JOURNAL OF MULTIDISCIPLINARY SCIENTIFIC KNOWLEDGE

Vol. 01, Issue. 02, June, 2026

Climate Change, Public Health, and Environmental Resilience: An Interdisciplinary Review of Emerging Risks and Adaptation Strategies

Ebrahim Abbasi

Received:- 07/05/2026, Revised:- 10/06/2026, Accepted:- 18/06/2026, Published:- 25/06/2026

Abstract

Public health is under growing threat from climate change, which has the potential to change environmental conditions, exacerbate extreme weather events, disrupt ecosystems, and exacerbate social inequalities. The connections between climatic hazards, emergent health risks, environmental resilience and adaptation strategies were explored using interdisciplinary synthesis of evidence produced during the period 2018-25. Scholarly studies and institutional reports found relevant to the topic were identified via major academic databases and authoritative international organisations. The results revealed that climate change was generating health threats, including increased temperatures, flooding, droughts, wildfires, air pollution, food and water insecurity, infectious diseases, mental-health pressures, and displacement; which were creating interconnected health burdens. Children, older persons, women, outdoor workers, migrants, low income groups and communities in environmentally sensitive areas were particularly impacted by these effects. Environmental resilience was identified as a key protective factor as it involves healthy ecosystems, green urban spaces, and reliable infrastructure, which contributed to the preparedness to recover from adverse conditions; and as it involves developing a social fabric that is conducive to resilience, which involves strong social networks; and as it involves ensuring that health systems are resilient to climate change, which entails their preparedness to adapt to adversity. Adaption was not just about individual solutions. The areas with the most potential for mitigation of risk included health-health action plans, early-warning systems, climate-sensitive disease surveillance, resilient healthcare facilities, nature-based solutions, participation of the community, and coordinated governance. Challenges such as lack of funding, poor institutional coherence, insufficient local information, insufficient monitoring and unequal access to adaptation resources were major hindrances. Moving forward, integrated climate health monitoring, continued investments, locally informed planning, and policies that ensure resilience for vulnerable populations and support environmental and health systems will be essential.

Keywords: Climate change, Public health, Environmental resilience, Emerging health risks, Adaptation strategies

[1]Research Center for Health Sciences, Institute of Health, Shiraz University of Medical Sciences, Shiraz, Iran

1. Introduction

Climate change is no longer a problem of warming up the atmosphere, but it is a public health, social and environmental issue that is linked. Increased temperatures, shifts in rainfall, sea-level rise, droughts, flooding, wildfire, and ecosystem degradation are affecting the context of people's birth, life, employment, and growing up. The impact is on health directly as people are exposed to hazardous weather, and indirectly as food, water, livelihoods, biodiversity, housing, sanitation, and health services are affected. The risks are already prevalent and some 3.3-3.6 billion people live in highly vulnerable climatic settings. Communities with the lowest contribution to GHGs are likely to be the most vulnerable, given their low capacity to prepare for and recover from hazards due to a lack of poverty alleviation, resilience building and access to healthcare and poor environmental characteristics (Intergovernmental Panel on Climate Change, 2023).

Recent climate observations indicate these threats are increasing. Near surface global mean temperature in 2024 was ~1.55 ± 0.13°C warmer than the long-term average (1850-1900). Ocean temperatures also rose, glaciers melted and sea levels rose, and populations in several areas were impacted by destructive weather. While one year of warming above 1.5ºC is not a breach of the long-term Paris Agreement limit, it does show the rate at which the conditions of exposure are changing (World Meteorological Organization, 2025).

It impacts upon public health via heat-related illness, cardiovascular and respiratory stress, spread of infectious illness, malnutrition, unsafe drinking water, occupational exposure, forced displacement and psychological distress. Climate shocks can also affect health facilities, cause disruptions in medicine chains, limit access to essential services and exacerbate inequalities. To ensure health, more than disaster response is necessary. It demands climate-resilient health systems, clean energy, safe water and sanitation, sustainable food systems and production, healthy urban environments and coordinated risk governance. Ten priority recommendations for global climate action featured health equity, resilient health systems, planning for adaptation, and the impact of emission reduction on health at the heart of policy responses (World Health Organization, 2021).

This change is necessary given the health burden measured. Heat-related deaths of adults over 65 years of age were more than double in 2023 compared with the 1990-99 period. Heat exposure also resulted in an estimated loss of 512 billion potential labour hours across the world; and income losses could reach US$835 billion. Ten of the 15 climate-related health hazards, exposures, and impacts that were monitored exceeded concerning records, highlighting that the costs of inaction are immediate to both human and economic health (Romanello et al., 2024).

Climatic change has been shown to cause deaths, respiratory and cardiovascular disease, infectious diseases, malnutrition, mental health impacts and bad outcomes for mothers and children in the health sector. However, evidence is still unevenly distributed and strong in lower income and climate-sensitive areas (Rocque et al., 2021). The current body of knowledge has also been focused on higher income nations, while many lower and middle income countries are far more vulnerable and with less capacity for adaptation (Berrang-Ford et al., 2021). The article thus explored a range of new climate-related health risks, the protective role that resilience of the environment plays, the

differential vulnerability, and adaptation strategies in health, ecological, social, technological and governance systems.

