands because trees have a higher potential to cool the climate and reduce the urban heat island effect and carbon dioxide (CO_2) levels. Municipalities should create a more livable urban environment for all citizens by planting and maintaining city trees (Özkaplan Yörüklü, 2021).

One of the most significant causes of climate change is increasing greenhouse gas emissions. Ecological agriculture practices reduce greenhouse gas emissions, increase soil carbon stores and water retention capacity, and improve crop yield and profitability. This production system takes into account the functioning of the natural cycle between soil, plants, animals and humans. The ecological agriculture philosophy refers to a farming culture described as a "closed system," where inputs are obtained as much as possible from within the farm or its immediate surroundings and the farm ensures its self-sufficiency (Çelik et al., 2017). Ecological farming practices can help mitigate the negative effects of climate change and contribute to the conservation of natural resources.

In agricultural production, the selection of drought-tolerant species and varieties with low water requirements, the implementation of efficient irrigation methods, the use of water harvesting techniques and practices aimed at conserving soil moisture through mulching with plant residues (e.g., leaves) are among the activities considered within the framework of climate change adaptation. In addition the transition to pressurized irrigation systems, aimed at ensuring sustainable agricultural productivity and efficient use of water resources, is among the key measures for adapting to climate change.

Understanding Climate Change through Technology-Based Education

Productivity in the agricultural sector is shaped by many factors, including plant characteristics, soil structure and climatic conditions. Therefore, both short-term weather forecasts and long-term climate data analysis are of great importance in planning agricultural activities. Agricultural decision-makers try to optimize production processes by considering daily and weekly weather forecasts along with long-term climate data. Daily agricultural practices are planned and implemented according to meteorological parameters such as cloud cover, probability and duration of precipitation, wind speed and direction, and minimum and maximum temperature values. These short-term forecasts offer significant advantages to producers in terms of reducing production costs and preventing potential crop losses. Weekly forecasts are particularly helpful in creating agricultural work programs for 5 to 7 days (Uslu et al., 2025).

Satellite imaging systems, supported by artificial intelligence (AI)-based sensor technologies, enable early detection of diseases and pests, optimize pesticide use in agriculture and slow down the rate of soil and water pollution. This training should provide information on technologies used to combat climate change. For instance smart agriculture techniques, vertical farming and hydroponic systems, projections on climate change should be explained.

***Virtual training games and simulations*:** Participants are expected to develop solutions for various climate change scenarios in virtual environments. Educational games and seminars will facilitate understanding of topics such as virtual modeling in agricultural production planning and combating the negative impacts of climate change.

Pre-Developed Projects for Climate Change Adaptation: In the fight against climate change, tools such as life cycle assessment, environmental product declaration and carbon footprint are crucial for businesses. These tools allow businesses to measure and report their activities that contribute to climate change (Fet and Knudson, 2021; Keskinden, 2024). In particular, the carbon footprint helps businesses reduce their impact on climate change by tracking greenhouse gas emissions generated in their production processes. In the fight against climate change, it is critical that businesses not only fulfill legal obligations but also assume environmental responsibilities for the future (Keskinden, 2024). Participants should be informed about projects related to climate change. Fieldwork can be conducted by visiting project-supporting institutions and organizations and observations can be made during some projects.

The training content includes environmentally friendly agricultural technologies (such as solar energy), water management, irrigation systems and water use efficiency. Farmers and businesses using modern irrigation systems should be visited. Photovoltaic and agrivoltaic systems should also be introduced through presentations.

Risk Management and Crisis Preparedness

***Disaster preparedness*:** Disaster risks have a significant impact on sustainable development and can lead to negative effects on lives and livelihoods (Tazegül Bekci and Şahinöz, 2024). The risks of recurrence of disasters encountered in the past, such as drought, floods, storms, hail and strong winds, should be identified and adaptation strategies should be developed to adapt to disasters. Training should be provided on how to prepare for natural disasters (floods, droughts, hail, storms, etc.) and other climate-related crises.

