

Ecological and Physiological Effects of Global Climate Change on Living Organisms

Ghazala Shaheen

University College of Conventional Medicine. Faculty of medicine and Allied Health Sciences. The Islamia University of Bahawalpur, Pakistan

Shafqat Rasool

School of Eastern Medicine, Minhaj University Lahore, Pakistan

Iftikhar Younis Mallhi

School of Human Nutrition and Dietetics, Minhaj University Lahore, Pakistan

Idrees Khan

Department of Eastern Medicine, Superior University Lahore, Pakistan

Rabia Mehmood

Chairperson Science and Research, National Council for Tibb, Islamabad Pakistan

Nighat Javaid

Department of Eastern Medicine, Faculty of Medical and Health Sciences, University of Poonch, Rawalakot Azad Kashmir, Pakistan

Saira Ghaffar

University College of Conventional Medicine. Faculty of medicine and Allied Health Sciences. The Islamia University of Bahawalpur, Pakistan

Sabahat Abbas

Indus Hospital and Health Network QF, NST and SMP Campus, Jubilee Town, Lahore Pakistan

Syed Waqas Hussain Shah

Department of Eastern Medicine, Faculty of Medical and Health Sciences, University of Poonch, Rawalakot Azad Kashmir, Pakistan

Muhammad Akram*

Department of Eastern Medicine, Government College University Faisalabad Pakistan. Corresponding Author Email: muhammadakram@gcuf.edu.pk

Muhammad Amjad Chishti

Department of Eastern Medicine, Superior University Lahore, Pakistan

ABSTRACT

Climate change, driven by rising greenhouse gas emissions and global temperatures, has profound biological consequences for both humans and other animals. Increased heat stress, the spread of vector-borne diseases, and deteriorating air quality contribute to escalating human health challenges. Species that cannot rapidly adapt or shift their ranges face heightened survival pressures, while more mobile species may experience altered competitive interactions and food availability. Climate-driven shifts in food web structure and habitat composition disrupt ecosystem services and

biodiversity, with cascading effects on ecological balance and human well-being. Furthermore, the frequency and severity of extreme weather events—such as hurricanes, floods, and heatwaves—amplify health risks and compromise critical infrastructure. In natural systems, climate change alters species distributions, reproductive behaviours, and survival rates, increasing extinction risks for those unable to adapt. These ecological disruptions undermine biodiversity and ecosystem functioning, ultimately affecting the services essential to both human and wildlife populations.

Keywords: Environmental Degradation; Temperature Rise; Climate Change; Air Quality; Extreme Weather Events

Introduction

The projected reduction in cold-related mortality during winter months is expected to be relatively modest and will not offset the anticipated increase in heat-related deaths. However, adaptive responses—such as the expanded use of air conditioning—may help mitigate the projected rise in mortality associated with extreme heat events.

Climate models project notable changes in several climatic variables for the period 2046–2065, relative to the 1981–2000 baseline under the RCP6.0 scenario. For instance, the coldest night of the year is projected to warm by 6–10°F nationwide, with slightly smaller increases in southern regions. The warmest day of the year is expected to be 4–6°F warmer across most areas. In addition, changes are projected in the intensity and duration of hydrological extremes. The wettest day of the year is anticipated to become wetter in many regions, indicating an increase in extreme precipitation events. Simultaneously, the length of the longest annual dry spell is projected to increase modestly, typically by less than two days (Alexander et al., 2006).

Despite substantial improvements in air quality since the 1970s, approximately 57 million Americans lived in areas that failed to meet national air quality standards in 2014 (Kaufman et al., 2020). Climate change is projected to exacerbate the difficulty of maintaining current air quality standards, with consequent increases in population exposure to harmful air pollutants.

Low-income countries may be particularly vulnerable to climate-sensitive diseases

due to limited capacity for prevention and treatment (Haque et al., 2014).

