ECOLOGICAL CHALLENGES AND CLIMATE CHANGE IN TÜRKİYE: RISKS, SUSTAINABLE DEVELOPMENT AND ADAPTATION STRATEGIES

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Abstract: This article examines the principal environmental challenges facing Türkiye in the context of climate change and considers policy options for strengthening ecological security and sustainable development. Based on a qualitative review of international assessments and national climate policy documents, the study analyses water stress, drought, extreme heat, wildfires, floods, coastal risks, biodiversity loss and greenhouse-gas emissions. It discusses the relationship between climate vulnerability and economic sectors, particularly energy, agriculture, urban infrastructure and tourism. The analysis highlights the importance of combining mitigation measures with adaptation planning, including renewable energy, energy efficiency, integrated water management, climate-resilient agriculture, early-warning systems and nature-based solutions. Türkiye's 2024–2030 climate mitigation and adaptation plans provide an institutional framework, while implementation depends on coordination among national and local authorities, businesses and communities. The article concludes that an integrated, evidence-based approach can reduce climate risks while supporting economic resilience and a fair green transition.

Keywords: Türkiye, climate change, environmental protection, ecological security, drought, water stress, wildfires, renewable energy, adaptation, sustainable development, green transition.

Climate change has become a major environmental and development challenge for countries across the Mediterranean region. Türkiye's geographical position, varied topography, long coastlines and concentration of population and economic activity in urban and coastal areas create a complex pattern of climate exposure. Rising temperatures, changing precipitation patterns and the growing likelihood of extreme events can intensify pressure on water resources, agriculture, ecosystems, public health and infrastructure. The World Bank's Country Climate and Development Report identifies Türkiye as vulnerable to climate-related hazards and emphasizes the importance of combining adaptation and resilience with the transition to a lower-emission economy [1].

Climate change is not only an environmental issue; it is also a question of economic stability, social welfare and regional development. Drought can reduce agricultural output and raise irrigation costs, while extreme heat increases health risks and energy demand. Forest fires threaten settlements, tourism assets and biodiversity; intense rainfall may cause flash floods and damage transport and urban infrastructure. These risks interact with existing pressures such as land-use change, urban expansion, pollution and unsustainable water consumption. The Intergovernmental Panel on Climate Change (IPCC) identifies increasing heat and drought risks as major concerns for the Mediterranean region [2].

Türkiye has announced a long-term objective of reaching net-zero greenhouse-gas emissions by 2053 and has developed climate mitigation and adaptation policy frameworks. Its 2024–2030 Climate Change Mitigation Strategy and Action Plan and Climate Change Adaptation Strategy and Action Plan provide a basis for action across key sectors [3]. Nevertheless, policy goals require effective implementation, reliable monitoring, financing and coordination between national

and local institutions. The purpose of this article is to examine the main ecological challenges associated with climate change in Türkiye, assess their implications for sustainable development and identify practical priorities for mitigation and adaptation.

International climate research increasingly treats climate change as a risk multiplier that can aggravate existing environmental and socioeconomic vulnerabilities. The IPCC's Sixth Assessment Report explains that the Mediterranean basin is exposed to increasing heat, water scarcity, drought, coastal hazards and ecosystem stress. These effects vary across locations, making regional and sector-specific adaptation essential [2]. In this context, the resilience of water systems, agriculture, cities and natural ecosystems is closely linked to governance quality and the ability to anticipate and manage risk.

The World Bank's Türkiye Country Climate and Development Report links climate action to economic development and identifies energy, transport, buildings, industry, agriculture and land use as important areas for transition. The report argues that climate resilience should be integrated into public investment, land-use planning, water management and disaster-risk financing. It also identifies opportunities associated with renewable energy and energy efficiency, while emphasizing the need to manage the social effects of the green transition [1].

Türkiye's official climate policy documents provide a national framework for both emission reduction and adaptation. The 2024–2030 mitigation plan covers major emitting sectors, while the adaptation plan addresses sectoral and cross-cutting vulnerabilities [3]. These documents suggest that environmental policy must go beyond isolated projects: it should connect energy planning, agriculture, water management, urban development, ecosystem conservation and public awareness. A key issue for further analysis is how national targets can be translated into measurable actions at provincial and municipal levels.

The literature therefore supports an integrated approach built around three mutually reinforcing directions: reducing greenhouse-gas emissions, adapting infrastructure and livelihoods to unavoidable climate impacts, and protecting natural systems that provide ecosystem services. This article uses those directions as an analytical framework for examining Türkiye's ecological challenges.