2. Methodology

A systematic interdisciplinary literature review was carried out to uncover evidence regarding climate change and public health, environmental resilience, emerging risks, and adaptation strategies. The literature search was done on Scopus, Web of Science, PubMed, ScienceDirect, and Google Scholar, and the relevant papers from 2018 to 2025 were found. Other documents from the World Health Organization, Intergovernmental Panel on Climate Change, World Meteorological Organization, United Nations Environment Programme, Food and Agriculture Organization, the United Nations Office for Disaster Risk Reduction, and the World Bank were also obtained. They were searching for phrases that combined "climate change" with "public health," "environmental resilience," "heat-related illness," infectious disease," "air pollution," "food insecurity," "water insecurity," "mental health," "climate vulnerability," and "adaptation strategies." English-language scholarly articles, international evaluations, policy documents and open access publications that are directly relevant to the study themes were selected. Records, editorials, conference abstracts, unavailable publications and publications that are not clearly relevant were removed. Titles and abstracts were first screened and then the full-text of the eligible sources was examined. Data on climatic hazards, health impacts, at-risk groups, climate resilience mechanisms, adaptation strategies, barriers to implementation, and research needs was gathered through a structured framework. Evidence selected was themed and compared thematically, both within and between environmental, health, social, and policy dimensions to provide an integrated overview and to clearly highlight cross-sectoral linkages.

3. Climate Change as a Driver of Environmental and Health Risks

3.1 Major Climatic and Environmental Changes

Climate has been modified by human activities, increasing the frequency of extreme heat, extreme rainfall, drought, wildfire and coastal hazard events. The mean (1850–1900) sea level rise of 0.20 m during 1901–2018 and the average surface temperature of 1.09°C over 2011–2020 (Intergovernmental Panel on Climate Change, 2021) are examples of changes that will affect the future.Changes that will affect the future include the mean (1850–1900) sea level rise of 0.20 m in 1901–2018 (Intergovernmental Panel on Climate Change, 2021) and the average surface temperature of 1.09°C over 2011–2020. During 2007–2016, agriculture, forestry and other land use accounted for approximately 23% of net anthropogenic greenhouse-gas emissions and climatic extremes affected food security, increased desertification and land degradation (Intergovernmental Panel on Climate Change, 2019a). These threats have been magnified by changes in the oceans and cryosphere, with the loss of ice from Greenland, Antarctica, and glaciers outside of the ice sheets of about 278, 155, and 220 gigatonnes per year, respectively, between 2006 and 2015 (Intergovernmental Panel on Climate Change, 2019b). Ecological disruption is also significant, as for instance, around one million species are considered to be at risk of extinction, and the abundance of native species in major terrestrial habitats has decreased by at least 20% (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019).

3.2 Pathways Linking Climate Change and Public Health

Health is impacted by climatic hazards directly and via changes in ecological and institutional conditions. Injury, illness, death, displacement and loss of services can occur due to heatwaves, floods, storms, fires, and droughts. The poverty, geography, governance and adaptive capacity, have contributed to unequal outcomes, with approximately 3.3–3.6 billion people living in settings vulnerable to climate change (Intergovernmental Panel on Climate Change, 2022). The apocalyptic consequences of the simultaneous deterioration of food, water and disease-controlling systems resulting from the synergies among the three crises (climate disruption, biodiversity loss and pollution) intensify these risks (United Nations Environment Programme, 2021). In 2018–2022, the average number of days with health-threatening temperatures was 86, with 60% of the days being more than twice as likely due to human-caused warming (Romanello et al., 2023). Climate damage can have cascading effects beyond the initial hazard, such as on electricity, transport, hospitals, water systems and supply chains, and add to resource strain on healthcare services (U.S. Global Change Research Program, 2023). Figure 1 shows the interacting pathways between climatic drivers, environmental disruption, social vulnerability, resilience and health outcomes.

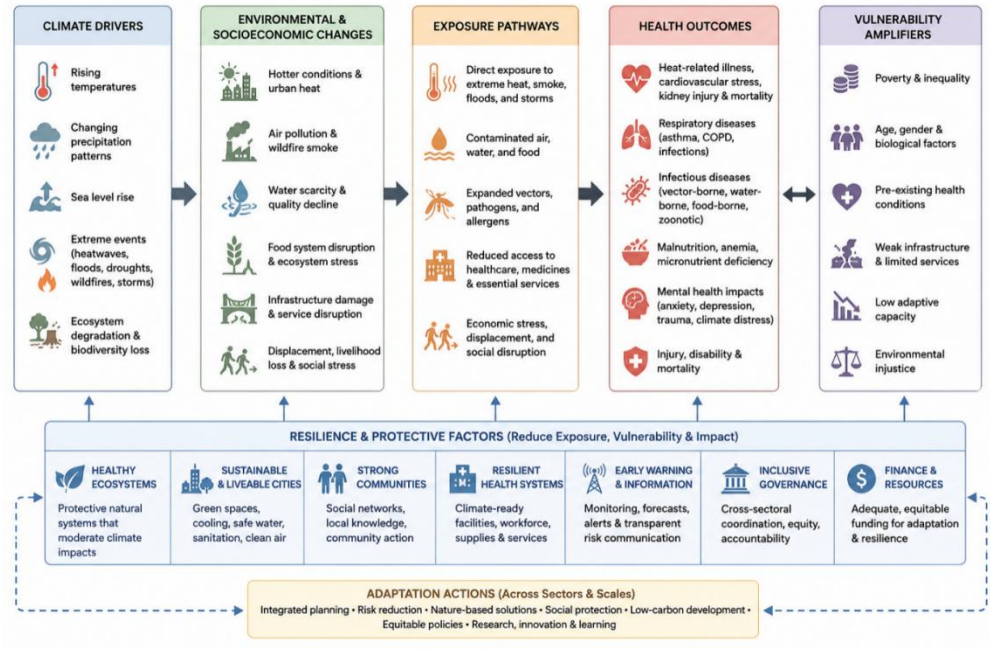

Figure 1. Integrated framework linking climate change, environmental disruption, vulnerability, resilience, and public-health outcomes.