In the United States, public health agencies, environmental regulators, and water resource managers provide a range of protective measures, even in scenarios involving water contamination. However, the effectiveness of these systems will be increasingly tested as climate-related stressors intensify.

Research GAP

Research into the biological impacts of climate change has shown that its long-term effects on humans and other species are not yet fully understood. In particular, there are gaps in research on genetic changes, new types of diseases, and survival strategies. Filling these gaps is essential

Environmental Degradation

Conflicts over the environment can also arise from poor management that causes deterioration, in which case local communities band together to oppose the forces responsible for the mismanagement. According to scientists, human action has caused the sixth major extinction catastrophe to occur on Earth. 68% of vertebrate species has disappeared since 1970 due to human activities, notably overconsumption, population expansion, and intensive agriculture, according to a 2020 World species Fund report. Women have a disproportionate share of the unpaid care load due to environmental constraints and implications, especially in rural regions where they are forced to cope with the consequences. (Tyagi et al., 2014)

Impact of Climate Change on Reproductive Health and Species Survival

The biological effects of climate change not only affect the health of humans and other species, but can also negatively impact their sexual potency. Environmental stress, food shortages, and temperature changes affect reproductive health. This can result in reduced reproductive rates and threaten the survival of species (Milligan et al., 2009).

Air Quality

Air quality data from a single monitoring station cannot accurately represent pollution levels across an entire city. Consequently, readings from different monitors within the same urban area may vary from those recorded by U.S. Embassy and Consulate stations. To interpret air quality data collected by these U.S. installations

in Pakistan, a CAST algorithm is applied. This method converts raw $PM_{2.5}$ concentrations into Air Quality Index (AQI) values, facilitating health-related decision-making. The AQI is calculated over a period of three to twelve hours, based on fluctuations in particulate matter concentration. $PM_{2.5}$ is a U.S. Environmental Protection Agency (EPA)-recognized pollutant. Further information about $PM_{2.5}$ and air quality standards can be found on the EPA's official website.

It is important to note that U.S. Embassy and Consulate monitors in Pakistan do not measure other key pollutants contributing to air pollution, such as coarse particulate matter (PM_{10}), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), or carbon monoxide (CO). Readings showing “–999” indicate missing data and should be disregarded.

Air Pollution in Faisalabad: Sources, Health Risks, and Mitigation Strategies

Faisalabad, formerly known as Lyallpur, is Pakistan's third-most populous city. Strategically located, it serves as a major industrial and logistics hub, well connected to surrounding regions by road and rail. The city is undergoing rapid economic and demographic growth, and has earned the nickname “Manchester of Pakistan” due to its thriving textile industry, echoing the industrial expansion of Manchester, UK, in the 19th century.

As is typical of rapidly industrializing urban centres, Faisalabad experiences severely degraded air quality. In 2019, the city recorded an annual mean $PM_{2.5}$ concentration of $104.6 \mu g/m^3$ —placing it within the “unhealthy” AQI category (55.5 – $150.4 \mu g/m^3$) and ranking it second among Pakistani cities and fourth globally. This level of pollution poses serious health risks to the population.

Key contributors to Faisalabad's air pollution include emissions from high volumes of vehicular traffic—particularly older vehicles operating on substandard fuels and lacking modern emission controls. Faisalabad air investigation revealed that it is one of the most heavily polluted cities in the country, with cadmium and lead levels above 500 ppm. (Zeeshan et al. 2024). Numerous brick kilns and textile mills, often operating without adherence to international environmental standards and relying on dirty fuels, further compound pollution levels. Additional industrial sources include chemical factories, foundries, sugar mills, and poultry feed plants.

Other contributing factors include transboundary pollution, roadside dust, and the domestic burning of biomass. These diverse sources collectively produce the extreme PM_{2.5} levels reported in the city, with wide-reaching consequences for public health and environmental sustainability (Jones et al.,1999). Rasool et al. (2025) proposed a roadside green belt dominated with *Syzygiumcumini* L. as an efficient method to reduce dust and pollution and their absorption by local vegetables and fruit.

