Climate Change and Global Health: Risks, Resilience and Sustainable Solutions

Tayyaba Akhtar[1,*], Naqshe Zuhra[1], Aaneeqa Irfan[1], Sadia Perveen[1], Ayesha Chaudhry[1], Hamza Ahtsham[1] and Riyan Ashraf[1]

[1]Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad, Pakistan
*Corresponding author: tayyaba.akhtar914@gmail.com

Abstract

The recognition of climate change and its detrimental impacts on human health has become universally accepted. A wide range of diseases and health issues encompassing those associated with heat and radiation, under-nutrition, respiratory and cardiac problems, water and vector-borne diseases, drowning, injuries, and mental stress arising from extreme and sudden weather events and their resulting population displacements have been connected to various facets of climate change. The exact characteristics and scope of these effects are yet to be definitively established, as other non-climate elements also influence similar results. This calls for additional investigation, especially in less developed nations, where the effects are particularly pronounced, but dependable data is still remarkably limited. Recognizing the importance of human influences on climate change, almost every country has adopted a range of strategies and initiatives to combat adverse environmental shifts. The anticipated effects on health are likely to be harmful, particularly for populations in low-income countries who are more vulnerable to adverse outcomes. The impacts of climate change are evident in various non-health sectors, highlighting the need for strong collaboration across different levels. This chapter aims to explore the diverse climatic influences on human health, as well as approaches for adaptation and mitigation.

Keywords: Climate change; Human health; Adaptation; Mitigation; Physical health; Mental health

Cite this Article as: Akhtar T, Zuhra N, Irfan A, Perveen S, Chaudhry A, Ahtsham H, and Ashraf R, 2025. Climate change and global health: risks, resilience, and sustainable solutions. In: Abbas RZ, Akhtar T and Arshad J (eds), One Health in a Changing World: Climate, Disease, Policy, and Innovation. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 187-193. https://doi.org/10.47278/book.HH/2025.130

A Publication of Unique Scientific Publishers

Chapter No: 25-026

Received: 03-Jan-2025
Revised: 07-March-2025
Accepted: 08-May-2025

Introduction

Weather and climate affect health in many ways. They include harsh temperatures and violent storms and less obvious linkages. West Nile virus and Lyme disease-carrying mosquitoes, ticks, and rodents are affected by weather and climate. Climate and weather can also alter water and food quality, affecting human health. Climate change's consequences on mental health and well-being are also important. Examine the ways in which specific exposure routes can lead to human illness to grasp the impact of climate change on health. Exposure pathways, adapted from the field of chemical risk assessment, illustrate the impact of climate change on health (Parsons et al., 2024). The ways in which individuals and communities are exposed to various factors change over time and across different regions, with climate change having distinct impacts on different populations. The health impacts of various climate change issues can accumulate or unfold in a cascading manner, even when examined individually. Climate change hazards can build, affecting resilience and health over time. Exposure, sensitivity, and adaptive capacity are linked to social and demographic factors like wealth, education, infrastructure, and ecosystem degradation. Poverty increases vulnerability to climate and weather risks, sickness, and nutritional deficiencies, and limits adaptive capability. In cities with deteriorated coastal ecosystems and inadequate water and wastewater infrastructure, severe storms may pose a larger health risk (Balbus et al., 2016).

Hippocrates understood climate affects health in many ways. Growing knowledge of climate change has piqued health experts' interest in its health effects. Health impacts will be mitigated by socioeconomic development and adaptation. Although most research has focused on climate change alone, other environmental changes such as population increase, urbanization, changes in land use, and freshwater depletion all pose threats to human health and may combine with climate change to make it worse. Health is affected by climate in many ways (Siiba et al., 2024). Heat waves, floods, and drought kill immediately and long-term. Flooded populations may have had higher rates of mental illness. Climate change may affect biodiversity and health-sustaining ecological services. Malaria, dengue, and diarrheal vectors are affected by temperature and rainfall. European tropospheric ozone pollution is affected by climate, but the links are uncertain. In nations where economic realities prevent sea defenses and other countermeasures, sea level rise may harm low-lying coastal populations (Haines & Patz, 2004; McMichael, 2006). Climate change can lead to flooding, drought, and environmental degradation, potentially displacing individuals and creating a new class of environmental refugees. Over the past twenty to thirty years, there has been a noticeable increase in global temperatures. One significant scientific hurdle is assessing the health implications of these alterations. Climate change effects on human health can be seen in Fig. 1.