4. Emerging Public-Health Risks

4.1 Heat-Related Illness and Mortality

Extreme heat impacts thermoregulation, exacerbates cardiovascular and kidney disease,

decreases work capacity and increases the risk of older adults, pregnant women, outdoor workers, and residents of heat-trapping cities (Ebi et al., 2021). 82% of warm-season heat-related mortality was attributed to human-induced warming in 1991 to 2018, according to Vicedo-Cabrera et al. (2021) based on evidence from 732 locations from 43 countries. Non-optimal temperatures were estimated to cause approximately 5.08 million deaths each year globally (9.43% of all deaths) between 2000 and 2019, with cold weather driving the majority of these deaths over these years, but with projections of more deaths each year from heat. (Zhao et al., 2021) Prevention continues to be the focus of urban design and occupational protection.

4.2 Climate-Sensitive Infectious Diseases

Changes in temperature and precipitation affect pathogen survivability, vector development, animal reservoirs and human contact. Projections for 2050 and 2080 showed that all three Aedes vectors (dengue, chikungunya and Zika) had areas of increased transmission suitability in the future, while extreme heat may lead to a decline in transmission suitability in some tropical areas (Ryan et al., 2019). In Europe, already there are risks associated to mosquitoes, ticks, food contamination and waterborne infections, which are triggered by climate change and therefore need to be monitored and prepared for, in the context of surveillance linked with meteorological information and preparedness (Semenza & Paz, 2021). Of the 375 reported human infectious diseases, 218, or 58%, were worsened by climatic hazards in any of the following ways: through an increase in vectors, sanitation, displacement and reduced host resistance (Mora et al., 2022).

4.3 Air Quality and Respiratory Health

Climate related wildfires produce Fine Particulate Matter, Carbon Monoxide, volatile compounds and other pollutants, which can deeply penetrate the respiratory system. Here in Southern California, every 10 μg/m³ increase in PM2.5 exposure from wildfires was linked to the increase of 1.3–10% in the number of respiratory hospital admissions, whereas the increase in the number of respiratory hospital admissions due to PM2.5 exposure from other sources was 1.3–10% per 10 μ/g/m³ (Aguilera et al., 2021). The evidence for longer-term impacts is limited, with 17 studies meeting the criteria for one synthesis, and the evidence suggested that wildfire exposure was associated with chronic respiratory, cardiovascular, psychological, and health care impacts (Grant & Runkle, 2022). Warm weather also can make ground-level ozone (O3) worse, extend the pollen allergy season and over time exacerbate asthma and chronic lung disease risks.

4.4 Food, Water, and Nutritional Insecurity

The impacts of climate variability on nutrition include lower agricultural production, food storage and transportation failures, higher food prices and food system food shifts (Fanzo et al., 2018). Carbon dioxide and climatic effects together may lead to a 19.5% decrease in protein, 13.6% decrease in iron, and 14.6% decrease in zinc nutrient availability by 2050 (Beach et al., 2019). In 2023, 733 million people were hungry, which represents 1 in 11 people worldwide and 1 in 5 people in Africa (FAO et al., 2024). Other waterborne infections like cholera are also promoted by floods, warming and inadequate sanitation in vulnerable developing parts of the world (Jung et al., 2023).

4.5 Mental Health, Displacement, and Social Disruption

Acute trauma, grief, anxiety, depression, and post-traumatic stress reactions can be observed following climate-related disasters, and helplessness, identity loss and uncertainty can result from a gradual decline of the environment (Cianconi et al., 2020). Evidence has been focused on the description of risk, rather than the evaluation of prevention, treatment, and health-system responses in the list of World Health Organization research priorities (Charlson et al., 2021). A recent study of 10000 individuals (aged 16-25) in 10 countries found that 59% were very or extremely concerned about the impacts of climate change and over 45% said climate change had affected how they functioned in their daily lives (Hickman et al., 2021). These psychological impacts can be significantly compounded by displacement, loss of livelihoods and of community networks. Table 1 shows the principle climate-related health risks and their routes of exposure.

Table 1. Major Climate-Related Public-Health Risks

Climate-related risk	Main health effects	Key evidence
Extreme heat	Heatstroke, cardiovascular stress, kidney injury, reduced work capacity, and mortality	Human-induced warming accounted for an estimated 37% of warm-season heat-related deaths across 732 locations
Infectious diseases	Increased vector-borne, waterborne, foodborne, and zoonotic diseases	Climate hazards aggravated 218 of 375 documented infectious diseases
Wildfire smoke and air pollution	Asthma, respiratory admissions, cardiovascular stress, and chronic lung disease	A 10 μg/m³ increase in wildfire $PM_{2.5}$ was associated with 1.3–10% higher respiratory admissions

Food and water insecurity	Hunger, malnutrition, micronutrient deficiency, diarrhoeal disease, and unsafe water exposure	About 733 million people experienced hunger in 2023
Mental health and displacement	Anxiety, depression, trauma, climate distress, livelihood loss, and social disruption	Among 10,000 young people, 59% were very or extremely worried about climate change

