



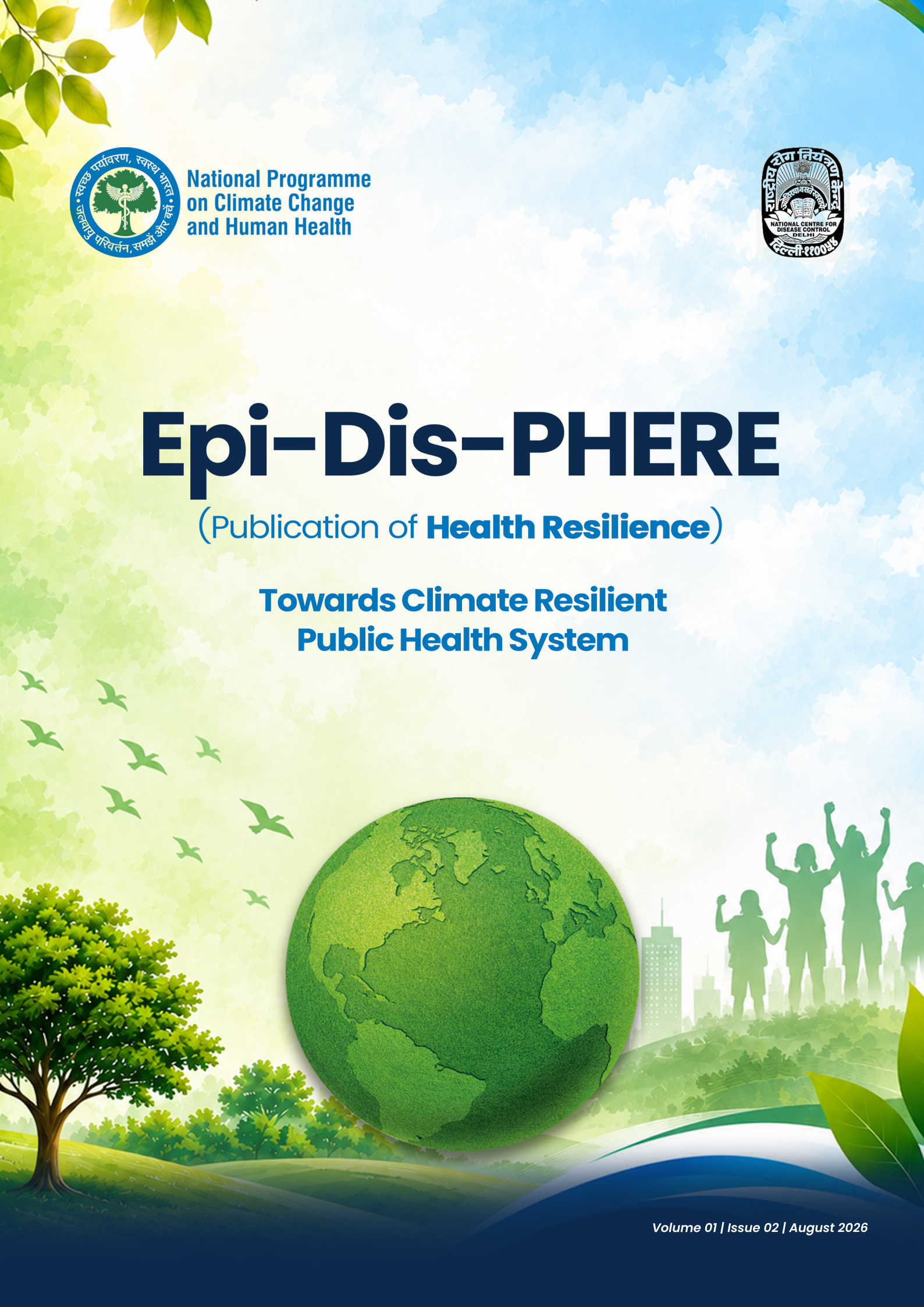
National Programme
on Climate Change
and Human Health



Epi-Dis-PHERE

(Publication of **Health Resilience**)

**Towards Climate Resilient
Public Health System**



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Accelerating the Indian Efforts to Adapt to Health Impacts of Climate Change

VM Katoch

Climate change is recognised as a reality. It is associated with human development and its negative impacts on environment, all types of life including humans and other animals and it demands an appropriate public health response (Hellerstedt et al 2017). It is also accepted that climate change is a major contributor to increase in environmental disasters like droughts, floods, landslides, wildfires and storms (WHO 2023, Hellerstedt et al 2017). Climate change is also contributing to disruption of food systems, increases in zoonoses and food-, water- and vector-borne diseases, and mental health issues. Furthermore, climate change is undermining many of the social determinants for good health, such as livelihoods, equality and access to health care and social support structures (WHO 2023).

During the last 3-4 decades, global community has made many efforts to mitigate and adapt to the adverse impact of developmental processes and their resultant consequences. To address the challenges of climate change, the United Nations Framework Convention on Climate Change (UNFCCC) came into force on 21st March 1994 which was adopted out of three conventions identified at “Rio Earth Summit” in 1992. This convention known as “Convention of Parties” has 198 countries, it represents collective will and response of global community to this problem.

India has undertaken many initiatives in pursuance to the obligation implied by UNFCCC which include: a) Identification of Ministry of Environment, Forest & Climate Change (MOEF&CC) as nodal ministry for matters related to Climate Change; b) Formulation

of National Environmental Policy 2006; c) Formulation of Prime Minister’s Council on Climate Change to advice proactive measures, facilitate inter-ministerial coordination and guide policy in relevant areas. Our country initiated eight missions related to climate change in 2008. The reconstituted Prime Minister Council on Climate Change (PMCCC) approved four new missions on Climate Change including the Health Mission in January 2015. The proposed ‘Health Mission’ has been undertaken by Ministry of Health & Family Welfare, Government of India under the umbrella of ‘National Action Plan on Climate Change’ by MoEFCC. As a follow-up action, MoHFW constituted a National Expert Group on Climate Change & Health (NEGCCH) to prepare action plan, recommend strategies for adaptation and response plan for diseases occurring due to climate variability and change. This National Action Plan for Climate Change and Human Health (NAPCCHH) was developed with National Centre for Diseases Control (NCDC) as the nodal centre for ‘Health Mission’ by Ministry of Health & Family Welfare, Government of India with representation from various departments/ agencies / other stake holders. NAPCCHH aims at strengthening health care services against adverse impact of climate change on health (MoHFW, NAPCCHH, weblinks). It has five specific objectives: (i) To create awareness among general population (vulnerable community), health-care providers and policy makers regarding impacts of climate change on human health; (ii) To strengthen capacity of healthcare system to reduce illnesses/ diseases due to variability in climate; (iii) To strengthen health preparedness and

response by performing situational analysis at national/ state/ district/ below district levels; (iv) To develop partnerships and create synchrony/ synergy with other missions and ensure that health is adequately represented in the climate change agenda in the country; (v) To strengthen research capacity to fill the evidence gap on climate change impact on human health. This was fine-tuned, priorities identified and approved as a National Programme in February 2019 (NPCCHH weblink and Kumar et al 2019), thus it has completed five years of its journey. It is best time to reflect, plan for future and do course corrections if needed.

NAPCCHH had set/ suggested several activities to be undertaken during the first 2 years. These included, (i) Establishment of 'Environmental Health Cell' in State Health Departments, (ii) Identification of State Nodal Officer- Climate Change at State Health Departments, (iii) Notification of Task Forces with representation of other health programmes (vector-borne disease, infectious diseases, nutrition etc) multi-sectors/ departments such as Disaster Management Authority, Health Information System, district unit of departments of Meteorology, Pollution Control Board, Water and Sanitation, Public Works Departments and civil societies etc. (iv) Vulnerability Assessment for baseline rate for Climate Sensitive Illnesses in terms of (a) Geography (Plain/ Mountain/ Desert/ Coastal), identify worst affected areas (districts), (b) Risk mapping with extreme events (heat/ cold/ drought/ flood/ cyclone/ other, (c) Affected Population (Total, density, Vulnerable, Occupation), (d) Contributing/ exaggerating factors for these Climate sensitive illnesses, (e) Healthcare Infrastructure/ facilities like PHC, CHC, District hospital, Tertiary care hospitals- Government as well as Private, (f) Identify areas for capacity building –human resource, technical and healthcare service delivery; (v) Preparation of State health adaptation plan for extreme events (heat related illness), Health effects of Air

Pollution, Vector borne diseases and Water borne illnesses, (vi) Identification and strengthening of State health system- departments/ institutes/ organizations/ health care facilities/ other stakeholders for providing assistance for management of cases and for monitoring and surveillance for climate sensitive illnesses, (vii) Coordinate with premiere institute/ organisation like Centre of Excellence for developing training module/ guidelines and inclusion of mitigation and adaptation measures in Students' Curriculum and (viii) Develop, integrate and implement media communication plan for common CSDs involving health determining sectors and communities.

During the second phase- three (2 to 5) years, several milestones were to be achieved: (1) Formulate specific implementation framework for climate sensitive diseases; (2) Contingency plans for climate sensitive illnesses - appropriate and efficient health personnel, logistics & resource allocation, (3) Capacity building and training of health care personnel on guidelines and treatment modalities against climate sensitive illnesses at district level in each state, (4) Development of early detection tools for CSDs (rapid diagnostics, surveillance) or mathematical /prediction models for preparedness of population and health care system, (5) Periodic reviews for improvements or deterioration of indicators (vulnerability, response capacity, preparedness, and environmental determinants) identified for each CSD, (6) Awareness generation- integrate IEC, engage local leaders & community, yearly "Advocacy network meeting" and health talks, specific day celebration, health melas etc. (7) With projected climate risks, adapt new technologies, building design, energy, water and sanitation provisions for new constructions of healthcare facilities, but if already existing, modify as per permissible building norms, (8) Link data on data of climate sensitive diseases, environmental factors determining health, meteorological information, and outcomes as morbidity and mortality, (9) Risk mapping and seasonal trend for CSDs:

multi-sector management approach and (10) Research and epidemiological studies / surveys on vulnerable population for climate sensitive illnesses.

From the update provided by Centre for Environmental & Occupational Health, Climate Change & Health at NCDC, it heartening to note that good progress has been made. However, the achievements are modest in terms of milestones set. Nearly a third of states and UTs have been proactive, others took much longer time even for preparing state action plans and establishing the working mechanisms. Considering the competing priorities, this is understandable. Most have now established governance structure, state action plans and mechanisms suggested to strengthen the infrastructure and human resources to effectively tackle the direct effects related to climate change. Nodal centre at NCDC has played its part very well in terms of consultations, preparation of training material/modules especially to deal with heat effects, air pollution effects and partnering in/ guiding the awareness campaigns etc. It is important that these mechanisms function efficiently especially in larger states with varying challenges. However, except for some work done in relation to awareness campaigns and capacity building other tasks set for second phase (2-5 years) do not seem to have progressed much. There would be success stories here and there, but a lot more needs to be done. It would be appropriate that there is in depth review of these targets to set fresh timelines and take commitments from all stakeholders. It is imperative that we make adequate progress on all these milestones for taking decisions that could guide the policy and emergency response in future.

Among the targets set for first two years of the programme, it was planned to carry out vulnerability assessment for baseline rate for Climate Sensitive Illnesses (CSDs). This assessment is essential for the health agencies

to identify vulnerable communities and areas affected by these changes so that proactive steps can be taken to strengthen the capabilities timely and in an cost-effective manner as emergency response requires lot more money and is not effective to the desirable extent. Vulnerabilities have been assessed through a study carried out by TERI (information available from NCDC) using indicators which may help in determining the sensitivity and adaptive capacity. TERI project aims at National Level Health Vulnerability Assessment and developing a Framework for Monitoring and Evaluation of the National Action Plan for Climate Change and Human Health (NAPCCHH) (TERI Website). It has already generated some useful information - While district level maps of CSDs exhibit a strong association with occurrence of some specific CSDs, the projected prevalence does not correlate in some districts. There is thus, apparent need for further improving the tool, carry out follow-up studies to validate/improve the same. Further, while weather data is available for last several years from all parts of the country, getting good quality data about health is challenging from a large part of country that too focused on geographical areas which have the problem. Another study carried by Chaudhary & Mukhopadhyaya (2023) has reported that nearly 56% of India's population in 344 districts is highly vulnerable to the health impact of climate change. While these and a few other studies on this aspect will be useful to move forward, lot more work is required to develop vulnerability assessment maps of entire country covering all geographical areas, eco-systems and population groups.

