Impact of Climate Change on Global Health: A Comprehensive Review

ABSTRACT

Climate change poses significant challenges to global health, with far-reaching implications for human health and well-being. This comprehensive review synthesizes evidence from diverse disciplines to elucidate the complex relationship between climate change and health. Key areas of focus include the direct impacts of extreme weather events, alterations in infectious disease transmission, air quality changes, food security issues, and mental health effects. Vulnerable populations, including low-income communities and indigenous peoples, are disproportionately affected, emphasizing the need for targeted interventions and equitable adaptation strategies. Methodologically, a search of peer-reviewed literature was conducted, covering studies published up to 2024. Both quantitative and qualitative studies were included, and thematic analysis was employed to identify patterns and trends. The review highlights gaps in current policy frameworks and international cooperation efforts, calling for enhanced collaboration and knowledge sharing to address the multifaceted challenges posed by climate change on health. Furthermore, proactive adaptation measures, robust public health infrastructure, and inclusive strategies are essential to mitigate adverse health impacts and foster resilience. By prioritizing collective action and interdisciplinary collaboration, we can work towards a healthier and more resilient future in the face of climate change.

Keywords:climate change, global health, epidemiology, environmental science, public health, and policy

INTRODUCTION

Climate change is one of the most pressing challenges of the 21st century, with far-reaching implications for various aspects of human existence [1]. Among its myriad consequences, the impact on global health emerges as a major concern. The intricate interplay between climate change and health encompasses a spectrum of direct and indirect effects, spanning from the rise in extreme weather events to altered disease patterns and exacerbation of existing health disparities [2].

In the past few decades, there has been a growing scientific consensus affirming the existence of anthropogenic climate change, attributing it primarily to the emission of greenhouse gases resulting from human activities. This acknowledgment has prompted extensive research into understanding the multifaceted ways in which a changing climate intersects with human health, both at the local and global scales [3, 74-76].

This comprehensive review aims to synthesize the wealth of knowledge accumulated from diverse disciplines, ranging from epidemiology and environmental science to public health and policy studies. By examining the latest scientific findings, statistical analyses, and case

studies, this review seeks to provide a holistic understanding of the complex relationship between climate change and global health.

METHODOLOGY

A comprehensive search of peer-reviewed articles, reports, and other relevant publications was conducted using electronic databases such as PubMed, Scopus, Web of Science, and Google Scholar. Keywords and search terms related to climate change, global health, epidemiology, environmental science, public health, and policy were used to identify relevant studies. The search was restricted to articles written in English and covered literature published up to 2004- 2024. Studies were included based on predefined inclusion criteria, which encompassed relevance to the intersection of climate change and health, originality of research findings, and methodological rigor. Both quantitative and qualitative studies were considered, including observational studies, ecological analyses, modeling studies, and systematic reviews/meta-analyses. No primary data collection was conducted as part of this study.

EPIDEMIOLOGY OF CLIMATE-RELATED HEALTH RISK

Climate change has profound implications for public health, with epidemiological studies offering critical insights into the complex relationship between environmental shifts and health outcomes [4]. A study investigating the correlation between climate change and health outcomes that investigated the Influence of temperature and precipitation on birth weight in Africa reported that that climate factors do affect birth weight, with implications akin to the influence of factors such as women's educational attainment or household access to electricity [5]. Other studies have revealed that child born in 2020 is expected to face 4–7 times more heat waves in their lifetime compared to one born in 1960, this increase in extreme heat correlates with higher risks of health issues such as renal and respiratory diseases, leading to excess mortality and morbidity [6].

An ecological time-series study which analyzed the impact of climate-sensitive variables on health outcomes using a generalized linear model over five years (2009-2014) reported significant increases in water-borne, vector-borne, and renal disease hospitalizations, along with heart disease hospitalizations and all-cause mortality attributed to temperature increases [7]. Similarly, an observational study which involved data from 5033 patients admitted to a tertiary hospital showed significant rises in disease incidence, particularly during the rainy season, positive correlations were found between temperature and diseases like malaria and diarrhea, while humidity correlated with malaria and diarrhea but inversely with meningitis and encephalitis [8]. Other climate-related health risks are linked with the social, economic and demographic disruptions often triggered by climate change [9]. Furthermore, a risk assessment on the disease burden from climate change indicates that the Pacific Ocean, the Indian Ocean, and sub-Saharan Africa bear the greatest health impacts of climate change [10–12].