5. Environmental Resilience and Public-Health Protection

5.1 Ecosystem Resilience and Health-Supporting Services

Ecosystems serve as buffers for populations by regulating temperature, carbon storage, water flow, pollution filtering, and flood and erosion protection. Well-designed monocultures or projects excluding communities can work for adaptation, mitigation, biodiversity and well-being, but can also lead to maladaptation (Seddon et al., 2020). A global evidence map revealed that ecosystem-based interventions had, on average, fewer trade-offs than engineered solutions, and were found to be as effective, if not more effective, than engineered solutions, albeit with limited evidence of cost-effectiveness (Chausson et al., 2020). Biodiversity has been found to regulate the immune system, provide nutrition, enable microbial exposure, provide psychological rest, and protect against infectious and non-communicable diseases (Marselle et al., 2021).

5.2 Urban and Community Resilience

Green space, safe housing, social cohesion, local knowledge, and preparedness for heat, flooding and other hazards all are important factors for urban and community resilience. Biocultural services are relevant to mental health planning; contact with natural environments that are diverse in their species can decrease stress, regulate attention, motivate physical activity, and promote social connection (Bratman et al., 2019). After reviewing 143 studies, higher greenspace exposure was found to be correlated with lower cortisol levels in saliva, heart rate, diastolic blood pressure, preterm birth, type 2 diabetes, cardiovascular mortality, and all-cause mortality (Twohig-Bennett & Jones, 2018). Equitable access is important as climate vulnerable neighbourhoods are less likely to have environmental resources.

5.3 Climate-Resilient Health Systems

Climate-resilient health systems need to provide safe health care services during periods of extreme weather and mitigate pressures from health systems operations. The facilities needed were reliable power, water, sanitation, waste disposal, trained staff, emergency plans and infrastructure that would withstand local hazards (World Health Organization, 2020). The operational structure was broken down into 10 interdependent components:

governance, workforce, vulnerability assessment, surveillance, climate informed programmes, infrastructure, supply chains, financing, emission management, and several others (World Health Organization, 2023). Recent guidance highlighted that climate adaptation, environmental sustainability and access to all essential services need to be integrated elements of safe facilities, rather than being addressed as distinct objectives (World Health Organization, 2024).

6. Unequal Vulnerability and Climate-Health Inequities

6.1 Vulnerable Populations

Climate hazards are not uniform and do not impact all populations in the same way. Malnutrition, diarrhoeal disease, respiratory illness, heat, and disruption of education and care are threats that are greater for children than for adults (Helldén et al., 2021). Almost a billion children were in countries that were extremely high risk due to high levels of environmental exposure and low levels of essential services (UNICEF, 2021). Heat, food insecurity, displacement and limited access to reproductive health services were additional risks to women, especially pregnant women, (Sorensen et al., 2018). Outdoor workers were also exposed, with a loss of 2.2% of global working hours due to heat stress by 2030, or 80 million full-time jobs (Kjellstrom et al., 2019).

6.2 Geographical and Socioeconomic Inequalities

Geographical vulnerability is the combination of unequal development and physical exposure. Lack of protective resources can make hazard exposure greater for low income countries, small islands, coastal areas, arid regions, informal settlements, and disaster prone communities. Climate exposure is only part of the equation of vulnerability, as it is influenced by historical marginalisation, insecure livelihoods, political exclusion, and unequal access to infrastructure, among other factors (Thomas et al., 2019). Without climate and development action, the number of people in six regions moving within countries due to slow-onset changes in water availability, crop productivity, and sea-level conditions could reach up to 216 million people by 2050 (Clement et al., 2021). These pressures can exacerbate the situation of poverty, crowding and the need for health services.

6.3 Structural Determinants of Adaptive Capacity

Adaptive capacity is linked to the ability to access safe housing, health care, education, income, information, and social protection prior to and following climatic shocks. Limited choices due to poverty restrictions on savings and mobility, and gender inequality, insecure tenure, weak governance and underfunded services. The disadvantages frequently overlap, resulting in a lack of representation of migrants, Indigenous people, informal workers and those with health needs in planning. Issa et al. (2023) found fragmented definitions, limited data, ethical concerns, insufficient funding, and poor collaboration to be barriers across the climate–migration–health nexus from 72 practitioners. For this reason, inclusive institutions, accessible services, accountable governance and social condition responsive policies were necessary for effective adaptation. The major dimensions of unequal climate-health vulnerability are presented in Table 2.

Table 2. Vulnerable Populations and Priority Protection Measures

Population or setting	Main vulnerabilities	Priority measures
Children and adolescents	Malnutrition, heat exposure, infectious diseases, disrupted education, and climate anxiety	Resilient schools, nutrition support, clean water, early warnings, and mental-health services
Women and pregnant populations	Heat exposure, food insecurity, caregiving burdens, displacement, and interrupted reproductive care	Maternal healthcare continuity, safe shelters, social protection, and gender-responsive planning
Outdoor workers	Occupational heat, dehydration, kidney stress, productivity loss, and weak labour protection	Hydration, shade, work–rest schedules, heat thresholds, and income safeguards
Migrants and low-income communities	Unsafe housing, limited healthcare, livelihood loss, overcrowding, and weak infrastructure	Planned mobility, primary healthcare, safe housing, livelihood support, and equitable adaptation finance

7. Adaptation Strategies for Health and Environmental Resilience

7.1 Public-Health Adaptation

Public-health adaptation took climate evidence and made it relevant to a variety of preventive services, emergency readiness, and care. The six areas that were covered by

effective health national adaptation plans were: leadership; cross-sector coordination; climate-sensitive health risks; adaptation actions; resources; and monitoring (World Health Organization, 2021). Some of the most useful elements were: Heat-health action plans, Disease surveillance, Vaccination, Emergency response, Risk communication when combined with local exposure data and with vulnerable groups. An evaluation of 19 national adaptation plans revealed that health issues had been acknowledged, but that the plans lacked clear plans for implementation, financing and measurable outcomes (World Health Organization & International Institute for Sustainable Development, 2021). More robust plans needed defined accountability and dedicated funding.