The study applies a qualitative desk-research design. It draws on secondary sources, including the World Bank's Country Climate and Development Report for Türkiye, IPCC assessment material on the Mediterranean region, and official Turkish climate strategy and action-plan documents [1–3]. The sources were selected for institutional authority, relevance to the research question and coverage of climate risks and policy responses.

Three complementary methods were used. First, document analysis was applied to identify recurring climate hazards, affected sectors and stated policy priorities. Second, comparative synthesis was used to connect physical risks—such as drought, heat, wildfire and flooding—with potential environmental, economic and social consequences. Third, a policy-oriented analytical framework was developed to group proposed responses into mitigation, adaptation and ecosystem protection. The article is conceptual and based on secondary sources; it does not claim to provide new field measurements or an original statistical estimate. Its conclusions should therefore be interpreted as a structured synthesis rather than as the results of primary empirical testing.

Water stress is one of the central risks because changes in precipitation and rising temperatures can increase evaporation and intensify competition among households, agriculture, industry and ecosystems. Water scarcity is especially consequential where irrigation demand is high or where urban growth increases pressure on supply systems. Sustainable water management requires better measurement of withdrawals, reduction of leakage, reuse of treated wastewater where appropriate, efficient irrigation and protection of watersheds. Water policy

should also account for environmental flows so that short-term demand does not undermine river and wetland ecosystems.

Drought and extreme heat can affect crop productivity, livestock welfare, soil quality and food prices. Farmers may face higher irrigation costs and uncertainty about planting dates, while heat stress can reduce labour productivity and create health risks for outdoor workers. Adaptation measures include drought-tolerant crop varieties, soil-moisture conservation, crop diversification, improved agricultural advisory services and climate information tailored to local conditions. Such measures should be designed with farmers and should avoid transferring adaptation costs disproportionately to small producers.

Wildfires are another serious ecological and economic concern. Hotter and drier conditions can contribute to fire-conducive environments, although ignition sources, land management and settlement patterns also influence fire outcomes. Fires damage forests, biodiversity, soils, tourism infrastructure and nearby communities. Prevention therefore requires fuel and landscape management, careful development controls in fire-prone areas, public education, early detection and coordinated emergency response. Restoration should prioritize suitable native species and ecosystem recovery rather than relying solely on rapid tree planting.

Flooding and intense rainfall can threaten settlements, roads, industrial areas and coastal infrastructure. Urban surfaces that prevent water infiltration, construction in floodplains and inadequate drainage can increase damage. Risk reduction calls for updated hazard maps, resilient drainage systems, protection and restoration of wetlands, river-corridor planning and warning systems that reach vulnerable groups. Coastal areas also need to consider sea-level rise, erosion and the combined effects of storms and development pressure.

Climate change interacts with biodiversity loss and pollution. Habitat fragmentation, excessive water extraction, waste and marine pollution can reduce the capacity of ecosystems to withstand climatic stress. Protected areas, ecological

corridors, wetland conservation, sustainable forestry and responsible coastal planning can strengthen ecosystem resilience. Nature-based solutions should complement, rather than replace, necessary infrastructure and emission-reduction measures.

Table 1.

Main climate-related ecological risks and possible responses in Türkiye

Risk area	Potential consequences	Priority responses
Water stress and drought	Pressure on drinking water, irrigation, ecosystems and food production	Integrated water planning; efficient irrigation; leakage reduction; wastewater reuse
Extreme heat	Health impacts, higher cooling demand and reduced outdoor labour productivity	Heat-health plans; urban shade and green space; building efficiency; public warnings
Wildfires	Forest and biodiversity loss, damage to settlements and tourism	Prevention, early detection, landscape management and coordinated emergency response
Floods and coastal hazards	Damage to homes, roads, infrastructure and coastal ecosystems	Risk mapping, drainage, floodplain protection and nature-based coastal measures
Emissions and air pollution	Contribution to warming and adverse health effects	Renewables, energy efficiency, cleaner transport and industrial decarbonisation

Mitigation is necessary to limit future climate change and can also generate local benefits. The World Bank identifies the energy sector—including power generation, transport, buildings and industry—as a major contributor to Türkiye's greenhouse-gas emissions [1]. Expanding solar and wind energy, improving energy efficiency, electrifying suitable end uses and modernizing electricity networks can reduce emissions and exposure to imported fossil fuels. However, the transition must be planned to maintain energy reliability, affordability and access. Buildings offer opportunities through insulation, efficient heating and cooling, improved standards and retrofits. In transport, public transit, rail, walking and cycling infrastructure, efficient logistics and electrification can reduce emissions while improving urban air quality. Industrial decarbonisation requires process efficiency,

cleaner energy, material efficiency and, where feasible, circular-economy practices. Waste prevention, recycling, methane management and improved wastewater treatment can also contribute. Policies are most effective when supported by transparent data, predictable regulation, investment and skills development.