Fourth objective of this programme is to develop partnerships and create synchrony/ synergy with other missions and ensure that health is adequately represented in the climate change agenda in the country. The MoHFW seeks to coordinate & collaborate with other Ministries, departments, institutions, NGOs/CBOs. Partners identified are: Ministry of Environment, Forest & Climate

Change, Ministry of Information & Broadcasting, Ministry of Human Resource Development, Indian Council of Medical Research, Ministry of Agriculture, National Medical Commission, Ministry of Drinking Water and Sanitation, Ministry of New & Renewable Energy, National Disaster Management Authority, Ministry of Women and Child Development, Indian Institute of Tropical Meteorology, Indian Institute of Tropical Meteorology, Department of Space, Department of Science & Technology, Council of Scientific & Industrial Research, Ministry of Home Affairs, Defence Research & Development Organization, Indian Council of Agricultural Research, National Institute of Malaria Research, Food Safety and Standards Authority of India, Department of Health Research and Indian Council of Medical Research, National Environmental Engineering Research Institute, Community Based Organizations, Public Health Foundation of India etc. Frame-work for their cooperation was largely decided in consultation with various stakeholders. It is seen that some mechanisms at level of officials have been established. Progress achieved in terms of this intersectoral collaboration and co-operation needs to be assessed, reviewed regularly to identify success stories, know the barriers/ solutions and define time bound agenda to jointly work and produce the desired results. We have huge capacity and capability to develop need-based strategies, technologies and generate new knowledge. Besides NCDC-MoHFW, National Institute for Disaster Management (NIDM-Ministry of Home Affairs) have also developed some manuals for training to deal with such effects (Health adaptation and resilience to climate risks -NIDM website). It would be important to transform the intersectoral collaboration into target based functional mechanisms rather than symbolic periodic events.

Fifth specific objective of this programme is to strengthen research capacity to fill the evidence gap on climate change impact on human health.

This research capacity will also be strengthened by better synergy among various stakeholders/ partners identified to achieve the above 4th objective of our national programme. Various science agencies including DST, DBT, CSIR, ICMR have programmes related to climate change and health. International partnerships have been sought to deliberate on climate change related impacts on human health. Importance of improving the surveillance, monitoring, and integration of meteorological, environmental, geospatial, and health data while working in parallel to implement adaptation strategies have been identified as priorities for India (Bush et al 2011). These research programmes need to address priority aspects like health effects of extreme heat/ cold temperatures, air pollution, vector-borne diseases, zoonoses, nutrition, women and child, health of marginalized communities etc. While initial infrastructure and human resource strengthening in hospitals and states may not need major research inputs, in the medium and long run the policy initiatives and actions should be evidence led. Considering the huge infrastructure and human resource available India can be leader on all aspects related to climate change and health. So far, there are only a few Indian studies specifically addressing this aspect:

- (i) Studies undertaken in India on malaria in the context of climate change impact reveal that transmission windows in Punjab, Haryana, Jammu and Kashmir and north-eastern states are likely to extend temporally by 2-3 months and in Orissa, Andhra Pradesh and Tamil Nadu there may be reduction in transmission windows (Dhiman et al 2010). What is really happening? Follow-up studies? Information about vector borne diseases like dengue and chikungunya shows (TERI study, other studies by Dhiman et al) that even today a lot more background work is yet to be done for progressing towards developing robust model(s).

- (ii) A comprehensive modeling method developed by Limaye et al (2023) has been reported to be adaptable to estimate local air quality and health co-benefits in other settings by integrating climate, energy, cooling, land cover, air pollution, and health data.
- (iii) There are studies on knowledge and perceptions of people and professionals. Perceptions of the people regarding climate change have been observed to be linked to their own experiences with their local weather conditions rather than the overall concept of climate change (Tripathi et al 2021). Another study by Sampath et al (2022) observed that the knowledge of health care professionals about climate change and immediate health effects like heat and VBD is good (80%), but basic knowledge regarding indirect effects like malnutrition is rather low (44%).
- (iv) Using NFHS-5 data, Mahapatra et al (2023) reported that there is a macro-level association between climate change vulnerability and women and child health (WCH), as districts that had high levels of climate change vulnerability also performed poorly in WCH. Thus, there is a need for an integrated approach that considers geography-specific climate change threats to develop health programs (Mahapatra et al 2023).
- (v) Three key barriers faced by public health professionals as key stakeholders were identified by Shrikhande et al (2023), namely: (1) political and institutional barriers; (2) education and awareness barriers; and (3) technical research barriers.
- (vi) Under aegis of Indian Network of Climate change some climate change scenarios on human health have been predicted by the year 2030 (Bhukta 2019).

It is possible that a few reports might have been missed. Overall, not much original work has

come-out from Indian studies so far which can guide the policy and further research. MoHFW has identified about 18 institutions as Centres of Excellence to become focal points for research and discussions on different aspects important for this area. Most of these have been funded also. While the initial budgetary allocations may appear small, it would be fair to argue that investments should be made when the plans are definitive, become acceptable and confidence about their out-put grows. It is important to emphasize that various science agencies should also work in synergy to support the studies on climate change and health adequately, these could be coordinated through this CoE's network or through other institutions who would work on these aspects.

To galvanize the research atmosphere focused on generating tools/ knowledge to guide policy we need to develop structured networks. Various science agencies, coordinating Centre for Environmental & Occupational Health, Climate Change & Health at NCDC, CoE at NIDM, various departments/ institutions should be part of this network. Example is Lancet countdown (Europe & China): Tracking progress on health and climate change (Watts et al 2015). Such network would be essential to accelerate all research cum intervention efforts.

To conclude, excellent beginning has been made to develop and initiate this national programme to address the health challenges linked to climate change. For achieving time bound progress on all milestones and to use the existing capability optimally the strengthening of coordination mechanisms by providing more human and financial resources appears essential. Working group approach to monitor each milestone individually could be considered as alternate or complementary strategy.

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Correspondence: Dr Vishwa Mohan Katoch, President, JIPMER, Puducherry; Former Director-General, ICMR and Secretary, Department of Health Research, MoHFW, Govt of India, Email: vishwamohankatoch18@gmail.com

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Pushing for a climate-resilient mental health ecosystem in India

Authors: Anirooddha Mukherjee, Puneet Khanduja, Boijayanti Sarker

Affiliation: MicroSave Consulting (MSC), New Delhi

As the impacts of climate change continue to escalate, the importance of addressing its effects on mental health is increasingly being recognized. In the Indian context, vulnerable populations are disproportionately affected by climate-related disasters. This paper attempts to take the existing body of research on the mental health impacts of climate change forward by propagating the need for a climate-resilient mental health ecosystem. Preliminary research on climate change and its effects on human health highlights the limited focus on building mental health ecosystems resilient to climate shocks, especially in India. Further, the paper describes the barriers to safe and affordable uptake of mental health services in India. The paper also outlines the resource availability and preparedness of the Indian healthcare system to tackle climate-induced mental health challenges, especially in the post-Covid era.

The paper identifies key hurdles to achieving resilience within the current mental health infrastructure and outlines potential strategies for overcoming these challenges in the Indian context. Recognizing the regulatory framework already established by the Government for mental health services, the paper emphasizes the importance of strengthening mental healthcare services being provided under the District Mental Health Programme in India. The paper advocates for integrating mental health considerations into climate adaptation and disaster response policies. The need for fostering enhanced collaboration between government agencies, civil society organizations, and local communities has also been highlighted. Additionally, the criticality of

more profound research to inform evidence-based approaches to building climate-resilient mental health systems has been underlined in the paper.

Keywords: climate change, climate resilience, mental health, health system strengthening, climate-resilience framework, climate-resilient health systems

Introduction

Well before the COVID-19 pandemic disrupted global health systems and moved the needle for adopting a focused approach to the intersectionality of climate change and health, climate change had been proclaimed as a medical and health emergency by leading organizations devoted to public health, environmental health, patient advocacy, medical practice, and nursing services.

There have been numerous dialogues, both at the policy and operational levels, with supportive research on the adverse effects of climate change on human health, thus driving the One Health agenda forward. These dialogues and research have largely been limited to the physical manifestations of climate shocks on human and animal health. However, the lesser-known effects of climatic events on mental and psychosocial well-being, especially on vulnerable populations, have not been well explored.¹

Land-vulnerable persons (either due to occupation or geographic location), indigenous persons, women, children, older adults, and climate migrants are traditionally among the most

vulnerable populations whose mental health is impacted by climate change. Environmental, social, and public health determinants mediate the effects of climate change on health.

A detailed review of 130 research papers on gender and climate change by the Global Gender and Climate Alliance (GGCA) found that women are more likely to be affected than men by climate impacts on health.² Females are also more vulnerable to the health impacts of climate change due to several factors, including limited access to resources such as land, credit, agricultural inputs, decision-making structures, technology, training, and extension services.³

Indigenous populations are uniquely vulnerable to the mental health impacts of climate change due to historical trauma, strong connections to the natural environment, limited adaptive capacities, and threats to cultural continuity and identity.^{4 5 6}

Children and older adults are more vulnerable to the mental health impacts of climate change due to factors such as disrupted physiological development, cognitive abilities, and emotional skills in children, intersecting with other threats like parental health, depression, anxiety, racism, poverty, and inadequate access to care. In comparison, older adults face greater physiological susceptibility to climate-related health effects, such as extreme weather events and heat waves, compounded by factors like physical disabilities, poor mental health, and limited access to resources and care.^{7 8 9}

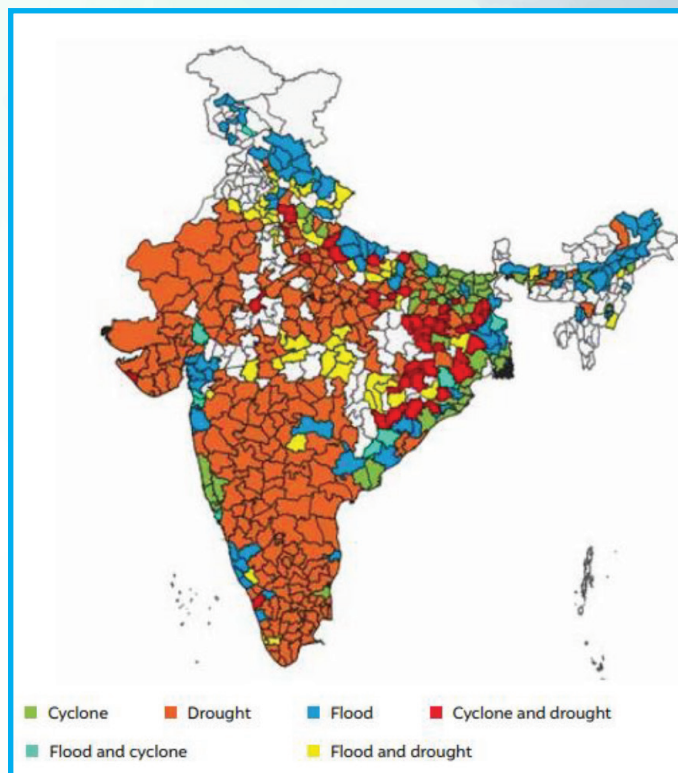


Figure 3: More than 75% of Indian districts are extreme climate event hotspots. Source: Abinash Mohanty, Council on Energy, Environment and Water (CEEW): Preparing India for Extreme Events

As the impacts of climate change intensify, including extreme weather events, rising temperatures, and environmental degradation, the psychological toll on individuals and communities is becoming increasingly evident. However, India's mental health infrastructure often lacks the necessary resources and strategies to address these challenges. Limited resources, inadequate training of mental health professionals in dealing with climate-induced psychological distress, and a general lack of awareness about the nexus between climate change and mental health further compound the issue.

Marginalized and vulnerable populations, including those living in low-lying coastal areas, urban slums, and rural regions, are particularly susceptible to the adverse mental health impacts of climate change due to their heightened exposure and limited access to mental health services.