7.2 Ecosystem-Based and Nature-Based Adaptation

Ecosystem based adaptation increased environmental protection and decreased exposure to health risks. The restoration of wetlands reduced flooding, protected water quality; reforestation reduced soil erosion, stored carbon, and reduced heat; watershed protection maintained water supplies; and biodiversity conservation maintained biological functions associated with nutrition and disease regulation. Urban greening also reduced radiant heat and made for cooler routes, neighbourhoods and public spaces. The interventions were most successful when designed based on species, water availability, maintenance requirements and community priorities. Green infrastructure should be considered alongside, not in place of, other heat-warning systems, safe buildings, hydration, ventilation, and accessible cooling, as no single intervention will protect populations during a severe heat event (Jay et al., 2021).

7.3 Infrastructure and Technological Adaptation

Infrastructure and technological adaptation to ensure services like health care, water systems, transport, energy and communication remain operational in times of climatic shocks. Health facilities needed flood safe locations, passive cooling, access to reliable electricity, protected medicine storage, water security, sanitation, and back-up supply chains. Digital monitoring associated weather forecast, heat illness, air pollution, vector activity, and emergency demand, thus enabling earlier action. The disaster mortality in countries with limited early-warning coverage was eight times that of countries with substantial and comprehensive early-warning coverage (World Meteorological Organization, 2023). To support climate-informed planning, the information should be interoperable, people should be trained, and alerts, equipment maintenance, and communication formats should be available to remote and marginalised communities in emergency situations.

7.4 Governance and Community-Based Adaptation

Governance was a factor in determining the delivery of adaptation resources to exposed communities. International adaptation finance to developing countries rose from US$22 billion in 2021 to US$28 billion in 2022, but the finance gap stood at US$187–359 billion (United Nations Environment Programme, 2024). The synthesis of evidence drawn from over 48,000 screened publications and 1,682 studies revealed that implemented adaptation was often local and limited in scope, and was often implemented in a piecemeal and incremental way (Berrang-Ford et al., 2021). Thus, a cross-sector co-ordination, community knowledge, transparent budgeting and meaningful community participation was required for implementation. People-centred climate policies also needed people-centred resilience, accountability of institutions and intergovernmental

and inter-agency and civil society cooperation (World Health Organization, 2024). The most important adaptation strategies and their protective functions are summarized in Table 3.

Table 3. Adaptation Strategies for Health and Environmental Resilience

Adaptation domain	Main strategies	Expected contribution
Public-health adaptation	Heat action plans, disease surveillance, emergency preparedness, vaccination, and risk communication	Earlier detection, reduced illness, and stronger emergency response
Nature-based adaptation	Wetland restoration, reforestation, watershed protection, biodiversity conservation, and urban greening	Reduced heat and flood exposure, improved water regulation, and ecosystem protection
Infrastructure and technology	Resilient hospitals, backup energy, passive cooling, secure water systems, digital monitoring, and early warnings	Continuity of essential services and faster hazard response
Governance and community action	Climate finance, local participation, social protection, transparent budgeting, and cross-sector coordination	More equitable implementation, stronger accountability, and improved community resilience

Figure 2 illustrates how ecosystem, community, infrastructure, health-system, governance, finance, and knowledge interventions operate as mutually reinforcing levels of adaptation.

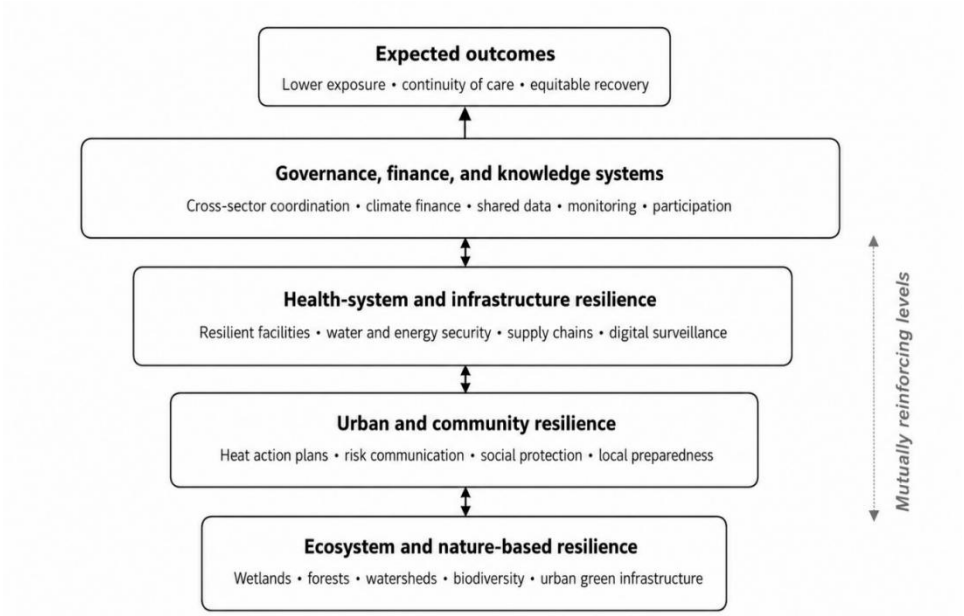

Figure 2. Multilevel model of adaptation for public health and environmental resilience.