EXTREME WEATHER EVENTS AND HEALTH IMPACTS

Studies indicate a rise in the frequency and intensity of hurricanes due to climate change, leading to significant physical and mental health consequences. Hurricanes are associated with the onset and worsening of various diseases, with adverse health effects peaking within

six months post-exposure. Additionally, chronic conditions such as cardiovascular disease and post-traumatic stress disorder (PTSD) persist for years following hurricane impacts [13,14]. Similarly, climate change-induced flood disasters have escalated in frequency and severity globally [15]. These events not only present immediate hazards to human health but also constitute ongoing consequences due to displacement and exacerbated living conditions, extreme whether events like floods pose immediate health risks like drowning, injuries, hypothermia, and animal bites, medium-term effects include infected wounds, mental health issues, and communicable diseases while long-term consequences include chronic diseases, disabilities, mental health issues, and poverty-related ailments like malnutrition [16,17].

The link between climate change and the frequency and intensity of extreme heat events is also well established with climate models predicting increased heat waves, especially in higher latitudes, impacting urban areas lacking adaptation measures [18]. Studies have shown that the growing awareness of the health risks from extreme weather has spurred policy interventions like warning systems, public education on creating cool environments, expanding green spaces, and improving infrastructure for ventilation and heat reduction. These measures aim to mitigate heat-related health issues and enhance public well-being [19].

VECTOR-BORNE DISEASES AND CLIMATE CHANGE

Several studies have documented the relationship between climate change and the distribution of vector-borne diseases like malaria, dengue fever, and Lyme disease with a resultant effect on the transmission of infectious, vector-borne diseases [20]. A regional analysis indicates that climatic anomalies linked to the El Niño-Southern Oscillation phenomenon, such as droughts and floods, are projected to become more frequent and intense. This trend is expected to also lead to increased outbreaks of malaria in Africa, Asia, and South America [21].

The principal vector for dengue (*Aedesaegypti*) is very sensitive to changes in climate and climate patterns and an European case study has reported elevated risk of the disease near the coastlines of the Mediterranean and Adriatic seas, as well as in the Po Valley in northern Italy [22,23]. Similarly, a study conducted using a climate-based logistic model revealed that the main vector of Lyme disease in North America, *Ixodesscapularis*, is projected to significantly expand its habitat northward into Canada, with a predicted increase of 213% by the 2080s, the vector is also projected to retract from the southern U.S. and shift its presence towards the central U.S due to changing climate [24]. Recent studies also reveal a shift in the approach to vector control measures from traditional methods which has several limitations to evidence-based approaches, informed by a better understanding of the factors influencing pathogen transmission and associated variations attributed to climate change [25, 26].

AIR QUALITY AND RESPIRATORY HEALTH

Climate change can impact air pollutant exposure through various mechanisms such as altering weather patterns, emissions from human activities, and natural emissions, as well as changing the distribution and types of airborne allergens [27], studies indicate that Europe is highly vulnerable to climate-induced changes in air pollution patterns due to urbanization which significantly impact respiratory health, both on their own and in combination with weather conditions [28].

Furthermore, a case-crossover study spanning from 2004 to 2013 found that the epidemiology of hospital admissions due to COPD exacerbation was adversely impacted by colder climatic conditions, including seasonality and absolute temperature, as well as short-term exposure to major air pollutants such as NO_2, O_3, CO and PM_{10} which are known to exacerbate the effects of climate change and complicate mitigating efforts [29].In addition, the rising temperatures associated with climate change exacerbate ground-level ozone pollution which can irritate the lungs and induce asthma attacks, the warming climate can also extend the pollen season potentially triggering asthma attacks in children whose asthma is allergy-induced [30–32].