1. Has Observed Climate Change Already Been Affecting Human Health?

Recent studies indicate that climate change is influencing vector-borne infectious diseases. Although vector species have observed alterations in Europe's climate, substantial evidence linking this to human vector-borne diseases like malaria is lacking (Purse et al., 2005). Furthermore, while there is evidence of latitudinal shifts in ticks that carry tick-borne encephalitis in Northern Europe (Lindgren et al., 2009; Skarphedinsson et al., 2005), the underlying causes of this trend, including changes in population dynamics, socioeconomic factors, and land use, continue to be debated. As far back as the last several decades, there is evidence that the frequency of severe weather events has altered. A number of health outcomes can be dramatically affected by isolated extreme events, such heat and rain. Analysis of the 2003 heat wave revealed that it was indeed unprecedented, with temperatures across Europe likely reaching their highest point since 1500 (Luterbacher et al., 2004). According to Stott et al. (2004), climatologists today consider it "very likely" that the likelihood of a heat wave like the one in 2003 has been at least doubled due to human influence on the global climate. Climate change has not been directly associated with a specific event like Hurricane Katrina, although there is new evidence that it could be a factor in the intensification of tropical cyclones, particularly an increase in sea surface temperatures (Emanuel, 2005). Determining the potential impact of climate change on disease patterns could be possible if we have access to health surveillance data spanning several decades up to the present. Confusion arises when trying to make sense of data because important health variables vary over time and because there are new ways to record diagnoses. To assess the health effects of recent climate change objectively, test hypotheses, and make adjustments, long time series of diligent monitoring, perhaps extending several decades, would be required. While this method follows accepted scientific principles, it would not provide enough evidence to sway policymakers to reduce emissions of greenhouse gases, which would have a positive impact on future health. On top of that, it wouldn't let us act quickly enough to adapt to the climate change that has already occurred due to our past greenhouse gas emissions. Therefore, the most accurate prediction of the long-term health impacts of climate change can only be derived from risk assessments that take into account our present and historical knowledge of how climatic variability affects human health, while also taking into account the influence of several modulating factors. Even small changes in precipitation and temperature can have an impact on diseases including malaria, diarrhea, flood-related injuries, and hunger, according to observations of short-term weather variations (Webster et al., 2005).

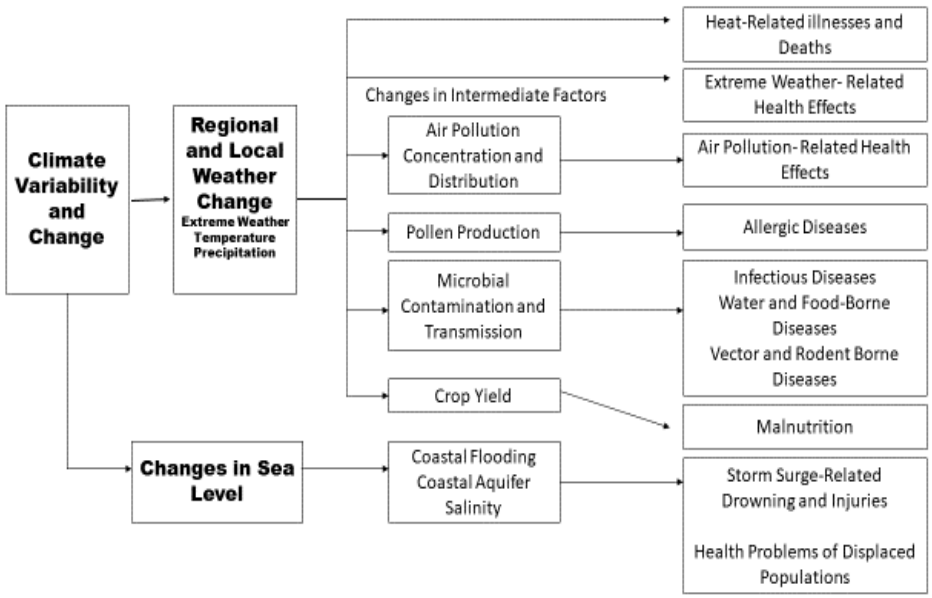

Fig. 1: Potential Health Effects of Climate Variability and Change.

i. Air Pollution Health Illness

Transboundary, indoor, and ambient air pollution are the three main types of air pollution. Changes in the weather have a significant impact on all three categories because of the interplay between precipitation, wind, temperature, and radiation. Also, air pollution is considered a key factor in the current "climate change" scenario. Up to 1.4 billion people living in urban areas throughout the world are exposed to air pollution levels that surpass the World Health Organization's (WHO) air guideline standards, according to the WHO. The transboundary transport of air pollutants has global and regional repercussions, despite the fact that air pollution is typically a locally sourced problem. Some of the new problems that cut across political lines are acid deposition, climate change, and the loss of ozone in the stratosphere. High emissions and bad weather work together to make air pollution a problem. When it comes to air pollution, surface ozone and particle matter are the two main concerns for public health. There is strong evidence that air pollution, of which transportation is a major contributor, directly affects mortality, respiratory illness, and cardiovascular disease. Greenhouse gases (GHGs), especially carbon dioxide, are released into the atmosphere when fossil fuels are burned (Shah et al., 2024).