8. Implementation Challenges, Research Gaps, and Future Directions

8.1 Barriers to Effective Adaptation

Barriers to implementation persisted, and included limited political tenure, lack of funding, weak local capacity, lack of coordination between health, environment, infrastructure and disaster agencies. The risk creation was still greater than the risk reduction, and the trends indicated that there may be approximately 560 events annually in the world or 1.5 event per day by 2030 (United Nations Office for Disaster Risk Reduction, 2022). Plans that did not include any enforceable responsibilities or budgets, community involvement, or tracking mechanisms to assess the effects of adaptation were found to be less effective. They needed to invest in risk-informed investments, share data, hold institutions accountable, and put policies in place to tackle interconnected hazards instead of viewing each emergency as a standalone incident.

8.2 Evidence and Knowledge Gaps

There were key areas of unfilled evidence needs in the climate field, health field, and resilience field. Lack of long-term exposure data, locally disaggregated health records, consistent resilience indicators and assessments of the impact of adaptation on illness or inequality were present in many countries. World Health Assembly (2024): Better surveillance, vulnerability assessment, health-system resilience, research, financing and integration of climate concerns into health programmes; health systems account for about 5% of global carbon emissions. Future studies required to differentiate planned actions from actual measures, and to assess effectiveness over time. An increase in the presence

of low-income areas, migrants, informal workers, women, children and Indigenous peoples was needed.

8.3 Future Interdisciplinary Priorities

Future priorities focused on integrated climate-health surveillance, climate services that are useful, finance that is equitable, and a closer coupling between research and decisions. The proportion of national meteorological and hydrological services providing climate services at an essential level was one third in 2024, with almost a third also providing advanced or full capacity climate services, highlighting significant global gaps (World Meteorological Organization, 2024). Financial constraints remained significant with developing countries still experiencing a high level of demand for adaptation compared to the level of financial flows (United Nations Environment Programme, 2025). Steps were needed to ensure that data were interoperable, One Health approaches were implemented, there was community-led planning, workforce development, transparent evaluation and long-term investment in resilient health and environmental systems.

9. Conclusion

Climate change is altering the environmental factors that underpin human health; exacerbating exposure to heat; exposure to infectious diseases; air pollution; food and water insecurity; psychological stress; displacement and straining of healthcare systems. The impacts are not uniform, with children, elderly, women, outdoor workers, migrants, low-income populations and people in climate-sensitive areas exposed to more impacts while having less protective capacity. Resilience to the environment is then a public-health role. A healthy ecosystem, climate-ready cities, resilient infrastructure, effective social networks, and responsive health services can limit exposure, aid recovery, and minimize hazards from turning into a crisis. No single intervention can lead to effective adaptation. It can't be achieved without coherence between public health, environmental management, urban planning, disaster governance, agriculture, water systems and social protection. Early-warning systems, heat action plans, climate-sensitive surveillance, NbS, resilient healthcare facilities and community-led planning provide practical pathways, and their effectiveness and implementation requires ongoing financial support, local engagement, institutional accountability and monitoring. There is a need to pay more attention to future action in vulnerable areas, long-term evaluation, integrated data systems, and equitable access to adaptation resources. Decisions for building resilience will need to be taken in a context-sensitive way, safeguarding health, restoring environmental functions and decreasing existing inequalities, while equipping societies for growing and future climate risks, across the generations and all the world.

References

[1] Aguilera, R., Corringham, T., Gershunov, A., & Benmarhnia, T. (2021). Wildfire smoke impacts respiratory health more than fine particles from other sources: Observational evidence from Southern California. Nature Communications, 12, Article 1493. https://doi.org/10.1038/s41467-021-21708-0

[2] Beach, R. H., Sulser, T. B., Crimmins, A., Cenacchi, N., Cole, J., Fukagawa, N. K., Mason-D'Croz, D., Myers, S., Sarofim, M. C., Smith, M., & Ziska, L. H. (2019). Combining the effects of increased atmospheric carbon dioxide on protein, iron, and zinc availability and projected climate change on global diets: A modelling study. The Lancet Planetary Health, 3(7), e307–e317. https://doi.org/10.1016/S2542-5196(19)30094-4