Nevertheless, there's a growing recognition of air pollution as a significant contributor to chronic, non-communicable diseases globally, acknowledging the shared responsibility in prevention [33], there's a push for expanding research and evaluation methods, as well as fostering inter-sectoral and cross-disciplinary collaborations to mitigate these risks [34].

FOOD SECURITY AND NUTRITION

Agricultural practices are very susceptible to the effects of climate change and projections to 2050 indicate a rise in global average temperatures and heightened weather variability, which will influence the types and geographic distribution of agricultural yields, food systems crop improvement and biodiversity worldwide [35, 36].

Climate change has also added a huge layer of uncertainty for food security projections and current estimates suggest that the impact of climate change on food systems will be most pronounced in the global South, particularly in regions such as Africa south of the Sahara and Southeast Asia, these areas are particularly vulnerable to the effects of rising temperatures and erratic weather patterns, posing significant challenges to agricultural systems and food security [37, 38]. In addition, malnutrition, and micronutrient deficiencies are often exacerbated by climate-induced disruptions to food systems this presents a huge challenge and severe threats to the health of children [39, 40].

Over the years strategies for enhancing food security, promoting sustainable agriculture, and improving nutritional resilience in the face of climate change have been growing with radical agro-ecological practices suggested as the most important measure to enhance the resilience of farmers and rural communities by diversifying agro-ecosystems through polycultures, agro-forestry systems, and crop-livestock mixed systems, even though No single solution is expected to suffice [41, 42].

WATERBORNE DISEASES AND SANITATION CHALLENGES

The impact of climate change on water quality, availability, and sanitation infrastructure has been very significant, from changing sources of drinking water which affects quality and renders them unsafe to increased rate of water pollutants as well as decreased water availability from saltwater intrusion and droughts [43].

An evaluation on the resilience of water supply and sanitation systems in anticipation of projected climate changes by 2020 and 2030 revealed that very few technologies are equipped to withstand the impacts of climate change undermining current advancements toward achieving the Millennium Development Goals (MDGs) [44]. In addition, analysis of

waterborne diseases such as cholera, typhoid fever, and diarrheal illnesses have been linked to inadequate access to clean water, sanitation facilities and the impact of climate change [45, 46].

As the body of evidence on the link between climate change and the incidence of waterborne diseases, as well as diarrheal diseases, expands, suggestions have emerged for incorporating social and ecological factors into understanding these relationships and utilizing this information for future projections [47].

MENTAL HEALTH AND PSYCHOSOCIAL IMPACTS

The mental health impacts of climate change ranges from minimal stress and distress symptoms to clinically diagnosed disorders, this spectrum includes manifestations such as anxiety, sleep disturbances, depression, post-traumatic stress, and suicidal ideation [48].

Growing body of evidence suggest that climate-induced mental health issues disproportionately affects vulnerable populations, including children, the elderly, and indigenous communities [49, 50]. Furthermore, climate-induced changes, alongside other factors influencing mobility, significantly influence human migration patterns. While there's growing attention to the adaptive aspect of migration, the mental health implications of climate-related migration, encompassing planned relocation and forced displacement, remain crucial areas of concern [51].

HEALTH INEQUALITIES AND VULNERABLE POPULATIONS

Analysis of the differential impacts of climate change on marginalized and vulnerable populations, including low-income communities, indigenous peoples, and refugees revealed that that climate change is anticipated to worsen existing vulnerabilities and inequalities. [52]

Research indicates that the primary factor contributing to population vulnerability to climate change is the absence of adaptive capacity, which remains a crucial concern in the interface between society and global environmental change. As climate patterns evolve, vulnerable segments of society, already susceptible to present climate variability, may experience heightened vulnerability due to increasing occurrences of extreme climate events like droughts and floods [53, 54].

However, further examination of the literature also reveals that governments are failing to implement adaptability mechanisms as prescribed by international frameworks. Moreover, marginalized groups are subject to discrimination, neglect, and exclusion from societal programs and interventions aimed at mitigating the effects of climate-induced disasters [54–56].