Türkiye's net-zero objective for 2053 establishes a long-term direction, but the credibility of the transition depends on near-term implementation. National targets should be translated into sector-specific milestones and reviewed against measurable indicators. Public procurement, financial incentives and climate-related disclosure can encourage private investment, while social protection and retraining can support workers and regions affected by structural change [1, 3]. Adaptation should be risk-based and locally tailored. A province exposed to drought may prioritize water demand management and agricultural resilience, while a coastal municipality may focus on flood protection, drainage and land-use controls. Local climate action plans can translate national objectives into practical investment programmes, identify responsible institutions and establish measurable indicators. Coordination is essential because water basins, ecosystems, transport networks and emergency risks often cross municipal boundaries.

Early-warning systems are most useful when forecasts are connected to clear response protocols and accessible communication. Authorities should identify populations at higher risk during heatwaves, floods and fires, including older people, children, outdoor workers and households with limited access to cooling or transport. Public education, school programmes and community participation can improve preparedness. Climate information should be understandable, regularly updated and available to local decision-makers. Financing is another condition for implementation. Public budgets can prioritize high-risk infrastructure and ecosystem protection, while private finance can support building retrofits, renewable energy and climate-resilient production. Project evaluation should

account not only for initial costs but also for avoided damage, health benefits, water savings and long-term maintenance. Monitoring and public reporting can help ensure that climate spending produces measurable results.

Table 2.

Suggested indicators for monitoring climate and environmental action

Policy area	Illustrative indicator	Purpose
Mitigation	Annual greenhouse-gas emissions by sector	Track progress against national targets
Energy	Renewable electricity share and energy intensity	Measure energy transition and efficiency
Water	Water losses, reuse and irrigation efficiency	Assess pressure on water resources
Disaster preparedness	Population covered by warning and response systems	Evaluate preparedness and public reach
Ecosystems	Forest-fire impacts and restoration outcomes; wetland condition	Monitor ecosystem resilience
Local governance	Number of local climate plans with annual progress reports	Strengthen accountability and coordination

The analysis indicates that climate policy should be treated as a development strategy rather than a separate environmental programme. Investments in water efficiency can support agriculture and urban services; cleaner energy can improve energy security and air quality; and ecosystem protection can reduce disaster exposure while supporting tourism and local livelihoods. The World Bank's assessment emphasizes that a resilient, lower-emission development pathway can create economic benefits over time, although it requires substantial investment and well-designed policies [1]. A fair transition is equally important. Climate impacts and the costs of policy change are not distributed evenly. Rural communities, low-income households, small businesses and workers in carbon-intensive sectors may have fewer resources to adapt. Assistance can include targeted financial support, vocational training, access to climate information, affordable public transport and support for small producers adopting water-efficient technologies. Participation and transparency can improve public trust and reduce the risk that climate policies

deepen existing inequalities. The proposed analytical framework connects three dimensions: mitigation of emissions, adaptation to climate hazards and protection of ecosystems. Progress in one dimension can reinforce the others, but trade-offs must be assessed carefully. For example, renewable-energy infrastructure should be planned to minimize harm to sensitive habitats; forest restoration should use ecologically appropriate species; and water-saving measures should consider downstream ecosystems. Integrated environmental assessment can help align these goals.

Türkiye faces interconnected environmental challenges associated with climate change, including water stress, drought, extreme heat, wildfires, flooding, coastal risks and pressure on biodiversity. These hazards can affect food production, public health, infrastructure, tourism and economic stability. Their consequences depend not only on the changing climate but also on land use, resource management, urban planning and institutional capacity. Therefore, reducing vulnerability requires action across several sectors rather than isolated environmental projects. The article's synthesis points to three priorities. First, Türkiye should continue reducing greenhouse-gas emissions through renewable energy, energy efficiency, cleaner transport, industrial modernization and improved waste management. Second, adaptation should be embedded in water policy, agriculture, urban planning, disaster preparedness and public-health systems. Third, ecosystem conservation and nature-based solutions should be integrated into land-use and infrastructure decisions. National strategies for 2024–2030 provide a policy foundation, while implementation requires adequate finance, local capacity, public participation and transparent monitoring [3]. The study is limited by its reliance on secondary sources and conceptual analysis. It does not provide original measurements or a province-by-province evaluation of policy implementation. Further research could compare climate vulnerability and adaptation capacity across Turkish regions, examine the effectiveness of local

climate plans, and estimate the costs and benefits of specific interventions. Overall, an integrated and socially fair climate strategy can strengthen Türkiye's ecological security while supporting sustainable development and long-term economic resilience.

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