Other common air pollutants include Sulphur dioxide, nitrogen oxides, carbon monoxide, volatile organic compounds, carbonaceous aerosols ("soot"), and nitrogen oxides. Secondary pollutants, including ozone, particulate Sulphur, nitrate, and organic matter, are formed when some of these molecules react with atmospheric oxygen (Deb et al., 2012). These pollutants have effects on both ecosystems and human health. Photochemical interactions between nitrogen oxides and volatile organic compounds (mostly from motor vehicles) in sunlight create tropospheric ozone and photochemical smog. Anticyclonic circumstances in temperate climates during summer months with high temperatures

and strong sunlight increase ozone levels. Global warming and stratospheric ozone loss increase UV light flux, which may promote photochemical pollution. This form of pollution might start in locations where it's unusual, and it could worsen and occur more often in already polluted areas. Ambient air ozone causes dose-dependent pulmonary function alterations. These modifications may be especially difficult for asthmatics and those with reduced lung function. Ozone also increases asthmatics' sensitivity to other contaminants (Lu et al., 2024).

ii. Impact of High Levels of Pollens, Allergens and Smog

Air allergens like pollen and mould spores, as well as ozone, fine particle, and dust concentrations in certain regions, will be more prevalent as a result of climate change. Some of these contaminants have the potential to induce or worsen respiratory illnesses in people who are already vulnerable. Mould spores and other precipitation-affected aeroallergens can cause lifelong respiratory allergic airway problems in 5% of the population. Pollens and allergies rise with temperature. In Pakistan, autumn and winter pollution from transport, industrial pollutants, and crop burning leftovers is almost routine. The air quality index might reach 600 on some days. A haze with low air quality persists. High pollen and allergen levels from air pollution cause respiratory disorders like asthma, hay fever, allergies, and eye diseases (Iqbal, 2020).

iii. Water Quality and Quantity

In many nations in the Third World, water is one of the leading causes of disease. Childhood diarrhea, cholera, and typhoid are just a few examples of water-borne diseases that continue to claim lives in impoverished communities where sanitation is inadequate. Poor personal and food hygiene, caused by a lack of domestic water, is the source of many watershed issues. Several factors, most notably the socioeconomic status of the impacted communities, impact each stage. The effects of climate change on human health are still very controversial because of these unknowns. Nonetheless, what we know now can help with making predictions. This evaluation starts with the more direct impacts of climate on health, as they are less fraught with ambiguity (Tulu et al., 2024).

iv. Floods and Storms

No effect of weather and climate on health is clearer than storm and flood injuries and deaths. Tropical storms cause the most damage. Only at sea surface temperatures above 27 °C do these form. Tropical storms may affect more people and more of the year in a warmer climate. Their maximal intensity, which depends on temperature, may increase, increasing their destructive potential. Natural disasters affect health in many ways. Rapid rising floods increase the risk of drowning, causing most flood-related deaths. Lead and cadmium pollution of floodplain soils after the 1993–1994 Meuse floods posed a health danger to river-bank residents, according to a case study. Industrial or agricultural land near residential area may increase risks. Insufficient study on chemical contamination from flooding has been done to determine if it affects morbidity and death in impacted populations. After floods, diarrhoeal and respiratory infections increase in high- and low-income nations, especially when displaced populations are crowded (Chan et al., 2024)

Although infections are less common in industrialised countries, they can nevertheless hurt the local economy and promote worry and sadness (Kim et al., 2014). Populations in low-income nations are more likely to be at risk because they live in flood plains and coastal zones, there is less public health infrastructure, and local and national economies are significantly more affected compared to industrialised nations. As a result, fewer individuals with modest incomes have health insurance. In low-income nations, droughts can exacerbate problems with air pollution, infectious diseases, and poor nutrition. Due to sea-level rise and channel silting, Pakistan sees intermittent inland river floods virtually every year. About 714,800 Pakistanis were impacted by seasonal floods in 2010. Climate change is expected to cause 1.5 million additional floods and 638,000 socioeconomic changes by 2030 (Biesbroek et al., 2010).

v. Infectious Diseases

Weather affects the transmission of many infectious disease pathogens, especially those that live outside the body. Ambient weather exposes insect-borne pathogens. The significance of temperature and rainfall in vector-borne illness seasonality is well known. In some places, vector-borne diseases like malaria vary year-to-year due to climate. Humidity, temperature, soil moisture, rainfall, and sea level rise can affect vector-borne infectious disease transmission. It is difficult to determine how these factors affect vector-borne illness risk. The spread and incidence of vector-borne diseases are influenced by several demographic, socioeconomic, and environmental factors (Zain et al., 2024).