Extreme Weather Events

Extreme weather and climate-related impacts may arise from natural climate variability—such as El Niño—but anthropogenic climate change is fundamentally altering the frequency, intensity, spatial distribution, duration, and timing of such events, occasionally resulting in unprecedented phenomena. Populated regions worldwide are already experiencing the impacts of climate change, with numerous observed shifts in extreme events now attributable to anthropogenic activities (IPCC AR6 SPM).

For example, with each 1 °C rise in temperature, the atmosphere can hold approximately 7% more water vapor, intensifying extreme precipitation events.

The frequency and severity of extreme heatwaves and heavy rainfall have increased, disproportionately affecting vulnerable populations. Human-induced climate change has likely elevated the risk of compound extreme events, such as simultaneous heatwaves and droughts, with increasing occurrence since the 1950s. Over the past five decades, the number of weather-related disasters has increased fivefold, driven largely by climate change, more intense weather, and improved reporting. However, advancements in early warning systems and disaster management have contributed to a nearly threefold reduction in mortality.

Reflecting growing global concern, World Meteorological Day 2022 focused on ‘Early Warning and Early Action,’ emphasizing the importance of timely response in the face of rising climate and weather extremes. Improved understanding and characterization of these events is critical for disaster risk reduction and evidence-based decision-making.

Extreme events—such as hurricanes, heatwaves, frosts, tornadoes, and heavy

rainfall—can have a severe impact on ecosystems, agriculture, and communities. While many of these are short-lived, some emerge from the interaction of longer-term climatic anomalies. For instance, wildfires may follow an unusually wet growing season, or prolonged droughts may result from extended periods of below-average precipitation.

Scientists typically assess extreme events using two main approaches. The first is probabilistic: estimating the likelihood of an event of a certain magnitude within a defined historical period (e.g., 1961–1990), where events with <10% probability are considered extreme. This method underpins attribution science, which assesses how global warming influences the frequency and severity of such events.

The second method, more commonly used in adaptation planning, defines extremeness based on impact thresholds. For example, a common metric for heatwaves is the number of consecutive days exceeding 100 °F. However, the same threshold may have vastly different effects depending on the location; a 100 °F day is anomalous in Burlington, Vermont, but relatively normal in Phoenix, Arizona. Thus, thresholds are often context-specific.

Different regions face distinct types of extreme events. In the western United States, for example, severe tropical cyclones (also known as hurricanes or typhoons) can trigger droughts and wildfires inland, while battering coastal zones with intense rainfall, winds, and storm surges. For further information on identifying, monitoring, and attributing extreme weather and climate events, and understanding their relationship to climate change, see the resources listed below (Mirza et al., 2003)

Disruption of Ecosystems and Biodiversity Loss

Ecosystem disruption and the impacts of climate change on biodiversity represent significant threats to global ecological stability. Rising temperatures, altered precipitation patterns, and an increased frequency of extreme weather events are contributing to the degradation of natural habitats (IPCC, 2021). These environmental changes compromise the suitability of habitats for numerous species, leading to shifts in species distribution, increased interspecific competition, the introduction of invasive species, and the potential collapse of local ecosystems unable

to adapt rapidly (Pecl et al., 2017). Particularly vulnerable groups include coral reefs, amphibians, avian species, and pollinators such as honey bees (WWF, 2023; Potts et al., 2010). The loss of such species disrupts trophic dynamics, pollination networks, and nutrient cycling, ultimately destabilizing entire ecosystems (Sala et al., 2000).

Impacts of Biodiversity Decline on Ecosystems and Humanity

Shifts in fish populations, for instance, have significant implications for coastal economies and food security. Furthermore, habitat fragmentation and biodiversity loss elevate the risk of zoonotic disease emergence in human populations (IPBES, 2020). Ecosystem services—including water purification, disease regulation, and climate moderation—are also compromised by biodiversity decline. Therefore, the conservation of biological diversity is critical not only for sustaining ecological balance but also for ensuring human well-being.