To be prepared for floods caused by excessive rainfall, some of the adaptation activities that need to be taken include creating flood risk maps and developing early flood warning systems and establishing safe housing areas in surrounding regions for emergencies (Talu, 2021). Increasing forest and tree cover contributes to disaster risk reduction. Forests play a critical role in combating climate change because they capture carbon dioxide. Since the carbon dioxide captured by trees will be released into the atmosphere during a fire, measures must be taken to prevent forest fires.

Building disaster resilience, especially in addressing climate-related risks requires cooperation among local, national and international stakeholders to achieve successful outcomes. Action is needed to prevent new risks from climate change, reduce existing vulnerabilities and achieve the goals of the Sendai Framework, the Paris Agreement and the Sustainable Development Goals (Tazegül Bekci and Şahinöz, 2024). Training can be provided on the importance of early warning systems and crisis management for emergencies that may arise from climate change.

To Offer Suggestions for Ensuring the Sustainability of Life

Nature-based solutions make significant contributions to mitigating the negative impacts of climate change through the conservation, restoration and sustainable management of ecosystems. Nature is, in many cases, the most effective insurance policy. Nature-based solutions offer opportunities to restore cities' broken relationship with nature. Natural ecosystems are living systems and are constantly under the influence of changing climatic and environmental conditions. These impacts, of varying severity, lead to disruptions and changes in ecosystems. Natural systems are designed to survive and have the ability to heal (repair) themselves when damaged. This ability provides resistance/resilience to the effects that cause disruption in natural systems. The ability of natural systems to heal and repair themselves is of great importance in the face of increasing problems with climate change. Nature-based solutions can be natural (natural ecosystems), semi-natural (hybrid solutions - swales, semi-natural stream corridors, coastal embankments, etc.) or human-created cultural solutions (roof gardens, green walls, etc.) (Coşkun Hepcan, 2022). Green belts should be created in urban areas. Bringing biodiversity to urban and industrial areas with green roofs, balconies and gardens will reduce the negative effects of heat islands in cities.

Low carbon footprint: Participants should be trained on reducing carbon emissions, making energy consumption more efficient, recycling and using renewable energy. It is important to properly inform people about carbon taxes in order to achieve social consensus in the fight against climate change. Additional taxes and trade restrictions can be imposed on companies that emit excessive amounts of carbon.

Raising awareness about the importance of investing in the green economy: Dependence on the use of fossil fuels has made the green transformation in energy a necessity. In industrialized cities, the use of green energy shapes sustainability policies due to its environmental and economic benefits. The use of green energy supports sustainable practices by reducing carbon emissions (Wang, 2021; Keskinden, 2024). Furthermore green roofs and walls reduce energy consumption in buildings, thus reducing the urban heat island effect. They also contribute to energy efficiency by reducing energy consumption in the summer months. In winter months, they can reduce heating costs by increasing building insulation (Campiotti et al., 2013; Keskinden, 2024). Information can be provided about green employment opportunities, environmentally friendly initiatives and projects.

Providing Information on Policies and Legal Frameworks

Deficiencies in legal and administrative regulations to combat climate change should be addressed. In addition The media, identified as a player as influential as local governments in the implementation of climate change policies, should assume greater responsibility for raising public awareness (Albayrak and Atasayan, 2017). Participants should be informed about national and international climate change agreements, such as the Paris Agreement and their impacts on social and economic life. Additionally, information can be provided regarding strategies developed by municipalities and local authorities to mitigate and adapt to climate change.

Awareness

People can be informed about actions they can take to combat climate change. Climate change education for younger generations can help them adopt conscious climate change behaviors. Maviş Demircioğlu (2019) aimed to determine the impact of a climate change program implemented with 5-year-old children in early childhood on their views of the concept of climate change. The experimental group was observed to give correct answers after the program when defining climate, explaining that climate is changing and addressing the situations that could affect them. They stated that climate change could harm living things, cause drought and cause sea levels to rise due to melting glaciers. Their solutions included using water and electricity economically, using A+ energy, generating cleaner energy through the

construction of solar panels and wind turbines and using public transportation. After the program, the children in the experimental group developed ideas about climate change, while no improvement was observed in the control group (Duran, 2023).

With climate change education, it should be aimed for children to realize the importance of the balance of production and consumption in daily life, to have knowledge for a sustainable life, to learn by observing life cycles and to follow nature conservation efforts. Knowing and connecting with nature means loving nature and loving nature means caring for it. Therefore, processes that strengthen children's connection to nature should be prioritized in education (Anonymous, 2025).