A sufficient number of reservoir hosts, competent vectors, and disease are required for transmission to continue. The length of the transmission season and the frequency of transmission in some areas may be impacted by global climate change. Minor shifts in transmission season may have a significant impact since transmission rates increase non-linearly with transmission season. Disease transmission may increase or decrease spatially as a result of climate-driven variations in vectorial capacity, which make transmission sustainable in some places but not others. Additional communities could be exposed if the disease spreads even slightly. More severe clinical disease can occur in new populations where acquired immunity is lacking (Haines et al., 2006).

Table 1: Climate-Sensitive Vector-Borne Illnesses.

Vector	Major Diseases
Mosquitoes	Malaria, dengue fever and yellow fever
Sandflies	Leishmaniasis
Triatomines	Chagas disease
Ixodes ticks	Lyme disease and tick-borne encephalitis
Blackflies	Onchocerciasis
Snails (intermediate host)	Schistosomiasis

Temperature, precipitation, and humidity greatly impact infectious agent and disease vector life cycles and growth. After the rainy and flooding season, water- and food-borne infections are most prevalent. The country's most frequent diseases are cholera, diarrhoea, hepatitis A, and typhoid. Pakistan experienced devastating floods from 2010 to 2015, killing many, especially riverside residents. These floods damaged freshwater resources and created several thousand stagnant ponds that harbored disease-causing insects, germs, and toxic algae. Pakistan has had multiple dengue epidemics in the past decade. Over 22,000 cases and 350 deaths were reported in Lahore in 2011. Over 44,000 people were infected with dengue fever in 2019, with many dying. Along with dengue, Zika is a frequent ailment in Pakistan. Clinicians focus on dengue and chikungunya, but Zika illnesses are rising throughout the country (Mohapatra et al., 2024).

Clinical protocols should include Zika virus diagnostic tests to identify the prevalence of the disease spread by *Aedes aegypti* and *A. albopictus* mosquitoes (Table 1). Pakistan estimates one million malaria cases annually. *P. falciparum* and *P. vivax* are the only significant parasites. The main vectors of this disease are *A. stephensi* and *A. culicifacies*. Hepatitis accounts for 50-60% of acute viral hepatitis cases in Pakistani children. Pakistan has the highest typhoid fever rate in Southeast Asia (451.7 per 100,000). *Salmonella typhi* and *paratyphi* infections produce this water-borne and water-washed illness. Many food-borne epidemics of this disease originate from polluted water. Increasingly drug-resistant forms of this bacterium threaten Pakistani health (Iqbal, 2020).

vi. Heat Waves and Natural Fires

Global Warming also increases extreme heat-related illness and mortality. The frequency of such events could increase dramatically if average temperatures continue to climb but daily variability stays the same. The number of days with temperatures above 38°C in Washington DC will increase from one per year now to twelve by the middle of the next century. Heat stress may also harm cardiovascular health, especially in sensitive groups like the elderly. Research of coronary heart disease and stroke mortality in US cities found that mortality rates rise dramatically after daily temperatures approach 25 °C. Britain too has higher heatwave mortality (Nojarov & Nikolova, 2022).

Table 2: Excess Mortality Attributed to The 2003 Hot Summer or Heat Wave Period in Europe.

Population	Excess mortality (% increase)
England and Wales — 2003	2091 deaths (17%) in heat wave period
Italy — 2003	3134 (15%) in all Italian capitals
France — 2003	14,802 (60%) in heatwave
Portugal — 2003	1854 (40%) in August
Spain — 2003	4151 deaths (11%)
Switzerland — 2003	975 deaths (6.9%)
Netherlands — 2003	1400–2200 deaths (3-5%)
Germany — 2003	1410 deaths in heatwave

Heat waves in temperate zones could cause vulnerable structures, such as healthcare facilities and retirement communities, to need more air conditioning (Table 2). Warmer temperatures promote bacterial reproduction, which in turn increases the risk of food poisoning (Epstein, 2005). Effects can range from mild to fatal depending on the microorganisms, dosages, and susceptibility. Pakistan's hot weather, especially in Sindh and Punjab, can cause dehydration, kidney stones, and heatstroke. Heatstroke killed around 1200 Karachi residents in 2015. Hot weather causes natural forest fires that kill wildlife and vegetation (Bakhsh et al., 2018).