Marginalized and vulnerable populations are at a higher risk of climate-induced mental health stresses

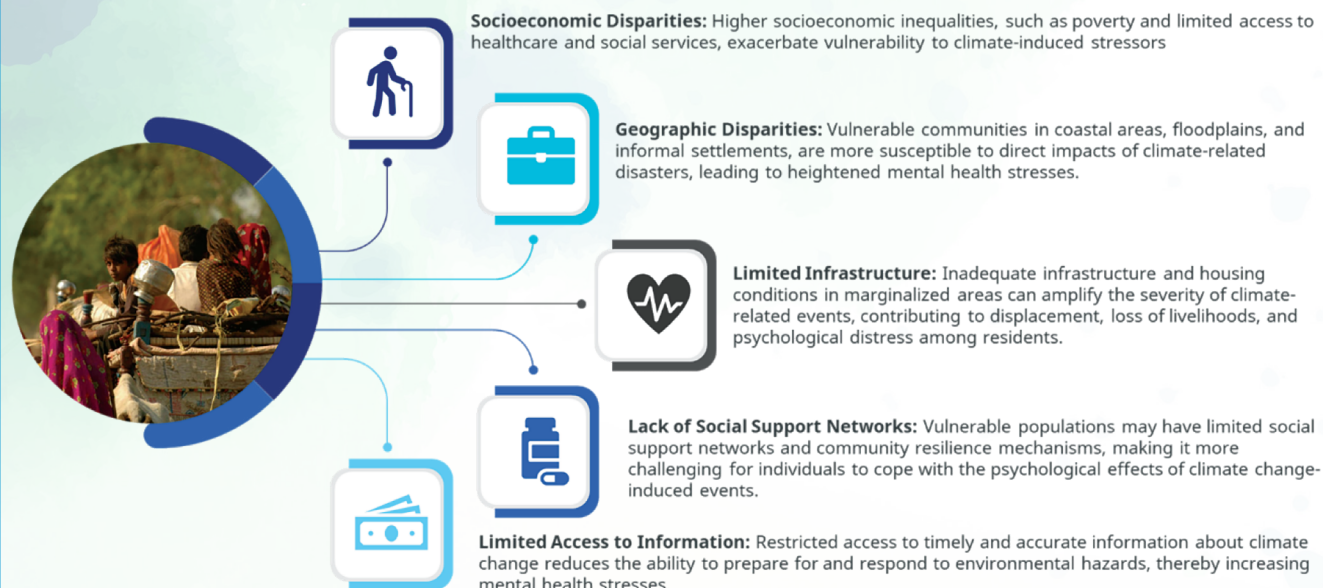


Figure 1 Higher risk of climate-induced mental health stresses for marginalized and vulnerable communities

The need for resilient health systems and institutional frameworks to enable care provisions for mental health challenges for their captive communities has been stressed by the World Health Organization in its World Mental Health Report 2022.¹⁰

The United Nations' Paris Agreement has already elucidated the global actions critical to creating a sustainable planet. The Intergovernmental Panel on Climate Change (IPCC) has also noted in its sixth report that "healthy ecosystems are more resilient to climate change."¹¹

However, most countries have failed to translate these directives into tangible frameworks. The World Economic Forum has highlighted the absence of a "global plan for the resilience of people, including those nearly 4 billion people living in communities most vulnerable to the impacts of the climate crisis". This has also been underscored by the WHO Health and Climate Change Survey Report 2021, published at the COP26 UN climate conference in November 2021.¹²

❑ Dual burden of health risks and catastrophic financial expenditure due to climate change

Climate change has diverse impacts on health, manifesting in various ways, such as heightened risks of mortality and illness due to more frequent extreme weather occurrences like heatwaves, storms, and floods. Additionally, it disrupts food systems, contributes to the rise of zoonotic diseases, and exacerbates issues related to food, water, and vector-borne illnesses, alongside mental health concerns. Moreover, climate change erodes key factors that promote good health, such as stable livelihoods, societal equality, and accessibility to healthcare and support networks. These health hazards exacerbated by climate change disproportionately affect marginalized and vulnerable groups, including women, children, ethnic minorities, impoverished communities, migrants, older individuals, and those with pre-existing health conditions.

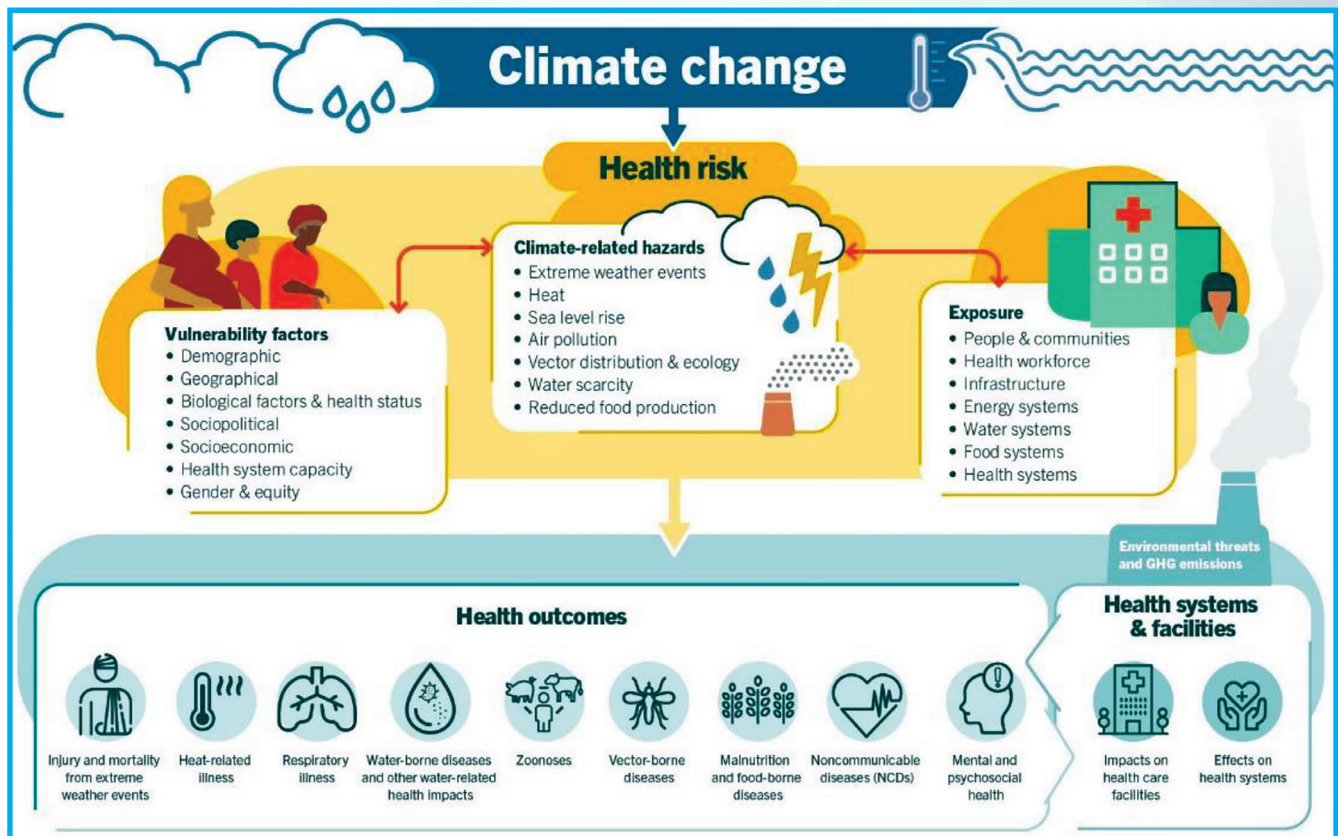


Figure 2: Overview of climate-sensitive health risks, their exposure pathways and vulnerability factors. Source: WHO Fact Sheet on Climate Change and Health

Extreme climatic events also impose a significant financial burden on vulnerable communities. These communities, already grappling with limited resources and socioeconomic challenges, bear the brunt of the economic fallout from climate-related disasters. The United Nations highlights how climate change accelerates financial burdens, particularly affecting those most vulnerable and impoverished.¹³ For instance, when extreme weather events strike, such as hurricanes, floods, or wildfires, these vulnerable groups often lack adequate insurance coverage or financial reserves to cope with the damages to their homes, businesses, and livelihoods.

The cost of rebuilding and recovery further exacerbates their financial instability, perpetuating a cycle of poverty and vulnerability.

Additionally, studies on reducing the inequitable health and financial burdens of climate change point out that government-provided financial assistance can help compensate individuals

for medical expenses incurred during climate events.¹⁴

□ Climate change and mental health: evaluating the existing evidence

The evidence indicates that climate change substantially and diversely influences mental health and emotional well-being. The relationship between experiencing the effects of climate change – such as rising temperatures or more frequent and severe extreme weather events – and worsening mental health, even resulting in more suicides, has been well-documented, especially after the COVID-19 pandemic.^{15 1}

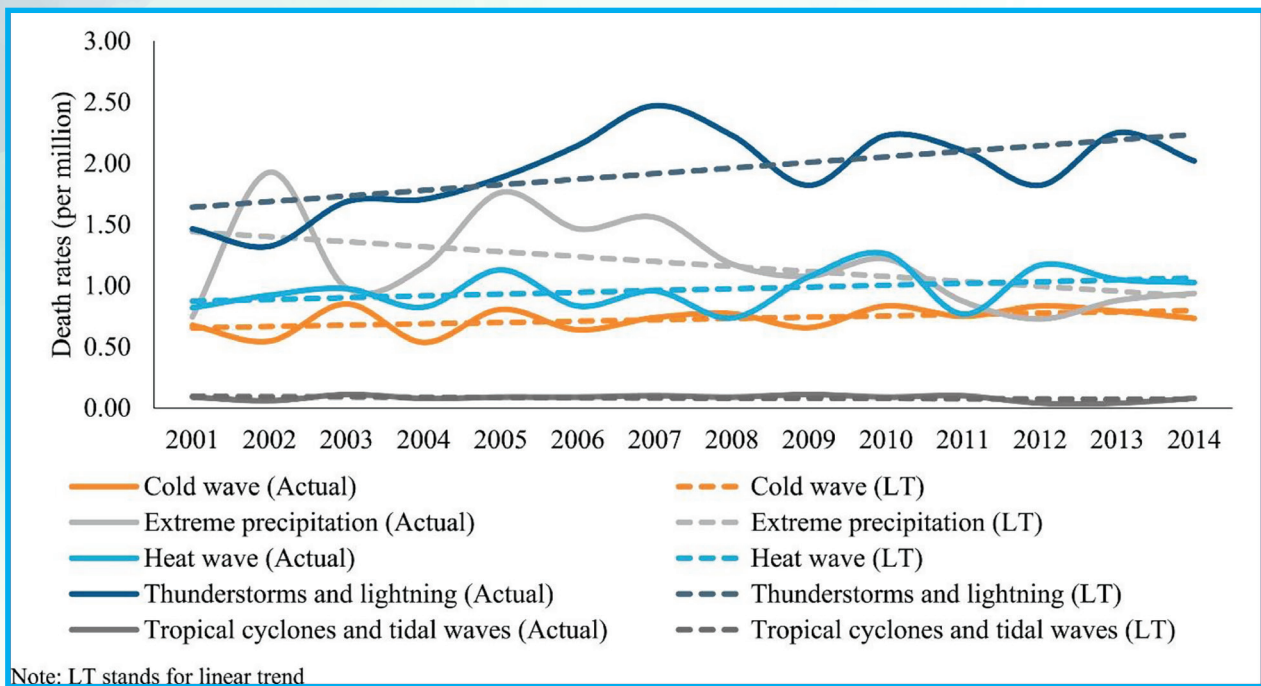


Figure 4: Trend of actual and adjusted death rates (per million) due to different extreme weather events. Source: Mahapatra et al, Weather and Climate Extremes 21, 2018

Other significant impacts of climate change on mental health range from minimal stress and distress symptoms to clinical conditions such as anxiety, depression, post-traumatic stress, and suicidal thoughts.¹⁶

The impact of climate change on mental health is likely to increase with rising temperatures, which can lead to aggression, violent suicides, and malnutrition.¹⁷ Similarly, prolonged winters and reduced sunlight exposure have been shown to result in seasonal affective disorder (SAD) driven by reduced levels of serotonin.¹⁸

The effects of climate change on mental health are unequally distributed, with vulnerable communities and groups of people who are less able to adapt to climate change being more likely to experience mental health problems.¹⁹ That being said, climate change does affect major social determinants of mental health, such as poverty, displacement, and access to mental health services.²⁰

Natural disasters such as floods and wildfires can significantly increase the number of people experiencing mental health problems, including post-traumatic stress disorder, depression, and

addiction issues.²¹

The delay in studies on climate change and mental health consequences is largely due to the complexity and novelty of this issue. It is also exacerbated by a significant lack of country-level commitments to refine existing health systems that can adapt to mental health and psycho-social well-being concerns. The 2021 WHO survey of 95 countries on health and climate change found that only nine have thus far included mental health and psychosocial support in their national health and climate change plans.¹²

□ Utilization of mental health solutions by the Indian population

India has a significant mental health burden, with more than 14% of the total population suffering from some form of mental disorder and requiring active therapeutic interventions, as reported in the National Mental Health Survey (NMHS) conducted by the National Institute of Mental Health and Neurosciences (NIMHANS)²². According to a study published in The Lancet, India's contribution to global suicide deaths increased from 25.3% in 1990 to 36.6% in 2016

among women and from 18.7% to 24.3% among men.²³ India reported a total of over 1.7 lakh suicides in 2022, nearly one-third of whom were daily wage earners, agricultural laborers, and farmers, according to the National Crime Record Bureau's (NCRB) Accidental Deaths and Suicides in India (ADSI) 2022 report. The National Mental Health Survey (NMHS) found the overall weighted prevalence for any mental morbidity in India to be 13.7% over a lifetime and reported that more than 80% of people in India struggling with mental illness receive no care due to a dearth of capacity and proper infrastructure.²²

However, the utilization of mental health solutions in India is low, with only 30% of mental health patients receiving help.²² The mental health treatment gap in India varies from 70 to 92% across a range of psychiatric disorders. The mental health infrastructure in India is mainly restricted to large, semi-permanent facilities that serve a small number of people, with only 0.329 mental health outpatient services per 100,000 people and 0.75 psychiatrists for every 100,000 population.^{22 23}

The overall availability of qualified mental health personnel in the public and private sector is scarce, with only 898 clinical psychologists and 1,500 psychiatric nurses compared to a demand of 3,000, as reported to the Lok Sabha in 2018. The Indian Psychiatric Society estimates 9,000 psychiatrists in India, with 700 psychiatrists graduating yearly. If India targets having three psychiatrists per lakh people, it will need 27,000 more psychiatrists.²⁴ The demand-supply gap is similarly steep for other mental health professionals such as psychologists, psychiatric social workers, and psychiatric nurses. The cost of accessing mental healthcare in India is high, with private therapy costing anywhere between INR 1,500 to 3000 (USD ~20 to 40) per session. Access to care is limited, particularly in rural areas, which struggle with a deeper stigma associated with mental health. The Government of India has made several policies and programmatic steps to address these concerns, such as the Mental Healthcare Act 2017 of 2017 and the District Mental Health Programme (DMHP), built on the Bellary model, to detect, manage, and treat mental health concerns.