Urgent Climate Action and Global Environmental Justice

Urgent and coordinated action is required to mitigate greenhouse gas emissions, preserve critical habitats, and implement effective adaptation strategies. The growing frequency of extreme weather events and their associated health risks underscore the necessity for robust public health responses and resilient infrastructure. Additional consequences of climate-induced biodiversity changes include altered species distribution, disrupted reproductive cycles, and increased resource pressures (Barange et al., 2018). Environmental challenges demand the implementation of climate justice frameworks that promote equitable, collaborative, and globally coordinated solutions among all stakeholders. (Schlosberg et al. 2025)

Adaptation Strategies and Conservation Efforts

Climate change poses a profound threat to biological systems; however, effective adaptation strategies and sustained ecosystem stewardship can substantially mitigate its adverse impacts. Adaptation tries to modify natural and human systems to minimize loss and damage, safeguard ecosystems, promote biological diversity, and preserve the environment without harming it. Public health improves with an early warning system against heat waves, floods, and explosions caused by climate change. Urban planning integrates green infrastructure such as green roofs and parks to counter the impacts of heat islands and stormwater management. The agricultural sector will adopt climate-smart practices—such as cultivating drought-

resistant crop varieties, employing water-efficient irrigation systems, and implementing crop-rotation schemes—to enhance resilience and safeguard yields under increasingly variable and extreme weather conditions (Mawdsley et al., 2009). Local coordination exists as well. Local societies along the coast hit by hurricanes and oceans will consequently invest in protective measures like mangroves, withdrawals and repair of walls whenever the situation occurs. Awareness campaigns and education allow people to live and adapt to the climatic medical risks sustainably. Further, politically influential actors who provide adaptive framework conditions like fair distribution of local knowledge, resources, and local context can ensure that threatened groups of population are not falling behind. The protected landing network is expanded and connected by wildlife corridors to allow animals to hike into enhanced habitats whenever environmental temperature and precipitation regimes shift. For example, polar and mountain species that like cold climatic conditions will like polar or upward habitats. When natural migration becomes impossible due to fragmented landscapes or abrupt environmental change, this is relocating species by design to more climatically suitable positions. However, such interventions must be implemented in ways that avoid ecological disruption within host ecosystems. Strategies grounded in ecological integrity can restore natural systems while sustaining conservation activities that deliver essential services to both humanity and the biosphere. For instance, wetlands mitigate flooding and simultaneously reduce vector-breeding habitats. Similarly, coral reef restoration initiatives—such as the deployment of coral nurseries and the cultivation of thermally resilient genotypes—aim to preserve marine biodiversity and support coastal fisheries threatened by ocean warming and acidification. Ex situ conservation initiatives, such as gene banks and captive breeding programmes, serve as critical reservoirs for preserving and improving genetic material for future breeding and reintroduction efforts. International frameworks, including the Paris Agreement and the Convention on Biological Diversity, underscore the need for targeted financial and technical assistance to support biodiversity conservation in developing nations—particularly in integrating biodiversity considerations into climate adaptation and mitigation strategies. Sustaining habitats in the face of shifting climatic zones requires coordinated global action, robust local government

engagement, targeted research, and sustained international investment. Such integrated efforts are essential not only to safeguard humanity but also to ensure the survival of diverse life forms beyond the threshold of mere persistence.(Lawler, 2009).

Conclusion

In conclusion, the biological repercussions of climate change are both extensive and multifaceted, influencing human health and the viability of species worldwide. The rising incidence of extreme weather events and the growing burden on public health systems highlight the urgency of adaptive responses and resilient infrastructure. Simultaneously, shifts in species distributions, disrupted reproductive patterns, and heightened extinction risks underscore the necessity of targeted conservation strategies. Given the intrinsic link between ecological integrity and human well-being, climate change must be addressed through integrated approaches that align environmental protection with public health objectives. Strengthening adaptation and mitigation frameworks is essential for preserving biodiversity, sustaining ecosystem services, and ensuring a more resilient and equitable future.