vii. Food Availability

Climate change is estimated to have considerable implications on agriculture, but these will vary by region. Higher temperatures can loosen climatic limits on agricultural productivity, increasing production in some locations. Water shortages in hotter summers, as expected for major cereal-growing regions in North America and Western Europe, could diminish agricultural output. Climate change may increase storm damage, weed growth, and agricultural pests and pathogens. In locations like sub-Saharan Africa where population pressure, a marginal climate, or environmental degradation make the food-people balance insecure, such changes are likely to be most severe. As sea levels rise, heavily populated, agricultural areas like Bangladesh and the Nile delta of Egypt may face serious problems from salinisation or flooding. Droughts caused by climate change impact food production and supply. Food insecurity and malnutrition result. The latest locust attacks (May 2020) in Africa and Asia owing to shifting weather are another food security hazard. Attacks like this destroy crops and incur tremendous losses. Growing population and wealth inequality can pose threats. In a country where nearly one-third of the population lives below the poverty line, such variables may make it harder for people to meet their basic food needs. Thus, malnutrition is rising nationwide. According to international standards, 11.2 million Pakistanis (6% of the total population) lived below the $1.9 a day poverty line in 2013 and 68.2 million below the $3.1(kim et al., 2014). Poverty worsens public health and makes them susceptible to many diseases. Because of the "growth stunting" effect of food insecurity, Pakistan has one of the world's highest rates of child malnutrition. A third of the children surveyed were stunted, forty-five percent were underweight, and ten percent were wasting in the last National Health Survey. Food instability, incorrect supplemental feeding, low birth weight (due to mothers' poor diets during pregnancy), inadequate nursing, low socioeconomic status, and infectious illnesses are causes. Such youngsters may have stunted growth and poor immunological function (Firdaus et al., 2019).

viii. Mental Health

More frequent and severe weather disasters, such as hurricanes, wildfires, and floods, are being caused by global warming. The frequency and severity of natural catastrophes are predicted to rise due to climate change. Living conditions are substantially affected by climate disasters. Financial losses and interpersonal issues are common outcomes of relocating and rebuilding. Factors that increase the likelihood of mental illness following a disaster include: being a female, being younger, having a lower socioeconomic status, less education, being a minority or

ethnic group, having a history of mental illness, having an unstable family, and not having enough social support. In 25–50% of cases, people's mental health can suffer as a result of severe weather. After a tragic event, most people's psychological reactions peak within a year and then gradually recover. A climate-related disaster is a kind of trauma that can cause early symptoms such as heightened awareness, evasion, anger, flashbacks, shame, anxiety, emotionality, trouble focusing, ruminating, fixation, and social isolation. Those who have been forced to flee their homes may experience psychological distress as a result of floods (Palinkas & Wong, 2020).

2. Strengthening Health System for Climate Adaptation Through Resilience

The Sixth Intergovernmental Panel on Climate Change report highlights that 'future human vulnerability will persist in areas where local, regional, and national governments, communities, and the private sector are least prepared to provide infrastructure and essential services.' To effectively tackle existing deficiencies and improve health system performance, it is essential to consider climate change and its fluctuations. This approach is crucial for adequately equipping the health system to face the looming climate crisis and ensure health security. Health systems need to comprehend how climate change and variability influence their capacity to finance, manage, and safeguard both public and individual health. They should assess the effectiveness of their interventions and systems across various climatic conditions and mediated impacts, while also pinpointing opportunities to enhance institutional iterative risk management capabilities at every level. Strategic planning and a dedicated commitment from the health system are essential for fostering multisectoral collaboration and engaging the community, ultimately enhancing access to crucial services and public health functions. Investments in health systems should be made promptly, tailored to the specific context, and encompass a wide range of factors (Lugten & Hariharan, 2022).

This approach aims to enhance current capacities and embed risk management practices throughout public and private sectors, along with community organizations, while evaluating resilience capabilities in both the short and long term. The USAID Health System Strengthening Vision 2030 emphasises that health systems exhibit resilience through the adaptation of resources, policies and priorities to address both current emerging challenges. The challenges posed by global phenomena such as COVID-19 and climate change underscore the necessity for integrated, holistic strategies aimed at enhancing health systems. USAID supports nations in their efforts to integrate, adapt, and progress in delivering consistent, affordable, reliable healthcare and public health services to their populations. Resilience plays a vital role in tackling ongoing health challenges, immediate emergencies, and prolonged disruptive trends. USAID creates health system initiatives tailored to local contexts to meet fundamental health system objectives through a comprehensive and inclusive societal framework. This entails working together with traditional public and private health partners, as well as organisations from sectors that influence health, such as water, sanitation, hygiene, agriculture, and the environment. It also includes engaging with faith-based groups, communities, and local organisations to oversee, anticipate, and adapt to health risks, ultimately enhancing health services and outcomes, particularly for at-risk populations (Lugten & Hariharan, 2022).