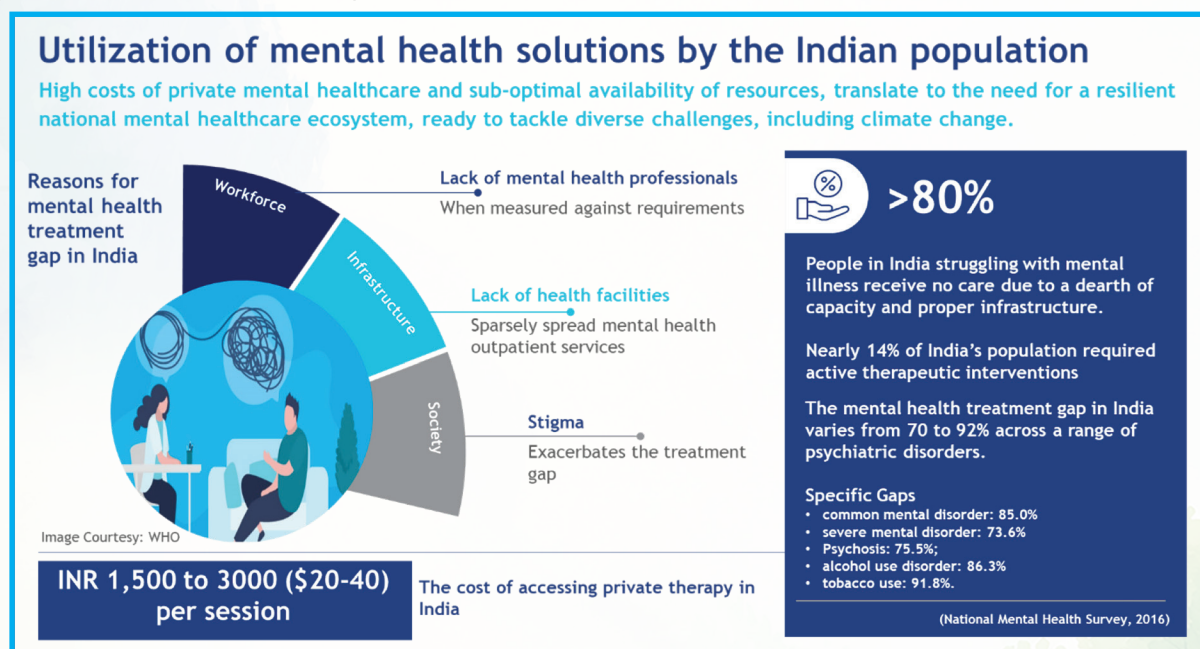


Figure 5: Utilization of mental health solutions by the Indian population, some facts and figures.

However, much more must be done to improve mental health in all aspects of society. The Ministry of Health & Family Welfare Standing Committee, in its report on Mental Health and its Management in Contemporary Times, observed that 'the issues highlighted in the 2015-16 NMHS have remained the same in 2023'. The report noted that there is considerable scope to improve the treatment gap in

the country and identified a lack of mental health professionals, weak mental health infrastructure, and stigma as the reasons for the gap.²⁴

The Mental Healthcare Act of 2017 requires the Central Government to establish a Central Mental Health Authority (CMHA) tasked with overseeing the quality of mental health services across India. Similarly, state-level authorities are mandated by the Act. These state authorities are required to form Mental Health Review Boards (MHRBs) to safeguard the rights of certain patients. However, the MoHFW Standing Committee noted that many states have not yet filled essential positions within their Mental Health Authorities or established MHRBs. The Committee suggested developing a tracking system to monitor progress on both fronts to address this.

❑ **Post-Covid preparedness of mental health systems for climate risks in India**

The COVID-19 pandemic and climate change have intertwined to create a complex and multifaceted challenge for India's mental health system. This section explores the interactions between climate change and COVID-19 and the implications for mental health preparedness in India.

The pandemic coincided with one of the hottest years globally (2020). The effects of climate change have also been observed globally, with implications for community vulnerability to diverse threats.²⁵ COVID-19 has given rise to mental health risks, as physical and mental health illnesses have caused increased risks of survival to millions of people.

The current strategies for preparedness and response to mental health impacts of climate change in India operate in distinct silos. Developing and implementing programs and practices for monitoring and treating mental health issues, training community health workers to deliver services, conducting inventories of

available resources, and assessing at-risk populations do not systematically consider the climate change lens. In fact, health system responses to climate shocks such as extreme heat, cold waves, and natural calamities have limited mental components, resulting in sub-optimal to practically non-existent on-ground implementation.

❑ **Adaptability of climate-resilient health systems to mental health challenges**

The COVID-19 pandemic and climate change have created a complex and multifaceted challenge for India's mental health system. To address these challenges, India must invest in strengthening its mental health system, including developing a robust climate-resilient mental health infrastructure. This will require a multifaceted approach that includes capacity building, public awareness, and the deeper integration of mental health services into primary healthcare systems.

It is imperative to promptly discover avenues for translating climate change and mental health research findings into tangible policies and actions, reinforcing advocacy efforts with empirical evidence and scientific knowledge.

It is also essential for private and public actors and agencies to co-create comprehensive and integrated solutions that tackle the intricate aspects of how climate change affects mental health and well-being, considering the various contexts in which these challenges arise. Addressing these problems requires a policy context managing disaster risk's political and social aspects. Advocacy for climate change mitigation policies and programs, adaptation of existing programs, and implementing evidence-based risk communication interventions are necessary.

Our proposed innovation triad integrates **policy, technology & community** for a climate-resilient mental healthcare ecosystem



Figure 6: Proposed framework for a climate-resilient mental healthcare ecosystem

Mental health services need to be agile and responsive to the variable mental health effects that disaster survivors may experience. Integrating technological innovations in the healthcare ecosystem can bolster mental health solutions in resource-constricted geographies. For example, Geographic Information Systems can enable mental health providers to locate specific at-risk locations and groups more effectively.²⁶

A comprehensive effort to prevent and treat these problems would also involve advocacy for climate change mitigation by promoting the mental health benefits of environmental conservation and promoting psychological growth and resilience.

□ Conclusion & Way Forward

In the Indian context, establishing a climate-resilient mental health ecosystem encounters several challenges. Firstly, there exists a pervasive stigma surrounding mental health issues, which inhibits individuals from seeking support and hampers the development of comprehensive mental health policies. High

costs of private mental healthcare and sub-optimal availability of resources point to the need for a resilient mental healthcare ecosystem ready to tackle diverse challenges, including climate stressors. Furthermore, the disparate impact of climate change on vulnerable populations, such as those residing in low-lying coastal areas or rural regions lacking adequate healthcare access, underscores the need for targeted interventions to address their unique mental health needs.

Moving forward, several key actions are imperative to foster a climate-resilient mental health ecosystem in India. Firstly, there must be a concerted effort to destigmatize mental health issues through widespread public awareness campaigns and community-based initiatives. Secondly, investments in mental health infrastructure, including expanding mental health services and training healthcare professionals in trauma-informed care, are crucial to enhancing the resilience of the mental health system to climate-related challenges. A comprehensive community-driven, locally-led adaptation of the directives contained in the Mental Health Act,

2017, spearheaded by the State Governments and district administrations, will initiate a much-needed feedback mechanism for impact.

Additionally, integrating mental health considerations into climate change adaptation and disaster response policies will ensure that mental health needs are prioritized and addressed in times of crisis. Lastly, fostering collaboration between government agencies, civil society organizations, and local communities is essential to developing holistic and culturally sensitive approaches to mental health resilience in the face of climate change.

There is also a pressing need for more profound research on climate-resilient mental health systems in the Indian context. Comprehensive studies exploring the intersection of climate change impacts and mental health outcomes are essential to inform evidence-based policies and interventions. This research should investigate the specific vulnerabilities of different population groups, assess the effectiveness of existing mental health services in mitigating climate-induced stressors, and identify best practices for building resilience at individual, community, and institutional levels.

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Decarbonizing Healthcare in India: An Ecosystem Review

Sandeep Thaker

□ Abstract

India has a multiple-entry point system of healthcare delivery with the private and public health system models, charitable and trust systems, private practitioners and others. The demand and functioning of these are also marked by the geographies, population characteristics, and the demand mechanism. It is imperative for the climate- health policy in the country to accommodate these models in its foundational framing. This paper is an attempt to understand the space of decarbonisation of the health systems in the climate –health policy for India. Climate change has been identified as a public health emergency by WHO. The national governments and the health programmes are to embed the climate change impacts in their functioning as a need to safeguard their populations and ensure the wellbeing of human health. In this regard, decarbonisation of healthcare systems is identified as an important step for climate mitigation, supporting the GHG emissions reduction, contributing to the SDG agenda, as well as upholding the medical principle of “do no harm”. The paper will draw insights on the current decarbonisation agenda at the global level, the indulgence of the public healthcare system in India towards the same from the institutional governance point of view, and the state of efforts. The paper intends to draw outputs from the review of the current ecosystem and present suggestions drawing from global view points as well as local and regional engagement in accordance to the learnings of the National Programme on Climate Change and Human Health (NPCCHH), functional under the NHM umbrella, MoHFW.

□ Context

The WMO provisional State of the Global Climate report confirms that 2023 was the warmest year on record. Data until the end of October shows that the year was about 1.40 degrees Celsius (with a margin of uncertainty of $\pm 0.12^{\circ}\text{C}$) above the pre-industrial 1850-1900 baseline (WMO, 2023). The Climate Data Store trend details that Global warming reached an estimated 1.25 degree Celsius in October 2023 and if the 30-year warming trend leading up to then continued, global warming would reach 1.5 degree Celsius mark by 2034 (WMO, 2023). Climate change and its impacts, informed by projections inform the urgency of action. Human health is impacted by climate change in multiple direct as well as indirect ways. The direct impacts include deaths and illnesses due to rise in frequency of extreme weather events such as floods, cyclones, heat waves and cold waves i.e. the sudden shock events leading to loss of lives and or impacting the vulnerable populations. The long term slow onset events also impact human health in myriad of ways such as droughts, change in pathogen behaviours, air pollution exposure, disruption of food systems, increase in zoonosis, and food and water borne diseases and mental health impacts (WHO, 2023). The infographic placed below highlights the pathways of climate hazards, vulnerabilities, and risks encompassing environmental, socioeconomic, and susceptibility parameters as per IPCC 6, and the consequent risks they pose for human health (IPCC, 2023). The figure then presents a listing of solutions to these challenges and exposure pathways by investing in strengthening the healthcare systems and developing climate resilient pathways.