S/No	**Health Impact**	**Short-Term Impacts**	**Long-Term Impacts**
1.	**Extreme Weather Events**	Immediate health risks (injuries, drowning, hypothermia, animal bites) Short-term effects (infected wounds, mental health issues,	Chronic conditions (cardiovascular disease, PTSD)

		communicable diseases)	
2.	**Vector-Borne Diseases**	Short-term outbreaks (malaria, dengue fever) due to climate anomalies Immediate increase in disease transmission rates	Long-term habitat expansion for vectors (e.g., Lyme disease) Sustained increase in disease incidence in new areas
3.	**Air Quality**	Short-term exposure to pollutants (NO_2, O_3, CO, PM_{10}) exacerbates respiratory conditions Increased ground-level ozone and prolonged pollen seasons trigger respiratory issues	Long-term respiratory health impacts due to poor air quality and prolonged pollen seasons
4.	**Waterborne Diseases**	Immediate impact on water quality and increased risk of diseases (cholera, typhoid) Short-term challenges in water sanitation and availability	Long-term degradation of water sources and sanitation infrastructure Increased salinity and decreased water availability affecting long-term water security
5.	**Mental Health**	Immediate stress, anxiety, and PTSD following extreme weather events and displacement Short-term psychological distress in vulnerable populations	Long-term mental health impacts (chronic stress, depression) Persistent psychological effects of climate-related migration and displacement
6.	**Food Security and Nutrition**	Immediate threats to food production and security Short-term malnutrition and micronutrient deficiencies	- Long-term threats to agriculture, particularly in vulnerable regions (sub-Saharan Africa, Southeast Asia) Increased malnutrition and micronutrient deficiencies due to disrupted food systems and climate-induced changes
7.	**Health Inequalities**	Immediate worsening of health disparities in marginalized	Long-term neglect and exclusion from

		populations	adaptive measures Increased health inequities

Table 1: Showing the summary of health impacts of climate change

ADAPTATION STRATEGIES AND RESILIENCE BUILDING

In recent years, the adaptation strategies aimed at minimizing the health impacts shown in Table 1, enhancing resilience in communities, healthcare systems, and public health infrastructure have been on the front burner [57]. Most of these discussions have focused on climate-resilient healthcare facilities, early warning systems, and emergency response plans for mitigating the effects of extreme weather events and health emergencies [58, 59]

Despite the considerable efforts of health professionals to tackle climate and environmental change and their associated health hazards, there remains a paucity of scientific literature supporting such initiatives, while studies evaluating the efficacy of interventions are notably deficient [60].

Case studies highlighting successful adaptation initiatives and lessons learned from past experiences in building health resilience to climate change have also shown the significant contribution of women to three major areas of community resilience: social, economic, and ecological resilience [61]. Successful projects on the mitigation of the effects of climate change often adopt innovative strategies and emphasize integrated and robust monitoring systems [61, 62].

POLICY RESPONSES AND INTERNATIONAL COOPERATION

The adoption of the Paris Agreement in 2015, was one of the major global policy response to mitigateclimate change effects promote adaptation, and finance interventions. The treaty aims to bolster the global response to climate change, including safeguarding public health from its effects. While, the World Health Organization (WHO) Framework Convention on Climate Change serves as the foundation for raising awareness about the health risks posed by climate change and assisting countries in integrating health concerns into their climate policies [63].

Regions, sub-regions and governmental agencies at country level have also developed policy frameworks, agreements, and initiatives that take local realities into cognizance in the development of measures aimed at addressing climate change and health at regional, and sub regionaland national levels [64–66].

In addition, international and non-governmental organizations are significantly contributing in coordinating efforts to tackle climate-related health challenges playing functional such as advocacy, activism, innovators, researchers, educators, watchdogs, and trainers [67].

Despite these efforts, there remain significant gaps in multi-stakeholder collaborations, knowledge sharing, and capacity-building that will foster global cooperation in addressing the intersection of climate change and health [68, 69,70-72].