[3] Berrang-Ford, L., Siders, A. R., Lesnikowski, A., et al. (2021). A systematic global

stocktake of evidence on human adaptation to climate change. Nature Climate Change, 11(11), 989–1000. https://doi.org/10.1038/s41558-021-01170-y
[4] Berrang-Ford, L., Sietsma, A. J., Callaghan, M., Minx, J. C., Scheelbeek, P. F. D., Haddaway, N. R., Haines, A., & Dangour, A. D. (2021). Systematic mapping of global research on climate and health: A machine learning review. The Lancet Planetary Health, 5(8), e514–e525. https://doi.org/10.1016/S2542-5196(21)00179-0
[5] Bratman, G. N., Anderson, C. B., Berman, M. G., et al. (2019). Nature and mental health: An ecosystem service perspective. Science Advances, 5(7), Article eaax0903. https://doi.org/10.1126/sciadv.aax0903
[6] Charlson, F., Ali, S., Benmarhnia, T., Pearl, M., Massazza, A., Augustinavicius, J., & Scott, J. G. (2021). Climate change and mental health: A scoping review. International Journal of Environmental Research and Public Health, 18(9), Article 4486. https://doi.org/10.3390/ijerph18094486
[7] Chausson, A., Turner, B., Seddon, D., Chabaneix, N., Girardin, C. A. J., Kapos, V., Key, I., Roe, D., Smith, A., Woroniecki, S., & Seddon, N. (2020). Mapping the effectiveness of nature-based solutions for climate change adaptation. Global Change Biology, 26(11), 6134–6155. https://doi.org/10.1111/gcb.15310
[8] Cianconi, P., Betrò, S., & Janiri, L. (2020). The impact of climate change on mental health: A systematic descriptive review. Frontiers in Psychiatry, 11, Article 74. https://doi.org/10.3389/fpsyt.2020.00074
[9] Clement, V., Rigaud, K. K., de Sherbinin, A., Jones, B., Adamo, S., Schewe, J., Sadiq, N., & Shabahat, E. (2021). Groundswell Part 2: Acting on internal climate migration. World Bank.
[10] Ebi, K. L., Capon, A., Berry, P., Broderick, C., de Dear, R., Havenith, G., Honda, Y., Kovats, R. S., Ma, W., Malik, A., Morris, N. B., Nybo, L., Seneviratne, S. I., Vanos, J., & Jay, O. (2021). Hot weather and heat extremes: Health risks. The Lancet, 398(10301), 698–708. https://doi.org/10.1016/S0140-6736(21)01208-3
[11] Fanzo, J., Davis, C., McLaren, R., & Choufani, J. (2018). The effect of climate change across food systems: Implications for nutrition outcomes. Global Food Security, 18, 12–19. https://doi.org/10.1016/j.gfs.2018.06.001
[12] Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development, UNICEF, World Food Programme, & World Health Organization. (2024). The state of food security and nutrition in the world 2024: Financing to end hunger, food insecurity and malnutrition in all its forms. Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/cd1254en
[13] Grant, E., & Runkle, J. D. (2022). Long-term health effects of wildfire exposure: A scoping review. The Journal of Climate Change and Health, 6, Article 100110. https://doi.org/10.1016/j.joclim.2021.100110
[14] Helldén, D., Andersson, C., Nilsson, M., Ebi, K. L., Friberg, P., & Alfvén, T. (2021). Climate change and child health: A scoping review and an expanded conceptual framework. The Lancet Planetary Health, 5(3), e164–e175. https://doi.org/10.1016/S2542-5196(20)30274-6
[15] Hickman, C., Marks, E., Pihkala, P., Clayton, S., Lewandowski, R. E., Mayall, E. E., Wray, B., Mellor, C., & van Susteren, L. (2021). Climate anxiety in children and young people and their beliefs about government responses to climate change: A global survey. The Lancet Planetary Health, 5(12), e863–e873. https://doi.org/10.1016/S2542-5196(21)00278-3
[16] Intergovernmental Panel on Climate Change. (2019a). Climate change and land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.
[17] Intergovernmental Panel on Climate Change. (2019b). IPCC special report on the ocean and cryosphere in a changing climate.
[18] Intergovernmental Panel on Climate Change. (2021). Climate change 2021: The physical science basis. Cambridge University Press. https://doi.org/10.1017/9781009157896
[19] Intergovernmental Panel on Climate Change. (2022). Climate change 2022: Impacts, adaptation and vulnerability. Cambridge University Press. https://doi.org/10.1017/9781009325844
[20] Intergovernmental Panel on Climate Change. (2023). Climate change 2023: Synthesis report. https://doi.org/10.59327/IPCC/AR6-9789291691647
[21] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2019). Global assessment report on biodiversity and ecosystem services (E. S.