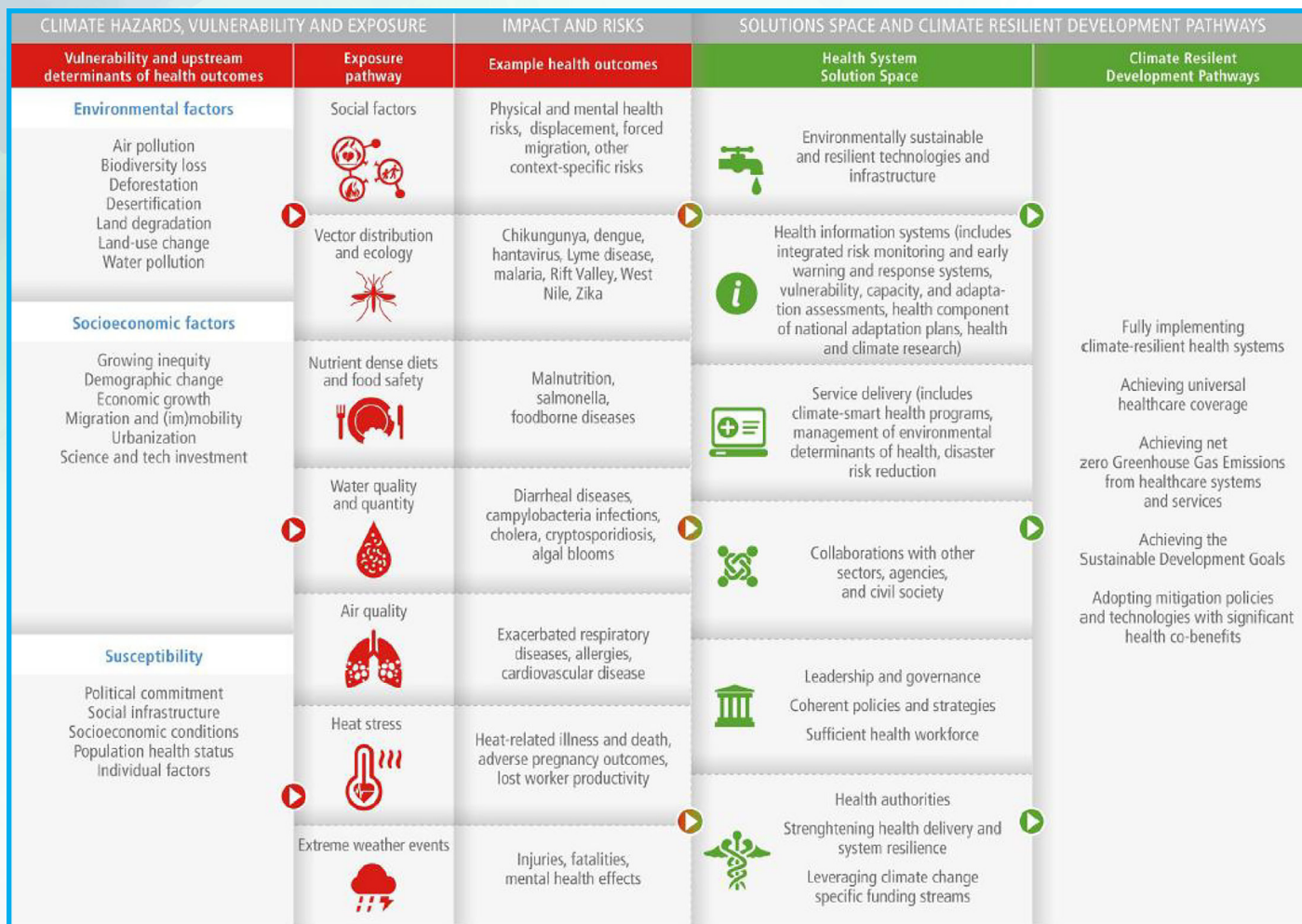


Figure 1- Climate change and human health and wellbeing- risks and responses

The **IPCC** AR6 document on health and climate change identifies climate resilient health systems as one of the key solutions to address the crisis. As per the report, climate resilient development has a strong potential to generate substantial co benefits for health and wellbeing and reduce risks of involuntary displacement and conflict. Sustainable and climate resilient development decreases exposure, vulnerability and societal inequity and that increases timely and effective adaptation and mitigation and reduce climate change impacts on health (IPCC, 2023). Further, addressing the threat of rising air pollution and related illnesses, given the overlap in sources of greenhouse gases and co pollutants in energy systems, strategies that pursue greenhouse gas emissions reductions and improvements in energy efficiency hold significant potential co benefits through air pollution reductions (IPCC, 2023).

Healthcare being at the core of wellbeing is to not only be informed by these trends in temperature and precipitation but also prepare to respond to the climate emergency. Building sustainable and resilient healthcare systems are key to long term strategy to address climate change. The recent events across the globe, specifically increased extreme weather events such as floods and heat waves indicate the urgency to strengthen the efforts for developing resilient healthcare.

The solution of decarbonizing healthcare is echoed by the Lancet Countdown 2023 report on *health and climate change: the imperative for a health centered response in a world facing irreversible harms*. As per the report, enabling a healthy future demands to go beyond the treatment of the health symptoms of climate change, to focus on primary prevention and rapidly increasing mitigation efforts. The findings

lay emphasis on a zero-carbon transition to not only avoid the health impacts but also deliver health and socio economic co-benefits. The 2022 report of the Lancet Countdown found that global health lies at the mercy of fossil fuels, and with the threat of climate change increasing, further delays in meaningful climate change mitigation put the world at risk of missing “a rapidly closing window of opportunity to secure a liveable and sustainable future”. (Lancet, 2023)

□ Healthcare Decarbonization in India- Understanding the Policy context

India's climate commitments pertain to the Nationally Determined Contributions (NDCs) under the Paris Agreement, as a part of which National Action Plan on Climate Change (NAPCC) was designed in 2008 and eight missions were adopted. Later on, the National Health Mission was also included in this commitment. The National Programme on Climate Change and Human Health (NPCCHH) was initiated under the National Health Mission MoHFW to address the rising challenges of climate change on public health. The programme has identified seventeen intervention areas based on climate sensitive illnesses. One of the functional components includes green and climate resilient healthcare facilities which houses the decarbonisation component by investing in energy efficiency, use of renewable energy sources for facility electrification, water efficiency, smart buildings, and resilient facilities. An important caveat to understand here is that the Health Ministry has not made any commitments for decarbonisation and or low carbon development. Only the Environment ministry i.e. the nodal climate change ministry for India has made the commitments for 2030 use of sustainable energy and reduction in greenhouse gas emissions. India is also not a signatory to the COP 28 Health Declaration which identifies reduction in fossil fuel usage for healthier environmental and human health outcomes. Thereby, there is a lack of concrete policy on decarbonisation of

healthcare systems in India. The current context and programme on climate change and health identifies only the two components which may be described as a derivative and or an outcome of the decarbonisation process i.e. climate resilient and environmentally sustainable healthcare and or strengthening healthcare systems to mitigate the climate impacts. The India's Long-term Low Carbon development Strategy, 2022, prepared by MoEF&CC, addresses the pillars of energy, buildings, transportation, and industries as key in developing the roadmap for low carbon development, whereas the healthcare pillar remains unaddressed. Subsequently, the NPCCHH programme and or any other Health ministry division has not made a net zero commitment. The state of Kerala, Directorate of Health Services, has enrolled for the Race to Zero emissions by 2050.

□ Decarbonizing Healthcare- Pathways

The concept of decarbonisation concerns with the process of achieving zero fossil based carbon emissions. Scientifically, the decarbonisation process and pathways for major contributors has been identified with the mapping of contributing agents. These have then been categorized as Scope 1, Scope 2, and Scope 3 emissions, contributing both indirectly as well as directly to the carbon footprint (HCHW, 2019). In accordance with the Greenhouse Gas Protocol general framework, which has also been extended to health sector, the sources of Scope 1, Scope 2, and Scope 3 emissions are illustrated below-

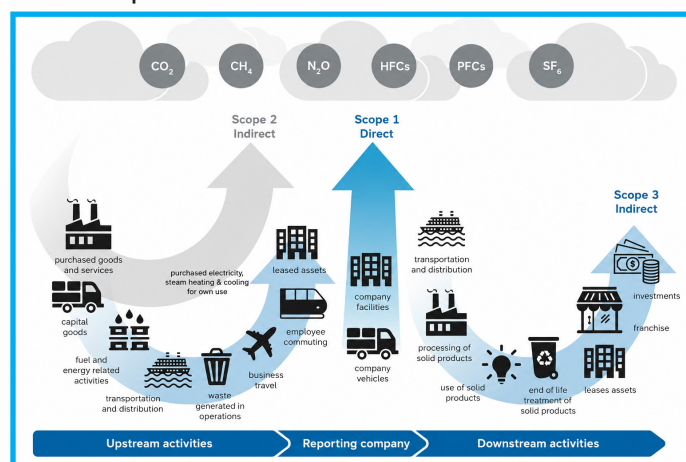


Figure 2- Greenhouse Gas Protocol Scopes 1, 2, and 3

It is important to note here that these present a guidance of the upstream and downstream activities and the associated emissions, it is suggested that national level studies may be conducted to understand the detailed emission profile. For example, the NHS England, has conducted multiple assessments to identify the emission sources, the percentage of their contribution to healthcare delivery to evidence inform the measures to be taken for climate mitigation by the health sector. These include- Energy consumption (transport, electricity, heating and cooling) as well as product manufacture, procurement, use and disposal.

- **Scope 1 GHG emissions** - Direct emission sources include those emanating directly from on-site fuel consumption in health care facilities and vehicles owned by health care facilities.
- **Scope 2 GHG emissions** - Indirect emissions refer to energy used by facilities, such as electricity, steam, cooling and heating
- **Scope 3 GHG** - emissions A third significant source of emission primarily derived from the health care supply chain is through the production, transport and disposal of goods and services, such as pharmaceuticals and other chemicals, food and agricultural products, medical devices, hospital equipment as well as instruments purchased and used by health care facilities

In accordance with the first Global study conducted by Healthcare Without Harm (HCHW), 2019, about 4.4% of the total global emissions are contributed by healthcare (HCHW, 2019). This figure was then identified to be nearing 5% in 2022-23. As per the study, although India was not categorized in the high-emitters list, it is observed that as per the increase in population, the healthcare demand, as well as the increased burden on healthcare due to climate change, there is to be a considerable increase in the emissions by the health sector in India. The study identified emissions per multiple areas of healthcare systems delivery were identified as per the WHO System of Health Accounts which included hospitals, long term care, ambulatory care, ancillary services, retailers, preventive care, admin+ finance, providing care at home, and providing care to non-residents. Furthermore, the study identified “energy generation and distribution” to have majority i.e. 40% contribution to the healthcare emissions followed by other supply chain contributions (HCHW, 2019) as illustrated in the figure below.

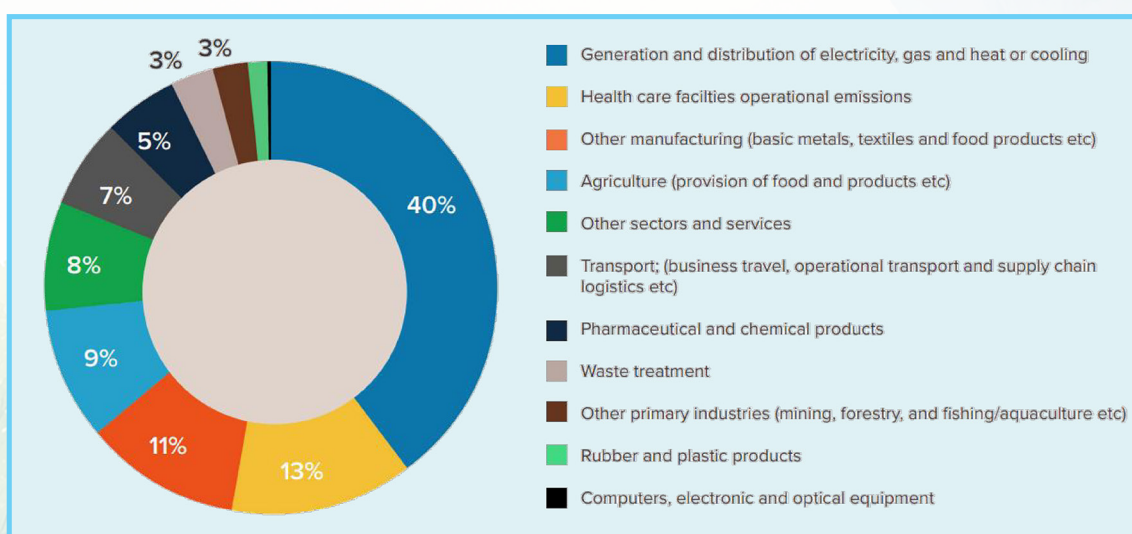


Figure 3- Emissions from Healthcare as per HCHW report

Healthcare Decarbonization in India- Current Approach and Practices

In India, public healthcare is a state subject, i.e. driven by both the central government as well as state level governments. Further, the delivery of healthcare services is supported by various actors including private hospitals, charitable and or trust driven hospitals and clinics and other models based on the patient catchment characteristics as well as the rural and urban geographies.

□ National Level-

As established in the policy section above, the decarbonisation component is being undertaken at the national level under NPCCHH programme as a part of building climate resilient healthcare. As the nodal agency, the programme has developed guidelines for Green and Climate Resilient healthcare which underscores the WHO Operational Guidelines and Framework for developing climate resilient facilities, 2015. Under the programme, Energy Efficiency, Water Efficiency, Green Buildings, Smart Healthcare, and Waste Management have been identified as key intervention areas. The programme is also supporting the component of solar powering healthcare facilities to improve energy access, healthcare service delivery during extreme weather events, ensuring service continuity during climate change impacts, and to reduce the carbon emissions due to usage of fossil based energy source. Under the programme, the state health departments are advised to undertake energy efficiency measures such as replacement of all light bulbs with LED bulbs, as well as installation of solar energy generation models.

The programme also supported the conduct of first baseline study in India to understand the energy consumption behaviour of public and private healthcare facilities in India. This is a remarkable step in documenting appropriate

data of energy patterns in the healthcare in order to design a roadmap for decarbonisation. The Towards Climate Smart Hospitals; Insights from a National Hospital Energy Consumption Survey, is a baseline for the public and private healthcare in the country, determining the energy consumption patterns as well as the projected CO₂ emissions. The study details the difference in consumption patterns across the public and private healthcare facilities related to lightning, use of alternate energy sources, HVAC system, refrigeration, as well as compiles the baseline Energy Performance Indices as well as Annual Energy Usage per Bed (AEUB) . These findings are to be analysed in the context of geographies, population in the catchment area of the facility as well as the kind of services being provided by the facility. In accordance with the computations made, public healthcare facilities (<2L) emit 7 lath tonnes of tCO₂ annually, whereas about 40 thousand private facilities emit around 70 lath tCO₂ annually (NPCCHH, 2023). Although, the study is informative to the extent of establishing the energy consumption pattern in private and public healthcare in the country, the scope of these studies needs to be expanded to develop a thorough understanding of the emissions per sources of other areas such as the waste management, pharma, transportation and other such intensive systems collaborating for effective healthcare systems to arrive at a robust decarbonisation mechanism.