References

- Alexander LV, Zhang X, Peterson TC, Caesar J, Gleason B, Klein Tank AM, Haylock M, Collins D, Trewin B, Rahimzadeh F, Tagipour A. Global observed changes in daily climate extremes of temperature and precipitation. *Journal of Geophysical Research: Atmospheres*. 2006 Mar 16;111(D5).
- Bolan S, Padhye LP, Jasemizad T, Govarthanan M, Karmegam N, Wijesekara H, Amarasiri D, Hou D, Zhou P, Biswal BK, Balasubramanian R. Impacts of climate change on the fate of contaminants through extreme weather events. *Science of The Total Environment*. 2023 Nov 11;168388.
- Breakwell GM. *The psychology of risk*. Cambridge University Press; 2014 Sep 18.
- Borchers A, Teuber SS, Keen CL, Gershwin ME. Food safety. *Clinical reviews in allergy & immunology*. 2010 Oct;39:95-141.
- Change C. *Climate change*. Synth. Rep. 2001.
- D'Amato G, Baena-Cagnani CE, Cecchi L, Annesi-Maesano I, Nunes C, Ansotegui I, D'Amato M, Liccardi G, Sofia M, Canonica WG. Climate change, air pollution and extreme events leading to increasing prevalence of allergic respiratory

- diseases. Multidisciplinary respiratory medicine. 2013 Dec;8:1-9.
- Emberlin J. The effects of patterns in climate and pollen abundance on allergy. Allergy. 1994 Jan;49:15-20.
- Eguiluz-Gracia I, Mathioudakis AG, Bartel S, Vijverberg SJ, Fuertes E, Comberiat P, Cai YS, Tomazic PV, Diamant Z, Vestbo J, Galan C. The need for clean air: the way air pollution and climate change affect allergic rhinitis and asthma. Allergy. 2020 Sep;75(9):2170-84.
- Funari E, Manganelli M, Sinisi L. Impact of climate change on waterborne diseases. Annalidel'Istitutosuperiore di sanita. 2012;48:473-87.
- Fraser AM, Brockert JE, Ward RH. Association of young maternal age with adverse reproductive outcomes. New England journal of medicine. 1995 Apr 27;332(17):1113-8.
- Haque MA, Louis VR, Phalkey R, Sauerborn R. Use of traditional medicines to cope with climate-sensitive diseases in a resource poor setting in Bangladesh. BMC Public Health. 2014 Dec;14:1-0.
- Hernández-Cortez C, Palma-Martínez I, Gonzalez-Avila LU, Guerrero-Mandujano A, Solís RC, Castro-Escarpulli G. Food poisoning caused by bacteria (food toxins). Poisoning: From specific toxic agents to novel rapid and simplified techniques for analysis. 2017 Dec 20;33.
- IPCC. (2021). Climate Change 2021: The Physical Science Basis. Intergovernmental Panel on Climate Change.
- Lawler, J. J. (2009). Climate change adaptation strategies for resource management and conservation planning. *Annals of the New York Academy of Sciences*, 1162(1), 79-98.
- Pecl, G. T., et al. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. *Science*, 355(6332), eaai9214.
- WWF. (2023). Living Planet Report 2022. World Wide Fund for Nature.
- Sala, O. E., et al. (2000). Global biodiversity scenarios for the year 2100. *Science*, 287(5459), 1770-1774.
- Potts, S. G., et al. (2010). Global pollinator declines: trends, impacts and drivers. *Trends in Ecology & Evolution*, 25(6), 345-353.