Global climate change concern levels are related to the level of knowledge and awareness about this issue. From this perspective, it is necessary to increase the number of courses on global climate change and global warming in pre-university educational institutions and universities, and to give more space to content, programs, publications, documentaries, films, etc. related to this issue in the media (Semenderoğlu et al., 2024).

Evaluation and Monitoring in Education

At the end of the trainings, surveys should be conducted to understand how much the participants have internalized what they have learned. In climate change adaptation training, incorporating practical and on-site observations alongside theoretical knowledge will increase the effectiveness of these trainings.

The Importance of Collaborations in Combating the Negative Impacts of Climate Change

Climate change adaptation training is crucial for raising public awareness and developing effective strategies. For these trainings to be successful, raising participants' awareness based on local conditions and needs can make a significant difference. What's more collaboration between the public, private sector and civil society can develop joint solutions to address the negative impacts of climate change. International collaborative efforts on climate change adaptation can be encouraged.

Approaches to Mitigating the Negative Impacts of Climate Change

Renewable energy sources are presented as alternatives to fossil fuels. Energy sources such as solar energy, wind, hydroelectric, hydrogen, geothermal, biomass and current energy are renewable energy sources. Renewable energy sources are those that can mostly be obtained from nature without undergoing any production or transformation stages or processing, are not fossil-based, produce low CO_2 emissions when generating electricity, have less environmental damage than other energy sources, are constantly renewed and exist in nature ready for use (Seydioğulları, 2013; Gedik et al., 2024). Climate change not only affects living organisms and the sustainability of life, but also causes economic, social and political impacts, shaping international policies. Since reducing greenhouse gas emissions, which cause climate change, also affects countries' production activities, climate change is also a development issue. Therefore, countries must transform their policies in a way that enables them to develop without harming the environment (Dellal et al., 2015; Dellal et al., 2020).

The decreases in agricultural products increase the prices of processed food, causing the general price level to rise and thus inflationary pressure. The high share of food products in total consumer expenditures in developing countries causes consumer inflation in these countries to increase more rapidly compared to developed countries. This situation makes it difficult for the monetary authorities to control inflation in many countries (Başkaya et al., 2008; Başoğlu, 2014). In order to mitigate the impacts of climate change, changes need to be made in our energy and food production systems and renewable energy sources need to become widespread (Anonymous, 2025).

Turning off lights and unplugging electronic devices when not needed helps reduce energy consumption. By repairing, reusing, or repurposing clothing in different ways, individuals can develop habits that conserve natural resources. Choosing cloth bags instead of using plastic bags can reduce plastic use. Furthermore, individuals determining the amount of waste they produce and taking measures to reduce it is important for environmental protection. In addition, reducing carbon dioxide emissions and protecting nature's carbon cycle have become a necessity in the fight against climate change (Anonymous, 2025). The causes of the climate crisis are not limited to

consumption habits and individual carbon emissions. Perhaps most importantly, it is necessary to examine historical production methods and energy source preferences (Ünsal, 2024). Countries should prepare their plans regarding energy resources by keeping economic priorities in the background and considering ecology and the environment (Gökkür and Şahin, 2015). In industry and transportation, the use of technologies that reduce carbon emissions should be disseminated. Incentives for the use of electric vehicles instead of all fossil fuel-powered vehicles should be increased.

When droughts or excessive rainfall occur frequently and intensely, crop losses increase. These changes in production volume affect costs (Dellal and McCarl 2007, Dellal 2018; Dellal et al., 2020). Drought-resistant crop varieties should be determined (Yalçın and Kara, 2014; Koç et al., 2016; Koç and Uzmay, 2016; Gökkür and Uysal, 2020; Hazar Kalonya, 2022).

Changes in temperature can affect the timing and duration of snowfall, thereby reducing the availability of water needed during the summer months. Groundwater availability is also negatively impacted by rising temperatures. Additionally, non-agricultural water demand in residential areas or certain industrial sectors can increase with rising temperatures. Consequently, intersectoral competition for water use can emerge (Dellal and McCarl, 2007; Dellal, 2018; Dellal et al., 2020).