Interestingly, the big private healthcare chains such as Apollo Hospitals Enterprise Limited (AHEL), as per their commitment to Sustainable Business practices, are engaging with the ESG frameworks for optimization of and reducing their carbon footprint. Although no regulatory commitments have been issued in this regard.

□ State Level-

As per the guidance from NPCCHH, the state governments are initiating measures for facilitating solar power in the public health

facilities. Under the programme, the Primary Health Centers, Community Health Centers, and District Hospitals are prioritized for installation of solar panels. The programme is also supporting the conduct of energy needs assessment for facilities to establish their current energy usage pattern and infrastructure support for solar models, via a mobile app. This assessment is to further inform the solarisation needs and costing estimations for the state government. Based on these, the states in collaboration with the technical expertise from REDAs are issuing tenders for solarisation. A few states such as Chhattisgarh have invested in this activity much before and have reached quite a scale.

Chhattisgarh initiated the measures for decarbonizing its public healthcare infrastructure during 2000s with the support from the Chhattisgarh Renewable Energy Development Agency (CREDA). As per the 2023 update, about 906 healthcare facilities have been solarized in Chhattisgarh including district hospitals, CHCs, PHCs, and sub health centers benefitting approx.. 80,000 patients per day (CREDA, 2023). Meghalaya, with support from Selco Foundation, remote areas access, labour room electricity and other such models of assurance. Certain other states are also investing in these initiatives, with identification of a few healthcare facilities, whereas scale up initiatives need to be invested in.

Other states making considerable progress in solar powering the healthcare facilities include Manipur, Meghalaya, Assam, Kerala, Uttar Pradesh, Gujarat, and Goa amongst others.

Solarization of Sub-Centres in Meghalaya to Reduce Energy Costs and Avail Financial and Environmental Benefits

“Before the installation of solar panels, the delivery of health services used to be affected due to power cuts. Since the installation, the Auxiliary Nurse Midwives have experienced

significant improvement in the functioning of sub-centres, especially in the way there is no interruption during the delivery of pregnant women. The sub-centres run entirely on solar energy. The staff has been trained on how to maintain the solar panels which includes cleaning it and refilling the distilled water in batteries.”

The subcentres are saving up to Rs 7,380/ annually each, while preventing approximately 25 tonnes of carbon dioxide emissions.

-As informed by State Nodal Officer- NPCCHH, Meghalaya

□ Discussion and Way Forward

At the outset it is important to note that decarbonisation of healthcare is a long drawn extensive process with a requirement of being driven by a clear policy, understanding the needs across the areas of healthcare delivery and mapping against efficiency measures and alternatives, prioritizing and preparing a roadmap. Using decentralized energy systems as a step towards decarbonisation is a comprehensive initiative addressing the major global commitments on climate mitigation. Additionally, when viewed in the context of India, wherein reliable energy access is still a gap, investing in this initiative serves a plethora of purposes towards strengthening public healthcare in the country.

As per the Lancet 2023 report, reliable electricity in health-care facilities is essential for quality health-care provision. Electricity is needed for basic amenities, such as lighting and clean water; it powers crucial devices in health-care settings, including vaccine and medication refrigeration, oxygen concentrators, and some diagnostic and surgical equipment; and it enables the use of key tools for maternal and child health, including ultrasounds, fetal heart monitors, and baby warmers. (Lancet, 2023). Health centres without

electricity perform fewer deliveries and have fewer patients. (Lancet, 2023). Thus prioritizing energy efficiency measures and solar powering facilities provides a platform to address these concerns.

A component of decarbonisation is being addressed in the NPCCHH with solar powering the healthcare facilities. This is a major step to support in the transition to non-fossil fuel based energy source while enabling sustainability, in addition to supporting the climate change mitigation efforts. The solarisation efforts currently are in their initial stages and thereby need to be viewed within a life-cycle approach for environmental sustainability; to be ensured by maximum resource utilization, proper maintenance and upkeep of the equipment, and safe disposal mechanisms. Further, currently in India, a fragmented approach is visible concerning this initiative, creating a requirement for strengthening the institutional governance and policy around the same. There is a need for the health directorate to be the nodal agency so as to ensure system ownership, monitoring the energy efficiency measures, as well as reduction in carbon footprint, comprehensive monitoring framework across the interventions required, ensure capacity building which in turn is to support the NDCs and building community resilience and efforts in reducing emissions as a safeguard against increased climate sensitive illnesses.

It is encouraging to view the models adopted by different states to support solarisation by building partnership with state REDAs, there is also a need for sensitization of healthcare staffs and personnel to undertake ownership of the equipment, monitor the impact of these initiatives, support and or explore joint financing models, and capacity building of the staff for ensuring maintenance for system continuity, and maintaining energy consumption behaviour. The synergies of the same may be explored with the Kayakalp initiative under the eco-friendly

facilities component as well as IPHS guidelines.

Clean, renewable energy presents an opportunity to provide electricity to remote settings or energy-poor settings, with the potential of saving lives and improving the health of vulnerable populations. Although extending national grids can be expensive and slow, options such as solar photovoltaics are cost effective and offer non-polluting energy without the need for grid connection or fuel input (Lancet, 2023).

Additionally, electrification has been shown to improve vaccination rates, emergency capabilities, and the quality of maternity care, it could be a key tool in limiting gender and health disparities. (Lancet, 2023).

Urgent mitigation can still keep temperatures within adaptability thresholds, simultaneously delivering health co-benefits in the immediate term. Increasing access to zero-carbon energy can, if delivered with health as a key priority, not only reduce energy poverty, but also improve air quality, saving millions of deaths each year. Urgent decarbonisation efforts for healthcare in India are a necessity needs to be built upon (Lancet, 2023)

A few steps in this direction include strengthening the drive and institutional mechanism for low carbon development by arriving at near term as well as long term net zero targets. Further, it is necessary to understand the need and growth of healthcare industry in India, service and patient care expansion and accordingly develop plans. Initiating financing mechanisms at the central government as well as state government levels to strengthen local measures for decarbonisation would also be a great contributory step.

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Emerging research priorities for climate change and health in India

Authors: Puneet Khanduja, Anirooddha Mukherjee, Gayatri Ahuja

Affiliation: MicroSave Consulting (MSC), New Delhi

Climate change presents significant health challenges in India, a country with a diverse geography and population. This paper explores the existing and evolving research priorities, effects, and policy implications of climate change on human health in India. The study finds that India's susceptibility to climate change is heightened by several factors, such as a large population, diverse regions, and expanding urban heat islands, among others. The National Action Plan on Climate Change (NAPCC) and the National Mission on Strategic Knowledge for Climate Change (NMSKCC) are key Government initiatives aimed at increasing resilience and reducing the impact of extreme weather events.

The study identifies several key research priorities of the Government, such as climate modeling, understanding extreme events, urban climate dynamics, aerosol impacts, and Himalayan ecosystem preservation. The study also delves into the adverse health effects of climate change in India, which include heat stress, pollution-related illnesses, vector-borne diseases, and food insecurity. The paper also highlights obstacles to climate change and health research in India, such as low priority, lack of trained personnel, and inconsistent funding.

Four key emerging priorities are outlined for enhancing climate resilience in India's healthcare sector, including developing comprehensive climate impact archives, improving environmental surveillance, encouraging interdisciplinary research, and expanding partnerships for

coordinated strategies.

Policy implications of this priority re-alignment include increasing research funding, conducting vulnerability assessments, investing in operational research for climate-resilient health systems, and establishing inter-ministerial monitoring mechanisms to effectively implement climate change policies. By prioritizing research, enhancing resilience, and implementing evidence-based policies, India can mitigate the adverse health impacts of climate change and build a sustainable future.

Keywords: climate change, climate resilience, environmental health, health research, health research priorities

Introduction

Climate change has been linked to various adverse health outcomes, and India, with its diverse geography and population, is particularly vulnerable.

On a global level, WHO reports that approximately 3.6 billion people are already at risk of climate change due to their location. Meanwhile, the damages caused to health and linked sectors till 2030 are approximately USD 2-4 billion per annum.¹ In India, the scale is a more significant challenge given the tremendous population, diversity of regions, and growing urban heat islands. To map the extent of the impact, it is vital to understand the themes India chose as research priorities.

The Department of Science and Technology (DST), Government of India launched the National Action Plan on Climate Change (NAPCC) in 2008 to enable India to become more climate-resilient and to develop the capacity to mitigate the impact of extreme events.

8 Missions under National Action Plan on Climate Change 			
	Coordinating Ministry		Coordinating Ministry
National Mission for a Green India	Ministry of Environment, Forests & Climate Change	National Mission on Strategic Knowledge for Climate Change	Dept. of Science & Technology
National Mission for Enhanced Energy Efficiency	Ministry of Power - Bureau of Energy Efficiency	National Mission for Sustaining the Himalayan Ecosystem	Dept. of Science & Technology
National Water Mission	Ministry of Jal Shakti	National Solar Mission	Ministry of New & Renewable Energy
National Mission for Sustainable Agriculture	Ministry of Agriculture	National Mission on Sustainable Habitat	Ministry of Housing & Urban Affairs

Figure 1: Details of the 8 Missions under the NAPCC and their Coordinating Ministries

Under the National Mission on Strategic Knowledge for Climate Change (NMSKCC), one of the eight national missions under the NAPCC, DST acknowledges that India, with its inherent diversity and geographical spread, cannot adopt and develop climate adaptation strategies based on the global averages of climate change.³ This means India has to indigenously build climate modelling studies and technological systems to mitigate adverse effects based on local and regional research.

i. Climate modelling

Climate modelling is crucial for India's development of mitigation strategies. While the Intergovernmental Panel on Climate Change (IPCC) reports that the simulations generated by Global Climate Models (GCMs) predict how anthropogenic warming affects different aspects of the Earth's system, it is unable to accurately simulate India's monsoon climate due to its inability to comprehend monsoon dynamics.⁴

The DST has identified long-term goals for climate resilience that involve building up technological capacities and infrastructure to simulate warming effects, learning from paleoclimatic studies, and enhancing mitigation strategies on all levels: national, state, and district. The short-term roadmap put in place by DST includes setting up bodies of academic institutions and researchers incorporating newer technologies to assess district-level vulnerabilities.

ii. Extreme events

The Climate Risk Index 2020 indicates that India was ranked the fifth most affected country in the world in 2018, with the highest death toll and economic losses among the ten most affected

countries.⁵ Extreme events arise from a limited

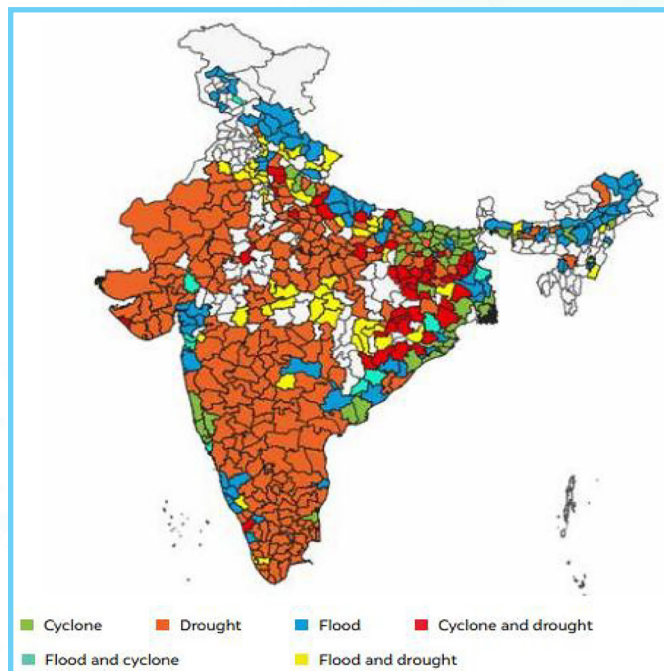


Figure 2: CEEW analyzed that >75% of Indian districts are extreme climate event hotspots

understanding of the physical and ecological properties of the Indian Ocean region, leading to an increase in events such as droughts, forest fires, and marine heatwaves. According to India's Climate Research Agenda: 2030 and Beyond⁶, the Indian Ocean's basic-wide warming has experienced an average rise of 0.15°C every decade since 1951. India's regional diversity experiences extreme events in distinct ways. Some of the events observed are coastal erosions and flooding, destruction of mangroves, impediments to food security, availability of clean drinking water, and disease control in the scenario of extreme sea level rise. Moreover, according to India's Climate Research Agenda, extreme events between 2006 and 2011 contributed to agricultural losses of approximately USD 3.75 billion.⁶

iii. Urban climate

India has the world's second-largest urban population. An increase in temperatures is impacting the urban environment, and cities are becoming 'urban heat islands' (UHI). The UHI effect, combined with the increasing sea levels, is resulting in warmer regions attracting cyclonic

events. Metropolitan cities are at increased risk due to their lack of vegetation and green cover, putting the large population at risk of the impacts of extreme heat stress. Heat waves are becoming more frequent, exacerbating water and electricity challenges, poverty, and sanitation in urban India.

iv. Aerosols

According to the IPCC, aerosols are the second highest radiators behind greenhouse gas emissions.⁷ In India, aerosols interact with different environments, such as radiation, precipitation, and climate, distinctly compared to the global norm. Natural dust and aerosols interact differently in diverse climates, while biomass burning also contributes to the dynamic. However, a lack of research on this subject has led to a superficial understanding of the impact of aerosols on monsoons and tropical cyclones, as stated by India's Climate Research Agenda. Technological capacities are to be strengthened by using satellites and instrumentation, which shall contribute to a deeper understanding of the adverse effects of aerosols.

v. Himalayan ecosystem

The Himalayan ecosystem interacts with the aforementioned themes, and their impact must be mitigated to conserve the ecosystem. Extreme events caused by oceanic disturbances result in extreme flooding and rain in the Himalayan region. In contrast, disturbances in the cryosphere have shrunk glacial areas in the region at an annual rate of approximately 0.36% during 1960-2010.⁸ Nearly 51 million people practice agriculture in the region. They are at various risks of climate change, and the DST, through the NMSHE initiative, has the objective of increasing knowledge networks and improving regional sustainability to create mitigation strategies specific to the Himalayan region.