CONCLUSION

In conclusion, this review underscores the intricate relationship between climate change and global health, emphasizing the urgent need for comprehensive action across all levels of society. The evidence presented highlights the multifaceted impacts of climate change on various aspects of human health, from exacerbating existing health disparities to amplifying the frequency and severity of extreme weather events and vector-borne diseases. Vulnerable populations, including low-income communities, indigenous peoples, and refugees, are particularly at risk, underscoring the imperative for targeted interventions and equitable adaptation strategies.

Furthermore, the review identifies gaps in current policy frameworks and international cooperation efforts, calling for enhanced collaboration, knowledge sharing and capacity-building to effectively address the complex challenges posed by climate change on health. It emphasizes the importance of integrating health considerations into climate policies and fostering multi-stakeholder partnerships to strengthen resilience and mitigate the adverse health impacts of climate change.

Moving forward, it is essential for policymakers, healthcare professionals, and communities to prioritize proactive adaptation measures, robust public health infrastructure, and innovative strategies that address the interconnectedness of environmental and human health. By leveraging collective action and leveraging the expertise of diverse stakeholders, we can strive towards a healthier and more resilient future in the face of climate change.

AVAILABILITY OF DATA AND MATERIALS

The authors confirm that the data supporting the findings of this study are available within the article.

REFERENCES

1. Damoah B. Reimagining Climate Change Education As a Panacea to Climate Emergencies. Int J Environ Sustain Soc Sci. 2023;4(4):977-987.
2. Scheelbeek PF, Dangour AD, Jarmul S, Turner G, Sietsma AJ, Minx JC, et al. The effects on public health of climate change adaptation responses: a systematic review of evidence from low-and middle-income countries. Environ Res Lett. 2021;16(7):073001.
3. Magnan AK, Pörtner HO, Duvat VK, Garschagen M, Guinder VA, Zommers Z, et al. Estimating the global risk of anthropogenic climate change. Nat Clim Chang. 2021;11(10):879-885.
4. Hobbs M, Atlas J. Environmental influences on behaviour and health: a call for creativity and radical shifts in thinking within contemporary research. N Z Med J (Online). 2019;132(1505):97-99.
5. Grace K, Davenport F, Hanson H, Funk C, Shukla S. Linking climate change and health outcomes: Examining the relationship between temperature, precipitation and birth weight in Africa. Global Environ Change. 2015;35:125-137.
6. Burrows K, Fussell E. A life course epidemiology approach to climate extremes and human health. Lancet Planet Health. 2022;6(7):e549-e550.
7. Shrestha SL, Shrestha IL, Shrestha N, Joshi RD. Statistical modeling of health effects on climate-sensitive variables and assessment of environmental burden of diseases attributable to climate change in Nepal. Environ Model Assess. 2017;22:459-472.
8. Chowdhury FR, Ibrahim QSU, Bari MS, Alam MJ, Dunachie SJ, Rodriguez-Morales AJ, et al. The association between temperature, rainfall and humidity with common climate-sensitive infectious diseases in Bangladesh. PLoS One. 2018;13(6):e0199579.

9. McMichael AJ, Woodruff RE, Hales S. Climate change and human health: present and future risks. Lancet. 2006;367(9513):859-869.
10. Berry P, Enright PM, Shumake-Guillemot J, Villalobos Prats E, Campbell-Lendrum D. Assessing health vulnerabilities and adaptation to climate change: a review of international progress. Int J Environ Res Public Health. 2018;15(12):2626.
11. Health effects of global warming: developing countries are most vulnerable. United Nations. https://www.un.org/en/chronicle/article/health-effects-global-warming-developing-countries-are-most-vulnerable. Published March 14, 2012. Accessed May 8, 2024.