Table 3: Strategies for Strengthening a Climate-Resilient Health System.

Themes	Strategies for Strengthen a Climate Resilient Health System
Leadership and governance	Formulate a national strategy for health and climate change adaptation.
	Involve the government
	Formulate an extensive policy
	Enhance the awareness of healthcare leaders
	Utilise climate vulnerability indices to establish a framework.
Financing	Supplying enough funds
	Growing research funding
	Long-term international financing access improvement
Health workforce	Employing a reliable, skilled crew
	Community microbiological water testing with nurses
	Engaging various stakeholders
	Training health workers at various levels
	Creating protective gear
	Sharing climate change health protection knowledge and skills
Healthcare items and technologies	Strategizing and implementing contingency solutions for electricity, air conditioning, ventilation, and water supply
	Design of low-carbon or net-zero healthcare facilities
	Enhanced resource use
	Improving laboratory facilities and testing

3. Mitigation Strategies

Mitigation policies usually follow climate change risk perceptions. However, absence of accurate and reliable risk data makes responding properly questionable. Recently, worldwide socioeconomic progress and health treatments have raised living standards, but declining global environmental conditions are now impacting human health (Change, 2014). Global environmental factors like climate change and ozone depletion effect health. Protecting health from climate change starts with reducing socioeconomic and technical development that worsens global environmental circumstances. Human activities have raised greenhouse gas concentrations since the industrial revolution. These include CO_2, CH_4, N_2O, and CFCs. Global reduction of greenhouse gas-induced stratospheric ozone depletion will protect health from climate change. National and international regulations on chlorofluorocarbons (CFCs) can minimize stratospheric ozone depletion. Since CFCs are the main

refrigerants in air conditioners, the international community should work to replace them. Human-induced global environmental processes such deforestation, desertification, freshwater depletion, biodiversity loss, and fossil fuel consumption should be mitigated to reduce climate change. According to La Documentation française, International climate change and health projects include (Nwoke et al., 2009; Naylor & Ford, 2023; Satheesh, 2024):

i. The first global warming article appeared in 1967.
ii. 1987: Montreal Protocol on ozone-depleting compounds
iii. 1988: IPCC established to scientifically monitor climate change.
iv. 1992: The Earth Summit in Rio (Brazil) establishes a Framework Convention on Climate Change, ratified by 50 nations and into force in 1994.
v. 1997: Kyoto (Japan) Protocol, which binds industrialized countries to cut greenhouse gas emissions by 5.2% by 2012, relative to 1990 levels. Polluting countries might evade objectives by subsidizing reduction in other countries.
vi. 2007: The 13th UN Climate Change Conference in Bali (Indonesia) agreed on a "road-map" for a 2009 Copenhagen accord. This pact replaces Kyoto in 2012. Cancun Agreements improved adaptability in 2010.
vii. 2015: Paris Agreement emphasizes adaptation and financial aid for disadvantaged nations.
viii. 2016: Kigali Amendment to Montreal Protocol Purpose: Phased down potent greenhouse gas hydrofluorocarbons (HFCs).
ix. Katowice Climate Package (2018) Paris Agreement implementation details.
x. 2021: Glasgow Climate Pact at COP26 called for increasing adaptation funding.
xi. 2022: Sharm el-Sheikh Implementation Plan (COP27) included a "Loss and Damage" fund for climate-vulnerable nations.
xii. Global climate action reached several milestones during COP28 in Dubai.

The Loss and Damage Fund, which aids vulnerable nations affected by climate change, was a milestone. A Global Goal on Adaptation calls for climate-resilient health services and disaster risk reduction.

Adaptation Strategies

Adapting to climate change is essential to alleviate current impacts and prepare for future consequences. Effective adaptation necessitates the management of natural resources, the assurance of food security, the development of social and human capital, and the enhancement of institutions. These efforts not only foster the creation of more climate-resilient communities, regions, and nations, but they also embody sound development concepts. The efficacy of adaptation relies on the sustained involvement of governments and stakeholders. Community adaption initiatives can gain by comprehending local resilience strategies. The National Adaptation Programmes of Action (NAPAs) aid the least developed countries in identifying their critical and immediate adaptation requirements through the use of existing knowledge and community input. To adapt, the majority of these nations necessitate external assistance in the form of financial support, technological transfer, and capacity development. The health sector must lead efforts to adapt to and alleviate the impacts of climate change, considering the magnitude of the healthcare business and the perspectives of prominent health organisations like the World Health Organization (WHO).