❑ Effects of climate change on human health in India

India has a population of 1.4 billion across diverse regions and environments, facing various challenges, especially regarding health. With the growing ill effects of climate change, vulnerable groups find it more challenging to adapt without proper support to mitigate the effects of climate change. Several factors should be considered, given that deaths are rising due to extreme weather events over the last five decades (India's Climate Research Agenda). This section briefly summarizes the pertinent interplay of climate change and human health, especially within the Indian context.

❑ Heat stress and pollution

There has been an average global temperature increase of 1.5-2°C, contributing to higher mortality risks across India. According to official figures, more than 23900 people have died from heat stroke between 1990 and 2020 in India⁹, with 2300 deaths in 2015 alone.¹⁰ India is also at high risk of air pollution, mainly due to the increase in the burning of fossil fuels. Research shows increased ozone levels due to pollution and high temperatures increase cardiorespiratory mortality and morbidity risk. Heat stress also causes an increase in day-to-day challenges such as nausea, headaches, and malaise.¹¹

❑ Vector-borne diseases

Sporadic climate conditions are linked to the rise in vector-borne diseases, primarily malaria and dengue. Excessive rainfall and humidity ensure sufficient breeding grounds for mosquitoes, and India has a long history of mortality risks associated with these diseases. Research shows that a 2–3°C increase in global temperatures would increase the risk of malaria by 3-5%.¹² The temperature rise also poses a risk of higher transmission of dengue and other endemic diseases like chikungunya, filariasis, Japanese encephalitis, and visceral leishmaniasis. There

is cause for concern that due to the impact of climate change, certain new areas like north-eastern states and Himachal Pradesh may witness new transmission windows, while re-emergence of chikungunya is a possibility for southern India.¹³

❑ Food security and nutrition

Increases in temperatures and erratic rainfall patterns impact agricultural yields. In India, there has been a growing concern among farmers about their crops being at higher risk of climate change. The impact on crops means an increase in food insecurity for a significant population. Malnutrition has been an ongoing struggle for the Indian population and is linked to reduced nutrition and food variety. Extreme weather also impacts maternal health, causing suboptimal breastfeeding and, hence, exposing the infant to more significant risks of malnutrition and low immunity.¹⁴

❑ Underlying barriers to research on climate change and human health in India

Barriers to climate change and health research in India present significant factors that impede progress in understanding and mitigating the impacts of climate change on public health. Among these factors, three key themes stand out: the low priority assigned to environmental health research, the lack of trained personnel, and inconsistent funding.

Despite the increasing recognition of climate change as a pressing global issue, environmental health research often receives lower priority in India compared to other areas, such as infectious diseases or maternal and child health.¹⁵ This may be due to a lack of awareness among policymakers and the public about the interconnectedness of climate change and health and competing priorities for limited research resources. As a result, insufficient

investment in studying the complex interactions between environmental factors, climate change, and human health hinders efforts to develop effective interventions and policies. The 1984 Union Carbide methyl isocyanate gas leak tragedy in Bhopal, considered one of the most severe global industrial disasters, was an inflection point in India's history of environmental health research and legislation. The Government of India took cognizance of the public health effects of methyl isocyanate. It established the National Institute for Research in Environmental Health in Bhopal under the ambit of the Indian Council of Medical Research.¹⁶

Another significant barrier is the shortage of trained personnel with expertise in environmental science and public health.¹⁵ Climate change and its impacts on health are interdisciplinary issues requiring diverse skills, including expertise in climatology, epidemiology, environmental science, and public health. However, there is a shortage of professionals in India who possess this interdisciplinary knowledge and can conduct high-quality research in this field. This shortage limits the capacity for conducting research and hampers the ability to translate research findings into actionable policies and interventions.

Inconsistent funding poses a significant challenge to India's climate change and health research. Research projects in this field often require long-term funding commitments to collect data, conduct analyses, and assess the effectiveness of interventions over time. However, funding for such projects tends to be sporadic and subject to shifting priorities, making it difficult for researchers to plan and execute comprehensive studies. Moreover, reliance on short-term funding cycles can discourage researchers from pursuing ambitious or innovative projects that may take years to yield results, further stifling progress in this critical area.

□ Evolution of research priorities for climate change and health

Over the past decade, research priorities for climate change and human health have evolved significantly. The field has expanded to include a broader understanding of the complex interrelationships between environmental change, human health, and socioeconomic transitions.

Initially, research focused on the direct impacts of climate change on human health, such as extreme weather events, changes in temperature, and the spread of infectious diseases. This approach recognized climate change's immediate and tangible effects on human well-being.

Researchers have recently broadened their scope to include the interplay between socioeconomic transitions and environmental change. This transdisciplinary approach acknowledges the complex interactions between human activities, ecosystems, and health.

Research now emphasizes the direct health impacts of climate change and the indirect effects mediated through social, economic, and environmental pathways. Studies have shifted towards recognizing the broader impact of climate change on human health, including indirect effects mediated through social, economic, and environmental pathways. This evolution in research priorities reflects a more comprehensive understanding of the complex interrelationships between climate change and human health, highlighting the need to consider the immediate health impacts and the underlying social, economic, and environmental factors that can influence health outcomes.^{17 18}

This broader perspective has also led to increased attention on vulnerable populations, such as low-income communities and indigenous groups, who are disproportionately affected by both climate change and health disparities.

The research priorities for climate change and human health have also evolved to include a broader understanding of the complex interrelationships between environmental change, human health, and socioeconomic transitions. This evolution has led to a transdisciplinary approach that spans multiple scales and disciplines and recognizes the need for evidence-based policies and programs to address the health risks associated with climate change.

This paper has identified four major forward-thinking priorities for India to promote a holistic view of the intersectionality between climate change and human health and build a future-proof, climate-resilient healthcare ecosystem.

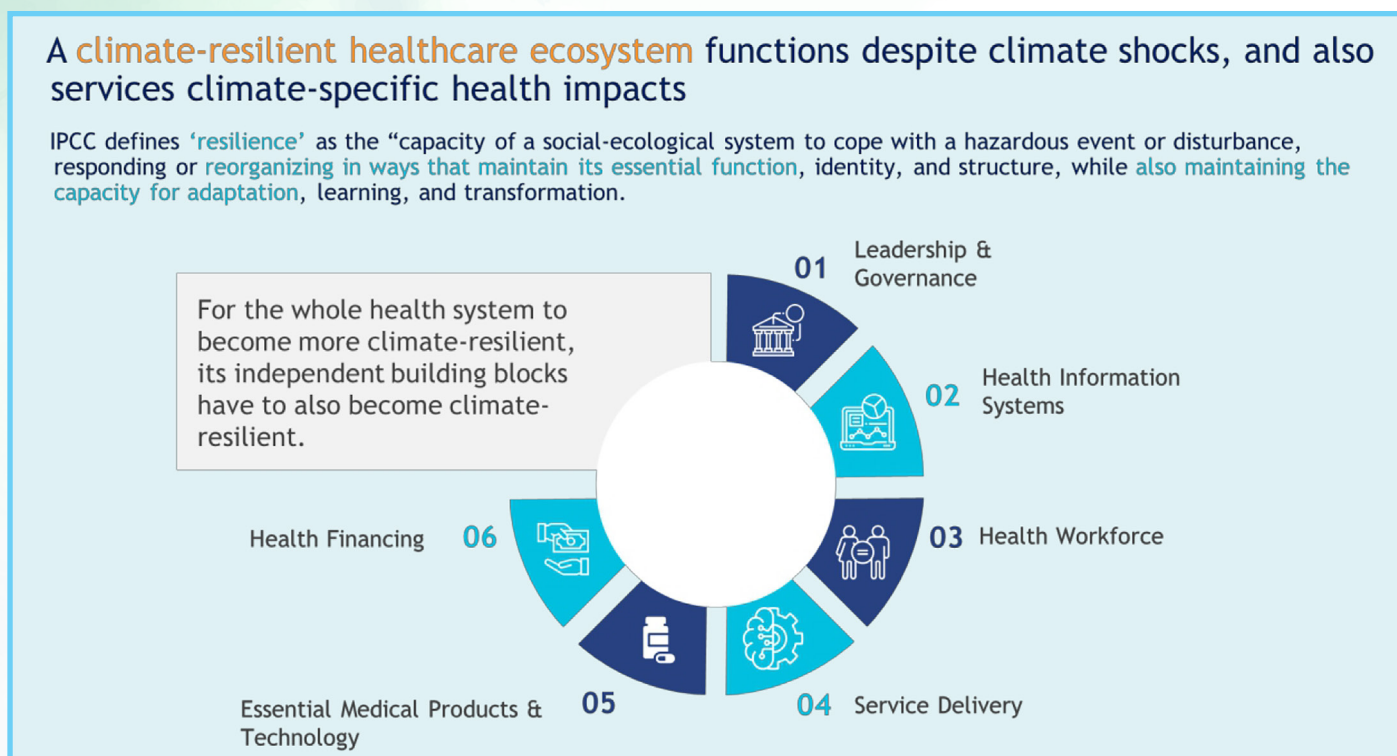


Figure 3: Building blocks of a climate-resilient healthcare ecosystem

i. Developing a Comprehensive Archive of Climate Change and Health Outcomes

Developing a comprehensive archive of climate change and associated health outcomes across the range of climatic and socioeconomic differences in India is crucial for understanding the diverse impacts of environmental changes on public health. Such an initiative can capture the varying health vulnerabilities and risks faced by different regions and populations in India due to climate change. By compiling a detailed archive that considers the broad spectrum of climatic conditions and socioeconomic factors present in the country, policymakers and healthcare professionals can tailor interventions and policies to address specific health challenges effectively. This comprehensive approach will enable a more nuanced understanding of how climate change influences public health outcomes in India, paving the way for targeted strategies to mitigate risks and enhance resilience.

The United States Environmental Protection Agency (USEPA) maintains a similar database¹⁹, with dedicated sections on health impacts on various sectors such as health, agriculture and food supply, air quality, ecosystems, and energy, among others.

Research efforts focusing on developing this archive are essential for informing evidence-based decision-making and resource allocation to address climate-related health challenges in

India. This archive will not only facilitate the identification of vulnerable populations but also guide the implementation of preventive measures and adaptive strategies to safeguard public health. Furthermore, by considering the complex interplay between climatic variations, socioeconomic disparities, and health outcomes, this comprehensive archive can serve as a valuable tool for promoting equity in healthcare access and improving overall resilience to the health impacts of climate change in India.

ii. Improving Environmental Monitoring and Surveillance Systems

Improving environmental monitoring and surveillance systems to gain a deeper understanding of the current climate-health associations in India is crucial for enhancing public health preparedness and response strategies in the face of climate change impacts. By strengthening these systems, policymakers and healthcare professionals can gain valuable insights into the intricate relationships between environmental factors and health outcomes, allowing for more targeted interventions and mitigation measures. Enhanced monitoring and surveillance capabilities enable the timely detection of emerging health risks associated with climate change, such as the spread of infectious diseases or the effects of extreme weather events, facilitating proactive measures to protect public health.

Furthermore, by investing in advanced environmental monitoring technologies and surveillance systems, India can effectively track and analyze the current climate-health associations across different regions and populations. This comprehensive approach provides valuable data on the immediate impacts of climate change on public health and helps identify vulnerable communities and develop tailored interventions to address their specific needs. Improved surveillance systems can also contribute to early warning systems for climate-

related health risks, enabling prompt responses and adaptive strategies to mitigate the adverse effects of environmental changes on human health in India.

iii. Encouraging Interdisciplinary Investigations

Interdisciplinary

Encouraging research on interdisciplinary and multidisciplinary investigations using environmental epidemiologic methods to elucidate health risks posed by climate change is essential for developing a comprehensive understanding of the complex interactions between environmental factors and public health outcomes. By promoting collaboration across disciplines, such as environmental science, epidemiology, and public health, researchers can uncover the intricate pathways through which climate change impacts human health. This approach allows for a more holistic assessment of the health risks associated with climate change, considering direct impacts and indirect effects mediated through social, economic, and environmental pathways.

iv. Expanding Partnerships for Coordinated Strategies

Expanding partnerships among researchers, governments, and communities in India is crucial to developing a coordinated strategy that effectively addresses public health challenges and risks associated with climate change. Despite limited engagement and research on the varied health impacts of climate change in India, collaboration between stakeholders can bridge this gap and foster a more comprehensive understanding of the nexus between climate change and public health. By forming strategic partnerships, researchers can leverage expertise from various fields to conduct interdisciplinary studies that elucidate the specific health risks posed by climate change in different regions of India.