12. McIver L, Kim R, Woodward A, Hales S, Spickett J, Katscherian D, et al. Health impacts of climate change in Pacific Island countries: a regional assessment of vulnerabilities and adaptation priorities. Environ Health Perspect. 2016;124(11):1707-1714.
13. Merdjanoff AA, Piltch-Loeb R. Hurricanes and Health: Vulnerability in an age of climate change. In: Frumkin H, McMichael AJ, Hess JJ, eds. Climate Change and Global Public Health. Jossey-Bass; 2021:339-351.
14. Waddell SL, Jayaweera DT, Mirsaeidi M, Beier JC, Kumar N. Perspectives on the health effects of hurricanes: a review and challenges. Int J Environ Res Public Health. 2021;18(5):2756.
15. Rahmani F, Fattahi MH. Investigation of alterations in droughts and floods patterns induced by climate change. ActaGeophys. 2024;72(1):405-418.
16. Paterson DL, Wright H, Harris PN. Health risks of flood disasters. Clin Infect Dis. 2018;67(9):1450-1454.
17. Du W, FitzGerald GJ, Clark M, Hou XY. Health impacts of floods. Prehosp Disaster Med. 2010;25(3):265-272.
18. Luber G, McGeehin M. Climate change and extreme heat events. Am J Prev Med. 2008;35(5):429-435.
19. O'Neill MS, Carter R, Kish JK, Gronlund CJ, White-Newsome JL, Manarolla X, et al. Preventing heat-related morbidity and mortality: new approaches in a changing climate. Maturitas. 2009;64(2):98-103.
20. Karypidou MC, Almpanidou V, Tompkins AM, Mazaris AD, Gewehr S, Mourelatos S, et al. Projected shifts in the distribution of malaria vectors due to climate change. Climatic Change. 2020;163:2117-2133.
21. Githeko AK, Lindsay SW, Confalonieri UE, Patz JA. Climate change and vector-borne diseases: a regional analysis. Bull World Health Organ. 2000;78(9):1136-1147.
22. Hopp MJ, Foley JA. Global-scale relationships between climate and the dengue fever vector, Aedesaegypti. Climatic Change. 2001;48:441-463.
23. Bouzid M, Colón-González FJ, Lung T, Lake IR, Hunter PR. Climate change and the emergence of vector-borne diseases in Europe: case study of dengue fever. BMC Public Health. 2014;14:1-12.
24. Brownstein JS, Holford TR, Fish D. Effect of climate change on Lyme disease risk in North America. EcoHealth. 2005;2:38-46.
25. Wilson AL, Courtenay O, Kelly-Hope LA, Scott TW, Takken W, Torr SJ, et al. The importance of vector control for the control and elimination of vector-borne diseases. PLoSNegl Trop Dis. 2020;14(1):e0007831.
26. Anoopkumar AN, Aneesh EM. A critical assessment of mosquito control and the influence of climate change on mosquito-borne disease epidemics. Environ Dev Sustain. 2022;24(6):8900-8929.
27. Bernard SM, Samet JM, Grambsch A, Ebi KL, Romieu I. The potential impacts of climate variability and change on air pollution-related health effects in the United States. Environ Health Perspect. 2001;109(suppl 2):199-209.