Efficient irrigation systems such as drip irrigation should be widespread and water should be applied directly to the roots of the plants. Drought-resistant crops that require less water should be cultivated. Soil conservation practices should be implemented in agriculture to reduce water evaporation and conserve soil moisture. The reuse of water from other sources, such as rainwater, should be encouraged (Şalvarlı, 2023). Additionally, rainwater and vegetable washing water can be collected and used to irrigate plants (Anonymous, 2025). Water meters should be installed so that farmers can monitor their water usage and make adjustments for water conservation. Water-saving technologies such as water sensors should be used (Şalvarlı, 2023).

While comparing rainfall and temperature data on a monthly basis can be helpful in field studies to determine plant water requirements for that year, it may not always yield accurate results in climate change projections. Monthly and annual rainfall values should be evaluated both according to the water year and annually according to the January-December period and assessments should be made regarding the status of groundwater resources (Gökkür, personal communication, November 20, 2025).

Irrigation water requirements vary depending on the plant species and varieties. Where possible, the optimum amount of irrigation water should be given according to the needs of the variety (Gökkür, personal communication, November 20, 2025). Efforts to protect water resources by preventing over-irrigation, raising awareness among rural producers and implementing sanctions should be improved (Yalçın and Kara, 2014; Koç et al., 2016; Koç and Uzmay, 2016; Gökkür and Uysal, 2020; Hazar Kalonya, 2022).

Food production should be carried out by taking measures to protect water and soil resources. It is important to reduce the use of chemical fertilizers and pesticides, use water resources efficiently in agricultural production through optimal irrigation, reduce plant waste generated during production and use this waste as fertilizer.

Studies should be carried out to prevent excessive use of chemical fertilizers by growers (Yalçın and Kara, 2014; Koç et al., 2016; Koç and Uzmay, 2016; Gökkür and Uysal, 2020; Hazar Kalonya, 2022).

Depending on the nature of the wastewater, pre-treatment or advanced biological treatment facilities should be established or Urban Wastewater Treatment Facilities should be constructed. Moreover legislation should be prepared to prevent marine litter such as fishing nets, fishing lines, etc. and to collect existing litter. In order to reduce marine litter at its source, rehabilitation activities should be planned to reduce litter in rivers. Separate system applications for rainwater and urban wastewater should be implemented. National monitoring systems and programs should be developed in all seas for important habitats and special species that ensure the continuity of marine and coastal biodiversity. Besides, pesticide/packaging waste should be evaluated within the scope of hazardous waste management and legislation. The Environmental Impact Assessment process should be carried out in accordance with the ecosystem approach (Eyüboğlu et al., 2022).

Legal regulations regarding the increase of pasture areas and the improvement of existing areas should be updated every year to take production planning into account (Yalçın and Kara, 2014; Koç et al., 2016; Koç and Uzmay, 2016; Gökkür and Uysal, 2020; Hazar Kalonya, 2022).

Efforts to provide agricultural credit and insurance opportunities to rural producers in drought-affected regions should be increased (Yalçın and Kara, 2014; Koç et al., 2016; Koç and Uzmay, 2016; Gökkür and Uysal, 2020; Hazar Kalonya, 2022).

Climate change must be taken into account in the preparation of agricultural policies and the updating of relevant legislation (Yalçın and Kara, 2014; Koç et al., 2016; Koç and Uzmay, 2016; Gökkür and Uysal, 2020; Hazar Kalonya, 2022).