Brondízio, J. Settele, S. Díaz, & H. T. Ngo, Eds.). IPBES Secretariat. https://doi.org/10.5281/zenodo.3831673
[22] Issa, R., Sarsour, A., Cullip, T., Toma, S., Ruyssen, I., & Scheerens, C. (2023). Gaps and opportunities in the climate change, migration and health nexus: Insights from a questionnaire-based study of practitioners and researchers. Journal of Migration and Health, 7, Article 100171. https://doi.org/10.1016/j.jmh.2023.100171
[23] Jay, O., Capon, A., Berry, P., Broderick, C., de Dear, R., Havenith, G., Honda, Y., Morris, N. B., Nybo, L., Seneviratne, S. I., Vanos, J., & Ebi, K. L. (2021). Reducing the health effects of hot weather and heat extremes: From personal cooling strategies to green cities. The Lancet, 398(10301), 709–724. https://doi.org/10.1016/S0140-6736(21)01209-5
[24] Jung, Y.-J., Khant, N. A., Kim, H., & Namkoong, S. (2023). Impact of climate change on waterborne diseases: Directions towards sustainability. Water, 15(7), Article 1298. https://doi.org/10.3390/w15071298
[25] Kjellstrom, T., Maître, N., Saget, C., Otto, M., & Karimova, T. (2019). Working on a warmer planet: The impact of heat stress on labour productivity and decent work. International Labour Organization.
[26] Marselle, M. R., Hartig, T., Cox, D. T. C., et al. (2021). Pathways linking biodiversity to human health: A conceptual framework. Environment International, 150, Article 106420. https://doi.org/10.1016/j.envint.2021.106420
[27] Mora, C., McKenzie, T., Gaw, I. M., et al. (2022). Over half of known human pathogenic diseases can be aggravated by climate change. Nature Climate Change, 12, 869–875. https://doi.org/10.1038/s41558-022-01426-1
[28] Rocque, R. J., Beaudoin, C., Ndjaboue, R., Cameron, L., Poirier-Bergeron, L., Poulin-Rheault, R.-A., Fallon, C., Tricco, A. C., & Witteman, H. O. (2021). Health effects of climate change: An overview of systematic reviews. BMJ Open, 11(6), Article e046333. https://doi.org/10.1136/bmjopen-2020-046333
[29] Romanello, M., Di Napoli, C., Drummond, P., et al. (2023). The 2023 report of the Lancet Countdown on health and climate change: The imperative for a health-centred response in a world facing irreversible harms. The Lancet, 402(10419), 2346–2394. https://doi.org/10.1016/S0140-6736(23)01859-7
[30] Romanello, M., Walawender, M., Hsu, S.-C., et al. (2024). The 2024 report of the Lancet Countdown on health and climate change: Facing record-breaking threats from delayed action. The Lancet, 404(10465), 1847–1896. https://doi.org/10.1016/S0140-6736(24)01822-1
[31] Ryan, S. J., Carlson, C. J., Mordecai, E. A., & Johnson, L. R. (2019). Global expansion and redistribution of Aedes-borne virus transmission risk with climate change. PLOS Neglected Tropical Diseases, 13(3), Article e0007213. https://doi.org/10.1371/journal.pntd.0007213
[32] Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society B: Biological Sciences, 375(1794), Article 20190120. https://doi.org/10.1098/rstb.2019.0120
[33] Semenza, J. C., & Paz, S. (2021). Climate change and infectious disease in Europe: Impact, projection and adaptation. The Lancet Regional Health–Europe, 9, Article 100230. https://doi.org/10.1016/j.lanepe.2021.100230
[34] Sorensen, C., Murray, V., Lemery, J., & Balbus, J. (2018). Climate change and women's health: Impacts and policy directions. PLOS Medicine, 15(7), Article e1002603. https://doi.org/10.1371/journal.pmed.1002603
[35] Thomas, K., Hardy, R. D., Lazrus, H., Mendez, M., Orlove, B., Rivera-Collazo, I., Roberts, J. T., Rockman, M., Warner, B. P., & Winthrop, R. (2019). Explaining differential vulnerability to climate change: A social science review. WIREs Climate Change, 10(2), Article e565. https://doi.org/10.1002/wcc.565
[36] Twohig-Bennett, C., & Jones, A. (2018). The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes. Environmental Research, 166, 628–637. https://doi.org/10.1016/j.envres.2018.06.030
[37] U.S. Global Change Research Program. (2023). Fifth national climate assessment (A. R. Crimmins et al., Eds.). https://doi.org/10.7930/NCA5
[38] UNICEF. (2021). The climate crisis is a child rights crisis: Introducing the Children's Climate Risk Index.
[39] United Nations Environment Programme. (2021). Making peace with nature: A

scientific blueprint to tackle the climate, biodiversity and pollution emergencies.
[40] United Nations Environment Programme. (2024). Adaptation gap report 2024: Come hell and high water.
[41] United Nations Environment Programme. (2025). Adaptation gap report 2025: Running on empty.
[42] United Nations Office for Disaster Risk Reduction. (2022). Global assessment report on disaster risk reduction 2022: Our world at risk—Transforming governance for a resilient future.
[43] Vicedo-Cabrera, A. M., Scovronick, N., Sera, F., et al. (2021). The burden of heat-related mortality attributable to recent human-induced climate change. Nature Climate Change, 11, 492–500. https://doi.org/10.1038/s41558-021-01058-x
[44] World Health Assembly. (2024). Climate change and health (WHA77.14). World Health Organization.
[45] World Health Organization. (2020). WHO guidance for climate-resilient and environmentally sustainable health care facilities.
[46] World Health Organization. (2021a). COP26 special report on climate change and health: The health argument for climate action.
[47] World Health Organization. (2021b). Quality criteria for health national adaptation plans.
[48] World Health Organization. (2023). Operational framework for building climate-resilient and low-carbon health systems.
[49] World Health Organization. (2024a). COP29 special report on climate change and health: Health is the argument for climate action.
[50] World Health Organization. (2024b). Safe, climate-resilient and environmentally sustainable health care facilities: An overview. https://doi.org/10.2471/B09119
[51] World Health Organization, & International Institute for Sustainable Development. (2021). Health in national adaptation plans: Review. World Health Organization.
[52] World Meteorological Organization. (2023). 2023 state of climate services: Health (WMO-No. 1335).
[53] World Meteorological Organization. (2024). 2024 state of climate services (WMO-No. 1363).
[54] World Meteorological Organization. (2025). State of the global climate 2024 (WMO-No. 1368).
[55] Zhao, Q., Guo, Y., Ye, T., et al. (2021). Global, regional, and national burden of mortality associated with non-optimal ambient temperatures from 2000 to 2019: A three-stage modelling study. The Lancet Planetary Health, 5(7), e415–e425. https://doi.org/10.1016/S2542-5196(21)00081-4