- Barange, M., et al. (2018). Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options. Food and Agriculture Organization of the United Nations (FAO).
- IPBES. (2020). Workshop Report on Biodiversity and Pandemics. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.
- Díaz, S., et al. (2006). Biodiversity loss threatens human well-being. *PLoS Biology*, 4(8), e277.
- Jones AP. Indoor air quality and health. *Atmospheric environment*. 1999 Dec 1;33(28):4535-64.
- Kraaijenbrink PD, Bierkens MF, Lutz AF, Immerzeel WW. Impact of a global temperature rise of 1.5 degrees Celsius on Asia's glaciers. *Nature*. 2017 Sep 14;549(7671):257-60.
- Kaufman JD, Elkind MS, Bhatnagar A, Koehler K, Balmes JR, Sidney S, Burroughs Peña MS, Dockery DW, Hou L, Brook RD, Laden F. Guidance to reduce the cardiovascular burden of ambient air pollutants: a policy statement from the American Heart Association. *Circulation*. 2020 Dec 8;142(23):e432-47.
- Luber G, McGeehin M. Climate change and extreme heat events. *American journal of preventive medicine*. 2008 Nov 1;35(5):429-35.
- Lei HY, Ding YH, Nie K, Dong YM, Xu JH, Yang ML, Liu MQ, Wei L, Nasser MI, Xu LY, Zhu P. Potential effects of SARS-CoV-2 on the gastrointestinal tract and liver. *Biomedicine & Pharmacotherapy*. 2021 Jan 1;133:111064.
- Lombardo JS, Buckeridge DL. Disease surveillance: a public health informatics approach. John Wiley & Sons; 2012 Nov 9.
- Mawdsley, J. R., O'malley, R., & Ojima, D. S. (2009). A review of climate-change adaptation strategies for wildlife management and biodiversity conservation. *Conservation Biology*, 23(5), 1080-1089
- Milligan, S. R., Holt, W. V., & Lloyd, R. (2009). Impacts of climate change and environmental factors on reproduction and development in wildlife. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1534), 3313-3319.
- Mirza MM. Climate change and extreme weather events: can developing countries

- adapt?. Climate policy. 2003 Jan 1;3(3):233-48.
- Michener WK, Blood ER, Bildstein KL, Brinson MM, Gardner LR. Climate change, hurricanes and tropical storms, and rising sea level in coastal wetlands. Ecological applications. 1997 Aug;7(3):770-801.#
- Rasool, A., Muhammad, S., Tayyab, M., Bajwa, A. A., Majeed, M., Munam, B., ... & Bilal, M. (2025). Ecological evaluation of dominant roadside plants through APTI and API for sustainable green belt development in cosmopolitan city (Lahore) of Pakistan. *Scientific Reports*, 15(1), 10496.
- Schiedek D, Sundelin B, Readman JW, Macdonald RW. Interactions between climate change and contaminants. Marine pollution bulletin. 2007 Dec 1;54(12):1845-56.
- Schlosberg, D., Rickards, L., Pearse, R., Della Bosca, H., & Moraes, O. (2025). Critical environmental justice in contemporary scholarship and movements: consensus and plurality of the discourse. *Environmental Politics*, 34(3), 399-420.
- Tyagi S, Garg N, Paudel R. Environmental degradation: Causes and consequences. European researcher. 2014;81(8-2):1491.
- Yoder J, Roberts V, Craun GF, Hill V, Hicks L, Alexander NT, Radke V, Calderon RL, Hlavsa MC, Beach MJ, Roy SL. Surveillance for waterborne disease and outbreaks associated with drinking water and water not intended for drinking--United States, 2005-2006. MMWR: Morbidity & Mortality Weekly Report. 2008 Sep 13;57.
- Zeeshan, N., Murtaza, G., Ahmad, H. R., Awan, A. N., Shahbaz, M., & Freer-Smith, P. (2024). Particulate and gaseous air pollutants exceed WHO guideline values and have the potential to damage human health in Faisalabad, Metropolitan, Pakistan. *Environmental Monitoring and Assessment*, 196(7), 659.