Legal regulations should be updated and prepared every year to encourage the use of renewable energy sources in the agricultural sector (Yalçın and Kara, 2014; Koç et al., 2016; Koç and Uzmay, 2016; Gökkür and Uysal, 2020; Hazar Kalonya, 2022). Indeed, although renewable energies have a great potential to reduce the destructive effects of fossil fuels on the environment, the possibility of such energy conversion processes having negative effects on ecosystems should not be ignored. Therefore, it is very important to act in accordance with ecological principles in the design and implementation of renewable energy projects. While large-scale adoption of renewable energy offers the potential to reduce greenhouse gas emissions and increase resource efficiency, it may run the risk of conflicting with biodiversity conservation and the sustainability of ecosystem services. However, spatial planning can help identify areas where such infrastructure will cause as little harm to biodiversity as possible. Ecosystems are undergoing rapid transformation in response not only to temperature changes, but also to climate change and other drivers of global change, such as changes in precipitation regimes, increases in atmospheric carbon dioxide levels, disruptions in the water cycle, differences in ocean chemistry and increases in the frequency and intensity of extreme weather events. The complex dynamics between environmental degradation and other stressors diversify the sensitivity of ecosystems to climate change and their responses to these changes. In this respect, it is critical that the development and implementation of renewable energy policies are not limited to technical solutions that only aim at emission reductions, but include holistic approaches that also center on the protection of ecosystems (Şimşek and Kurtuluş, 2025). Consequently, investments in renewable energy sources such as solar, wind, hydroelectricity and biomass energy, which utilizes waste, should be increased instead of fossil fuels. Activities should be undertaken to expand the use of public transportation.

It should be ensured that female and male producers in rural areas receive the same wages (Yalçın and Kara, 2014; Koç et al., 2016; Koç and Uzmay, 2016; Gökkür and Uysal, 2020; Hazar Kalonya, 2022).

Closely monitoring current developments related to climate change is of great importance, both for updating scientific research and for developing effective strategies to address it (Anonymous, 2025).

According to McKeown and Hopkins (2010), climate change education programs should focus on lifelong learning and include not only elementary and middle school students but also individuals of all ages (Barak, 2018).

Conclusion

Significant increases in temperatures, decreases in rainfall and groundwater resources, reduced yields of some agricultural products, increased forest fires, severe and unexpected rainfall, tornadoes, biodiversity loss, deaths in some parts of the world due to heat waves, increased energy demand and consumption due to the increased need for cooling systems, some diseases transmitted from animals to humans, increased water demand for agriculture and domestic use, rising sea levels threatening groundwater resources in coastal areas with saltwater intrusion, decreased soil moisture due to increased evaporation, decreased snowfall, economic hardship for people working in sectors such as agriculture, livestock farming and fisheries due to unusuall changes in farming practices caused by changing climate parameters are among the negative impacts of climate change in recent years. Declines in agricultural yields due to climate change can lead to excessive price increases in some agricultural products. These yield losses negatively affect the supply processes of industrial facilities that use these products as raw materials, causing raw material shortages. Furthermore, as climate change makes it increasingly difficult to cultivate some agricultural crops, the cultivation of alternative crops in their

place will become necessary in the future. Besides, the yield losses caused by climate change in agricultural production, resulting in price increases for some staple products, increase the risk of malnutrition in certain segments of society, negatively impacting public health and food security. To ensure that products with a high export share can be offered to consumers at affordable prices in the domestic market of the countries where they are produced, the necessary regulations must be implemented. Furthermore, in order to mitigate the effects of climate change on agricultural production and ensure supply security, it is crucial to conduct scientific and policy studies aimed at identifying and evaluating substitute products. Besides, reducing food waste and fighting obesity can have a significant impact on mitigating the negative effects of climate change.

To ensure sustainability in agriculture by adapting to climate change, it is necessary to develop crop varieties with low chilling requirements, high tolerance to extreme heat and cold and resistance to diseases and pests that may emerge following excessive rainfall. In addition, to monitor the effects of climate change on agricultural production and to develop effective strategies for disease and pest control, phenological monitoring needs to be implemented. Disease and pest control programs based on phenological monitoring should be updated annually.

By adding new rings to the value chains of all products or objects produced, such as reduction, reuse (including for different purposes) and recycling, we can contribute to the sustainability of the circular economy. In addition, when we reduce the amount of consumption of all products produced, use them for different purposes or recycle them, the circular economy can slow down the rate of extinction of the world's biodiversity.

Reducing tillage in agriculture will help slow the rate of increase in atmospheric CO_2 and protect soil structure and biodiversity. Besides to mitigate the negative effects of air pollution on human health, it is crucial to increase afforestation efforts, promote energy-efficient systems and effective filtration technologies in cities and industrial facilities, encourage green roof applications and implement pollinator-focused practices that strengthen urban-nature interaction and increase biodiversity.