28. De Sario M, Katsouyanni K, Michelozzi P. Climate change, extreme weather events, air pollution and respiratory health in Europe. EurRespir J. 2013;42(3):826-843.
29. de Miguel-Díez J, Hernández-Vázquez J, López-de-Andrés A, Álvaro-Meca A, Hernández-Barrera V, Jiménez-García R. Analysis of environmental risk factors for chronic obstructive pulmonary disease exacerbation: A case-crossover study (2004-2013). PLoS One. 2019;14(5):e0217143.
30. Ainsworth EA, Yendrek CR, Sitch S, Collins WJ, Emberson LD. The effects of tropospheric ozone on net primary productivity and implications for climate change. Annu Rev Plant Biol. 2012;63:637-661.
31. Zhang J, Wei Y, Fang Z. Ozone pollution: a major health hazard worldwide. Front Immunol. 2019;10:2518.
32. Choi YJ, Lee KS, Oh JW. The impact of climate change on pollen season and allergic sensitization to pollens. Immunol Allergy Clin. 2021;41(1):97-109.
33. Howse E, Crane M, Hanigan I, Gunn L, Crosland P, Ding D, et al. Air pollution and the noncommunicable disease prevention agenda: opportunities for public health and environmental science. Environ Res Lett. 2021;16(6):065002.
34. Ayejoto DA, Agbasi JC, Nwazelibe VE, Egbueri JC, Alao JO. Understanding the connections between climate change, air pollution, and human health in Africa: Insights from a literature review. J Environ Sci Health C. 2023;41(3-4):77-120.
35. Fonta W, Edame G, Anam BE, Duru EJC. Climate change, food security and agricultural productivity in Africa: Issues and policy directions.
36. Yadav SS, Hunter D, Redden B, Nang M, Yadava DK, Habibi AB. Impact of climate change on agriculture production, food, and nutritional security. Crop wild relatives and climate change. 2015:1-23.
37. Baldos ULC, Hertel TW. Global food security in 2050: the role of agricultural productivity and climate change. Aust J AgricResour Econ. 2014;58(4):554-570.
38. Fanzo J, Davis C, McLaren R, Choufani J. The effect of climate change across food systems: Implications for nutrition outcomes. Glob Food Secur. 2018;18:12-19.
39. Rocklöv J, Ahlm C, Scott ME, Humphries DL. Climate change pathways and potential future risks to nutrition and infection. In: Nutrition and infectious diseases: shifting the clinical paradigm. 2021:429-458.
40. Agostoni C, Baglioni M, La Vecchia A, Molari G, Berti C. Interlinkages between climate change and food systems: the impact on child malnutrition—narrative review. Nutrients. 2023;15(2):416.
41. Altieri MA, Nicholls CI, Henao A, Lana MA. Agroecology and the design of climate change-resilient farming systems. Agron Sustain Dev. 2015;35(3):869-890.
42. Dietz WH. Climate change and malnutrition: we need to act now. J Clin Invest. 2020;130(2):556-558.
43. Howard G, Bartram J. The resilience of water supply and sanitation in the face of climate change Technical report. Who Vis. 2010;2030:42.
44. Howard G, Charles K, Pond K, Brookshaw A, Hossain R, Bartram J. Securing 2020 vision for 2030: climate change and ensuring resilience in water and sanitation services. J Water Clim Change. 2010;1(1):2-16.
45. Levy K, Woster AP, Goldstein RS, Carlton EJ. Untangling the impacts of climate change on waterborne diseases: a systematic review of relationships between diarrheal diseases and temperature, rainfall, flooding, and drought. Environ Sci Technol. 2016;50(10):4905-4922.
46. Walker JT. The influence of climate change on waterborne disease and Legionella: a review. Perspect Public Health. 2018;138(5):282-286.
47. Levy K, Smith SM, Carlton EJ. Climate change impacts on waterborne diseases: moving toward designing interventions. Curr Environ Health Rep. 2018;5:272-282.
48. Cianconi P, Betrò S, Janiri L. The impact of climate change on mental health: a systematic descriptive review. Front Psychiatry. 2020;11:49026.