Public health strategies for adapting to evolving disease transmission and managing natural catastrophes encompass an efficient surveillance and response system, integrated measures for rapid reaction post-disaster, and the procurement of enough supplies. Energy-efficient facilities that incorporate natural ventilation and lighting, manage on-site rainwater collection and treatment, address waste and sewage, enhance healthcare accessibility via public transportation, and utilise telehealth exemplify viable mitigation techniques. The collection of rainwater is a conservation activity promoted by the WHO South-East Asia Region. Health professionals may significantly aid other sectors in addressing climate change by disseminating their expertise. In addition to climate change, public health should advance. Considering the significance of long-term ecosystem growth and preservation for human health, any authentic preventative strategy must prioritise the establishment and sustenance of healthy ecosystems (Fawzy et al., 2020).

Conclusion

Climate change is no longer a distant threat; it's a pressing reality impacting human health on a global scale. The warming planet, altered precipitation patterns, and extreme weather events are already affecting our well-being, both physically and mentally. Climate change has many direct and indirect impacts on human health. Climate change influences human health in direct ways (heatwaves, floods, and droughts) and indirect ways (vector-borne diseases, air pollution, food security and mental health). To address these challenges following strategies are necessary (mitigation, adaptation, strengthening health systems and international cooperation). These strategies will work in the following way mitigation strategy will work (Reducing greenhouse gas emissions to slow down climate change), adaptation (implementing strategies to reduce vulnerability and build resilience to climate change impacts), strengthening health systems (investing in healthcare infrastructure, early warning systems, and public health programs) and international cooperation (collaborative efforts between countries to share knowledge, technology, and resources). Many international agreements and mitigation strategies are going on to strengthen the health system impacted by climate change. By understanding the complex relationship between climate change and human health, we can take proactive steps to protect our well-being and ensure a sustainable future for generations to come.

References

Bakhsh, K., Rauf, S., and Zulfiqar, F. (2018). Adaptation strategies for minimizing heat wave induced morbidity and its determinants. *Sustainable Cities and Society*, *41*, 95-103.

Balbus, J., Crimmins, A., Gamble, J. L., Easterling, D., Kunkel, K., Saha, S., and Sarofim, M. C. (2016). Climate change and human health. *A Scientific Assessment*, *8*, 25-42.

Biesbroek, G. R., Swart, R. J., Carter, T. R., Cowan, C., Henrichs, T., Mela, H., & Rey, D. (2010). Europe adapts to climate change: comparing national adaptation strategies. *Global Environmental Change*, *20*(3), 440-450.

Chan, F. K. S., Lu, X., Li, J., Lai, Y., Luo, M., Chen, Y. D., & Chan, H. K. (2024). Compound flood effects, challenges and solutions: Lessons toward climate-resilient Chinese coastal cities. *Ocean & Coastal Management*, *249*, 107015.

Deb, A. K., Kanungo, S., Deb, M., and Nair, G. B. (2012). Impact of climate change on health and strategies for mitigation and adaptation. *WHO South-East Asia Journal of Public Health*, *1*(1), 8-19.

Emanuel, K. (2005). Increasing destructiveness of tropical cyclones over the past 30 years. *Nature*, *436*(7051), 686-688.

Epstein, P. R. (2005). Climate change and human health. *New England Journal of Medicine*, *353*(14), 1433-1436.

Fawzy, S., Osman, A. I., Doran, J., & Rooney, D. W. (2020). Strategies for mitigation of climate change: a review. *Environmental Chemistry Letters*, *18*, 2069-2094.

Firdaus, R. R., Senevi Gunaratne, M., Rahmat, S. R., & Kamsi, N. S. (2019). Does climate change only affect food availability? What else matters? *Cogent Food & Agriculture*, *5*(1), 1707607.

Haines, A., and Patz, J. A. (2004). Health effects of climate change. *Journal of the American and Medical Association*, *291*(1), 99-103.

Haines, A., Kovats, R. S., Campbell-Lendrum, D., and Corvalan, C. (2006). Climate change and human health: impacts, vulnerability and public health. *Public Health*, *120*(7), 585-596.