The most effective way to solve the increasing energy demand is energy saving. Temperature changes and population growth in some parts of the world can cause differences in energy supply. By spreading the use of energy saving devices around the world, the world's total energy consumption can be kept at certain levels. In addition, renewable energy facilities should be located in areas where biodiversity will not be harmed.

In order to assess the impacts of climate change in a more comprehensive and accurate manner, it is necessary to develop scientific projections that take into account humidity, evaporation and temperature variables. Plant water consumption should be determined not only by the amount of evaporation, but also by the age of the plant, its growth vigor and soil structure. Moreover, to ensure the sustainability of groundwater resources, effective measures should be taken to prevent the drilling of unauthorized groundwater wells and the widespread adoption of technologies and practices that enhance water conservation in all sectors, especially agriculture, should be encouraged. In order to protect our water and soil resources, the use of pressurized irrigation systems should be expanded in agricultural lands suitable for irrigation.

Projects are being prepared and studies are being carried out all over the world to combat the effects of climate change. On the days when these projects will be announced around the world, 100 trees should be planted symbolically for each project (planting trees sequester carbon dioxide, increases biodiversity and help protect soil and water resources). In the meetings of awareness-raising and adaptation projects related to climate change, practices or activities regarding combating climate change should be included.

To prevent the negative impacts of climate change, mitigation and adaptation policies at national and international levels should be determined in line with the sustainable development goals. Preparing digital content, videos, brochures, books, meetings, workshops and seminars on the impacts of climate change and adaptation will help increase the positive impact of education. Developing a holistic approach to training that embraces all sectors and establishing standardization for climate change adaptation efforts will positively impact the sustainability of life worldwide. Furthermore developing sector-specific and disaster-specific training will also ensure success in combating climate change.

Recommendations

Wetlands, agricultural lands and forested areas must be protected from practices that could disrupt the ecological balance, such as urbanization. Similarly, coastal areas hosting settlements, tourism regions, ports and transportation infrastructure need to have their resilience increased against rising sea levels and extreme weather events such as storms and tornadoes.

Increasing the number of green buildings that integrate biodiversity into urban life in both urban and rural areas, implementing ecological restoration efforts in all areas with ecological remnants and expanding green spaces in cities are fundamental elements of sustainable urban planning. Furthermore, preventing the establishment of industrial facilities in areas close to agricultural lands will provide long-term environmental benefits.

Improving awareness of the importance of conserving and enhancing biodiversity through increased educational activities, developing and implementing sustainable policies for the protection of agricultural lands and expanding afforestation activities to increase carbon sequestration as part of the fight against climate change are of great importance. Furthermore, to effectively combat natural disasters, it is necessary to prepare agreements that will strengthen international cooperation among countries.

Slowing the rate of depletion of water resources through water resource management necessitates meeting the water needs of different sectors in a balanced and sustainable manner. In this context, the need for drinking and domestic water, the ecosystem water requirements necessary for the continuation of biodiversity, the need for agricultural irrigation water and the water demands of the industrial, energy and tourism sectors should be addressed with a holistic approach. Promoting water conservation, effectively controlling groundwater wells and renewing irrigation networks that cause excessive water consumption or have reached the end of their economic lifespan are of great importance. Furthermore, transitioning to modern irrigation systems that allow for less water consumption will increase water efficiency.

To mitigate negative impacts such as increased flooding and soil erosion, infrastructure (drainage) projects for rainwater harvesting and utilization need to be widespread in all regions of the country. The development of technologies for the treatment and reuse of rainwater should be supported. In addition, ensuring the efficient use of wastewater in urban landscape areas and other sectors and making rainwater storage facilities mandatory in the construction of new landscape areas, are critically important for sustainable water management. Activities aimed at conserving water resources need to be diversified and expanded in scope. In this context, it is crucial that education and dissemination efforts are carried out in a planned and continuous manner to encourage the adoption of water-saving methods across all sectors.

To enable farmers to continue their activities in the agricultural sector and overcome the economic problems they face, reducing the negative impacts of climate change on agricultural production is of great importance. Implementing policies and practices aimed at the more optimal use of agricultural inputs that increase production costs is necessary to protect farmers' income levels.

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