49. Lebel L, Paquin V, Kenny TA, et al. Climate change and Indigenous mental health in the Circumpolar North: A systematic review to inform clinical practice. Transcult Psychiatry. 2022;59(3):312-336.
50. Charlson F, Ali S, Benmarhnia T, et al. Climate change and mental health: a scoping review. Int J Environ Res Public Health. 2021;18(9):4486.
51. Schwerdtle P, Bowen K, McMichael C. The health impacts of climate-related migration. BMC Med. 2018;16:1-7.
52. Otto IM, Reckien D, Reyer CP, et al. Social vulnerability to climate change: a review of concepts and evidence. Reg Environ Change. 2017;17:1651-1662.
53. Mainali J, Pricope NG. High-resolution spatial assessment of population vulnerability to climate change in Nepal. ApplGeogr. 2017;82:66-82.
54. Adger WN. Approaches to vulnerability to climate change. CSERGE; 1996:1-63.
55. Ngcamu BS. Climate change effects on vulnerable populations in the Global South: a systematic review. Nat Hazards. 2023;118(2):977-991.
56. Smith GS, Anjum E, Francis C, et al. Climate change, environmental disasters, and health inequities: the underlying role of structural inequalities. Curr Environ Health Rep. 2022;9(1):80-89.
57. Abbass K, Qasim MZ, Song H, et al. A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environ SciPollut Res. 2022;29(28):42539-42559.
58. Sharifi A. Co-benefits and synergies between urban climate change mitigation and adaptation measures: A literature review. Sci Total Environ. 2021;750:141642.
59. Malhi GS, Kaur M, Kaushik P. Impact of climate change on agriculture and its mitigation strategies: A review. Sustainability. 2021;13(3):1318.
60. Dupraz J, Burnand B. Role of health professionals regarding the impact of climate change on health—an exploratory review. Int J Environ Res Public Health. 2021;18(6):3222.
61. Singh P, Tabe T, Martin T. The role of women in community resilience to climate change: A case study of an Indigenous Fijian community. Womens Stud Int Forum. 2022;90:102550.
62. Palinkas CM, Orton P, Hummel MA, et al. Innovations in coastline management with natural and nature-based features (NNBF): Lessons learned from three case studies. Front Built Environ. 2022;8:814180.
63. World Health Organization. COP26 special report on climate change and health: the health argument for climate action. World Health Organization. 2021.
64. Wolf T, Sanchez Martinez G, Cheong HK, et al. Protecting health from climate change in the WHO European region. Int J Environ Res Public Health. 2014;11(6):6265-6280.
65. Higginbotham N, Connor LH, Baker F. Subregional differences in Australian climate risk perceptions: coastal versus agricultural areas of the Hunter Valley, NSW. Reg Environ Change. 2014;14:699-712.
66. Opoku SK, Filho WL, Hubert F, Adejumo O. Climate change and health preparedness in Africa: analysing trends in six African countries. Int J Environ Res Public Health. 2021;18(9):4672.
67. Haris SM, Mustafa FB, Raja Ariffin RN. Roles of non-governmental organisations in the national climate change governance: A systematic literature review. J Admin Sci. 2021;18(2):222-248.
68. Mliless M. The Nexus of Climate Change and Policing: Guidelines to Improve Climate Change Governance. Int J Police Sci (IJPS). 2024;3(1).
69. Virji H, Padgham J, Seipt C. Capacity building to support knowledge systems for resilient development—approaches, actions, and needs. CurrOpin Environ Sustainability. 2012;4(1):115-121.

70. Abhijeet, Singh , E. A., &Shindikar , M. R. (2023). A Comprehensive Review on Climate Change and Its Effects. International Journal of Environment and Climate Change, 13(11), 924–931. https://doi.org/10.9734/ijecc/2023/v13i113240
71.Olawale Ahmed, O., &OluniyiOgunola, S. (2016). Climate Change: Effects and Adaptive Measures in Africa. Journal of Geography, Environment and Earth Science International, 8(1), 1–13. https://doi.org/10.9734/JGEESI/2016/26416
72.McMichael AJ, Woodruff RE, Hales S. Climate change and human health: present and future risks. The lancet. 2006 Mar 11;367(9513):859-69.
73. Public Health Nigeria. Why is climate change important to public health? Public Health Nigeria website. https://www.publichealth.com.ng/why-is-climate-change-important-to-public-health/. Published May 15, 2023. Accessed May 17, 2024.

74. Abhijeet, Singh , E. A., &Shindikar , M. R. (2023). A Comprehensive Review on Climate Change and Its Effects. International Journal of Environment and Climate Change, 13(11), 924–931. https://doi.org/10.9734/ijecc/2023/v13i113240

75. Olawale Ahmed, O., &OluniyiOgunola, S. (2016). Climate Change: Effects and Adaptive Measures in Africa. Journal of Geography, Environment and Earth Science International, 8(1), 1–13. https://doi.org/10.9734/JGEESI/2016/26416

76. McMichael AJ, Woodruff RE, Hales S. Climate change and human health: present and future risks. The lancet. 2006 Mar 11;367(9513):859-69.