Iqbal, M. P. (2020). Effect of Climate Change on Health in Pakistan: Climate Change and Health in Pakistan. *Proceedings of the Pakistan Academy of Sciences: Life and Environmental Sciences*, *57*(3), 1-12.

Kim, K. H., Kabir, E., and Ara Jahan, S. (2014). A review of the consequences of global climate change on human health. *Journal of Environmental Science and Health*, *32*(3), 299-318.

Lindgren, E., Talleklint, L., and Polfeldt, T. (2009). Impact of climatic change on the northern latitude limit and population density of the disease-transmitting European tick, *Ixodes ricinus*. *Environmental Health Perspectives*, *108*(2), 119-123.

Lu, C., Liu, Q., Qiao, Z., Yang, X., Baghani, A. N., & Wang, F. (2024). High humidity and NO2 co-exposure exacerbates allergic asthma by increasing oxidative stress, inflammatory and TRP protein expressions in lung tissue. *Environmental Pollution*, *353*, 124127. crops and management. *Journal of Environmental Management*, *351*, 119978.

Lugten, E., and Hariharan, N. (2022). Strengthening health systems for climate adaptation and health security: Key considerations for policy and programming. *Health Security*, *20*(5), 435-439.

Luterbacher, J., Dietrich, D., Xoplaki, E., Grosjean, M., and Wanner, H. (2004). European seasonal and annual temperature variability, trends, and extremes since 1500. *Science*, *303*(5663), 1499-1503.

McMichael, A. J., Woodruff, R. E., and Hales, S. (2006). Climate change and human health: present and future risks. *The Lancet*, *367*(9513), 859-869.

Mohapatra, R. K., Bhattacharjee, P., Desai, D. N., Kandi, V., Sarangi, A. K., Mishra, S., & Zahan, K. E. (2024). Global health concern on the rising dengue and chikungunya cases in the American regions: Countermeasures and preparedness. *Health Science Reports*, *7*(1), e1831.

Naylor, A. W., and Ford, J. (2023). Vulnerability and loss and damage following the COP27 of the UN Framework Convention on Climate Change. *Regional Environmental Change*, *23*(1), 38.

Nojarov, P., & Nikolova, M. (2022). Heat waves and forest fires in Bulgaria. *Natural Hazards*, *114*(2), 1879-1899.

Nwoke, B., Nwoke, E., and Ukpai, O. (2009). Effect of climate change on human health and some adaptive strategies–A review. *Bayero Journal of Pure and Applied Sciences*, *2*(1), 168-172.

Palinkas, L. A., and Wong, M. (2020). Global climate change and mental health. *Current Opinion in Psychology*, *32*, 12-16.

Parsons, E. S., Jowell, A., Veidis, E., Barry, M., & Israni, S. T. (2024). Climate change and inequality. *Pediatric Research*, *4*, 1-8.

Purse, B. V., Mellor, P. S., Rogers, D. J., Samuel, A. R., Mertens, P. P., and Baylis, M. (2005). Climate change and the recent emergence of bluetongue in Europe. *Nature Reviews Microbiology*, *3*(2), 171-181.

Satheesh, S. K. (2024). United Nations Climate Change Conference COP 28 and beyond. *Current Science*, *127*(1), 1-15.

Shah, I. H., Manzoor, M. A., Jinhui, W., Li, X., Hameed, M. K., Rehaman, A., & Chang, L. (2024). Comprehensive review: Effects of climate change and greenhouse gases emission relevance to environmental stress on horticultural crops and management. *Journal of Environmental Management*, *351*, 119978.

Siiba, A., Kangmennaang, J., Baatiema, L., & Luginaah, I. (2024). The relationship between climate change, globalization and non-communicable diseases in Africa: A systematic review. *Plos One*, *19*(2), e0297393.

Skarphedinsson, S., Jensen, P. M., and Kristiansen, K. (2005). Survey of tickborne infections in Denmark. *Emerging Infectious Diseases*, *11*(7), 1055.

Stott, P. A., Stone, D. A., and Allen, M. R. (2004). Human contribution to the European heatwave of 2003. *Nature*, *432*(7017), 610-614.

Tulu, D., Hundessa, F., Gadissa, S., & Temesgen, T. (2024). Review on the influence of water quality on livestock production in the era of climate change: perspectives from dryland regions. *Cogent Food & Agriculture*, *10*(1), 2306726.

Webster, P. J., Holland, G. J., Curry, J. A., and Chang, H. R. (2005). Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science*, *309*(5742), 1844-1846.

Zain, A., Sadarangani, S. P., Shek, L. P. C., & Vasoo, S. (2024). Climate change and its impact on infectious diseases in Asia. *Singapore Medical Journal*, *65*(4), 211-219.