Moreover, involving governments and

communities in these partnerships is essential for translating research findings into actionable policies and interventions that mitigate the adverse effects of climate change on public health. India can effectively develop tailored strategies to address climate-related health challenges by fostering collaboration between policymakers, researchers, and local communities. This coordinated approach not only enhances the resilience of communities to climate change impacts but also promotes sustainable public health practices that prioritize the well-being of all individuals, especially those most vulnerable to the health risks associated with environmental changes.

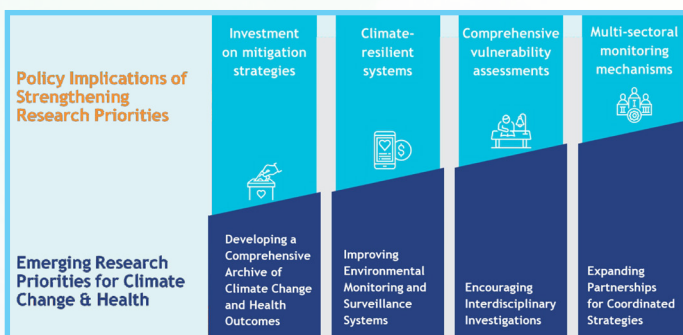


Figure 4: Inter-dependence of research priorities and policy actions

□ Policy Implications of Strengthening Research Priorities

As part of the National Action Plan for Climate Change (NAPCC) formulated by the Government of India in 2008, the National Mission on Strategic Knowledge for Climate Change (NMSKCC) highlights systematic knowledge gaps in crucial underlying scientific areas of climate change. Further, it underscores that critical scientific gaps persist alongside inadequate data on climate change impacts across agriculture, ecosystems, and health sectors. Fragmented knowledge networks, limited connectivity, and a lack of institutional mechanisms hinder effective decision-making. There's also a need for a global technology watch system linking technology choices with climate responses. Furthermore, a system for scenario-based impact assessment and risk-minimized technology selection is

absent, impeding developmental goals.³

As the global climate crisis escalates, its profound implications on human health are increasingly evident. In the Indian context, strengthening and streamlining the existing research and policy efforts dealing with climate change and public health has become imperative. The policy implications of bolstering the identified research priorities highlight the potential pathways to build a comprehensive knowledge base tailored to India's geographical and social diversity.

i. Increasing funding for research on the mitigation of health impacts of climate change

While there is enough documented evidence on the interplay between climate change and health, the research landscape for climate-risk mitigation strategies for health systems is relatively scant.²⁰ Increasing funding for research on strategies to mitigate the effects of climate change on the Indian health system can enable researchers to collect longitudinal data related to climate variability and health outcomes in specific locations and use decision-analysis frameworks to weigh the costs and benefits of interventions. Further, the National Center for Disease Control can spearhead cutting-edge research on climate-sensitive outcomes that have been less studied and that incorporate economic research to understand the health-related costs of climate change. It is an opportune juncture to formalize India's G20 commitments on climate action through a policy-level consensus between the Government and leading global funding organizations and research-based agencies.

ii. Pan-India Vulnerability Assessment of Health Systems to Climate Change

A pan-India vulnerability assessment of health systems to climate change is crucial for informing the National Programme for Climate Change and Human Health (NPCCHH), being administered by the National Centre for Disease Control

(NCDC). Such an assessment would enable a deeper understanding of the impacts of climate change on health systems across India. The vulnerability assessment in the Indian Himalayan Region commissioned by the Dept. of Science & Technology, for example, highlights ecosystems' fragility and the millions' dependence on these regions for water, food, and energy. A study by Berry et al. provides valuable insights into the dynamic risks climate change poses on health systems. It emphasizes the importance of evidence-based information in supporting public health officials in addressing these challenges.²¹

iii. Investing in operational research on building climate-resilience

Climate change has notably impacted various aspects such as the environment, ecology, economy, agricultural production, and global food security, including human nutrition.²² Therefore, operational research on building climate resilience is crucial for addressing the impacts of climate change on health and nutrition systems in India. The World Health Organization has been pushing for creating resilient health systems that can effectively respond to the challenges posed by climate change.²³ The Union Ministry of Health & Family Welfare operates the National Programme for Climate Change & Human Health (NPCCHH) under the NHM umbrella. Under this Programme, an Energy Assessment of healthcare facilities has already been initiated, covering 18 States/UTs representing all five climate zones of India, covering nine building typologies and 1600 healthcare facilities. Additionally, a Health Facility Energy Ranking is being developed to calculate the Energy Performance Indicator of health facilities.

Systems thinking can provide a holistic view of the interconnectedness of various factors contributing to public health outcomes and their interplay with India's food and nutrition ecosystem.

These factors are particularly relevant to India's Public Distribution System (PDS), which is crucial in ensuring populations' access to food and nutritional support amidst changing environmental conditions. Field trials in wheat, maize, rice, and soybeans have now established that rising environmental carbon-monoxide levels, largely due to fossil fuels burning, have significantly reduced the levels of the essential nutrients iron and zinc and cutting protein levels.²⁴ Diversifying the household nutrition basket through the PDS and scaling up climate-resilient crop varieties can help the PDS become more climate-resilient and future-proof.²⁵

iv. Establishing an inter-ministerial monitoring mechanism for guiding the implementation of NAPCC

To enable streamlining and institutionalization of efforts for effective implementation of the National Action Plan for Climate Change, in line with the Mission LiFE (Lifestyle for Environment) envisioned by the Prime Minister's Office (PMO), it is proposed that as a first step, a dedicated Climate Change Governance Cell may be established within the PMO or the NITI Aayog. This Cell would be suitably positioned to streamline the efforts of the 8 Ministries involved in implementing the National Missions under the National Action Plan on Climate Change. This approach is also echoed by the Mission Document of the National Mission on Strategic Knowledge for Climate Change (NMSKCC), which recommends the establishment of Oversight Committees and inter-ministerial approval mechanisms. This approach can help guide the implementation of the NAPCC and ensure that the various missions are aligned for cohesive action.

Discussion

Geography has emerged as an interdisciplinary player connecting the realms of health and public policy with data that is crucial to informing

effective decisions. Therefore, India's geographic diversity can be turned into an advantage for building systemic climate resilience across diverse sectors, much like the demographic dividend of the country's 1.4 billion-plus population. Localized action on targeted challenges, backed by digital technologies, has been documented to develop stakeholder mobilization and garner sustainable community support.²⁶ Further, domains such as household nutritional diversity also have the potential to benefit from a systems approach to building resilience.

Addressing the emerging research priorities for climate change and health in India is crucial to mitigate and adapt to the health impacts of climate change. The need for increased funding for research on the mitigation of health impacts of climate change is paramount. This funding will support research on strategies to reduce the health risks associated with climate change and promote interdisciplinary research toward creating a centralized knowledge repository.

Conducting multi-sectoral vulnerability assessments to climate change across geographies, is essential for understanding the impacts of climate change on government service delivery systems in diverse regions of India. This assessment will help identify the most vulnerable pockets and populations, enabling the development of targeted interventions. By investing in operational research on building climate-resilient health systems, India can develop strategies to enhance its adaptability to changing climatic conditions.

Establishing an inter-ministerial monitoring mechanism for guiding the implementation of the National Action Plan on Climate Change (NAPCC) in India is crucial for ensuring effective and coordinated action across various sectors. This mechanism will help track progress, identify challenges, and ensure the plan's successful implementation, balancing climate objectives with domestic priorities of growth, development, and poverty reduction.

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Impact of climate anomalies on health determinants in states with co-endemicity of leprosy and other NTDs

Subhojit Goswami, Swagata Yadavar, Nikita Sarah

□ Abstract

Title: Impact of climate anomalies on health determinants in states with co-endemicity of leprosy and other NTDs

Background: Seven states contribute more than 75% of the total leprosy cases in India every year. These states are co-endemic for Lymphatic Filariasis and Kala-azar. At least 70% of the districts across these states are vulnerable to extreme weather events, which puts at risk their nutrition security and sanitation safety—prerequisites for disease prevention and ending community transmission.

Objectives: Understanding the impact of climate anomalies on social determinants that influence health outcomes in people affected with leprosy, living in areas with co-endemicity of NTDs.

Methods: It is a mixed methods study that involved semi-structured interviews with persons affected by leprosy and their families across two states, and an analysis of the existing government data on disease prevalence, climate vulnerability and multidimensional poverty. The study also drew insights from peer-reviewed literature and media reports.

Results: Identified 30 districts with high number of at-risk populations having the triple burden of high leprosy prevalence, climate vulnerability and multidimensional poverty. Demonstrated that large concentration of tribal population, recurring droughts and floods, and poor adaptive capacity are the risk factors for leprosy and other NTDs.

Conclusion: The study points to a need for a multi-dimensional assessment of vulnerability

in areas co-endemic for leprosy and other NTDs while prioritising efforts towards health systems strengthening and climate adaptation & mitigation. What emerges is the scope for implementing a holistic One Health approach towards elimination of NTDs that goes beyond only the clinical aspects of the diseases.

Key words: health determinants, disease prevention, Neglected Tropical Diseases, climate adaptation, One Health approach

Authors: Subhojit Goswami¹, Swagata Yadavar², Nikita Sarah¹

Affiliations

1. The Leprosy Mission Trust India
2. Independent Consultant

India has the highest leprosy prevalence in the world, contributing about 55 per cent of the global cases reported each year. Historically, seven states—Bihar, Chhattisgarh, Jharkhand, Maharashtra, Odisha, Uttar Pradesh, and West Bengal—contribute 70-80 per cent of the cases¹, as per data with the Directorate General of Health Services (DGHS) under the Union Ministry of Health and Family Welfare. (Refer Table 1)

A body of research suggests that nutritional deficiencies can facilitate a progression from *Mycobacterium leprae* infection to the clinical presentation of leprosy by impairing immune system.² The results of the studies conducted in South Asia and Africa bear a striking resemblance as almost all of them draw a connection between protein-energy malnutrition, inadequate intake of vitamins and/or minerals, reduced cell-mediated

immunity, and leprosy transmission.

There are other studies that attribute leprosy transmission to “lack of hygiene and proper sanitation, poor and inadequate supply of water”.³ A study by The Leprosy Mission Trust India,⁴ published in the Indian Journal of Dermatology, Venereology, and Leprology in 2018, suggested that the contacts of active Leprosy cases “are getting constantly exposed directly to both patients and an environment (soil and water) wherein *M. leprae* has been shown to remain alive in all seasons for long duration.” The study recommended improving the environment for health and hygiene, without which “shedding of bacilli from infected cases will prove to be a continuous source of exposure to infection”. This is true for many other neglected tropical diseases (NTDs).

As an organisation focussed on leprosy and other NTDs, and being present in several climate-vulnerable states, we could hypothesize that a steady rise in both sudden and slow onset climate anomalies such as extremely heavy rain, intense cyclones, floods, and droughts has raised concerns over food security and access to clean water and sanitation—prerequisites for stopping transmission of leprosy and other NTDs.

□ Methodology

We approached this problem statement in two different ways. We visited some of the most climate-vulnerable villages in West Bengal and Bihar. The villages were mapped based on the layered vulnerability we had experienced during our past community interventions. We met 60 members from 10 households in the Sundarbans and Muzaffarpur and had semi-structured discussions with them to understand the challenges they face in accessing livelihood and health care, and how resilient are they in the face of extreme climate events. Most of these households had one or two members either cured of leprosy or undergoing treatment for leprosy or have some form of disability.

We also delved into the observations made by government reports and multilateral organisations. Insights were drawn from research papers on the intersection of leprosy, poverty, and access to hygienic living conditions. Media reports were also referred to for understanding the widespread impact of extreme climate events on the targeted population in highly endemic districts. Available data on leprosy was also analysed to map hotspots and level of endemicity.

□ Results

The Government of India report, *Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework*,⁵ which assessed Sensitivity (“degree to which a system or species is affected by climate variability”) and Adaptive Capacity (“ability of systems, institutions, and humans to adjust to potential damage and respond to consequences”), identified states that are highly vulnerable to climate change. This study found that those are the same states with high endemicity of leprosy and other neglected tropical diseases (NTDs) such as lymphatic filariasis. Similar patterns emerged from the NITI Aayog’s Multidimensional Poverty Index,⁶ which measured “multiple and overlapping deprivations” in basic parameters of health, education, and living standards. The districts that perform poorly in nutrition intake and other socio-economic indicators are also co-endemic for leprosy and other NTDs. (Refer Table 3)

Bihar, for example, on an average, reports about 15% of new leprosy cases in India each year. It is a state whose more than half (51.9%) of its population is ‘multidimensionally poor’. At district levels, this percentage shoots up further. Consider the three northern districts of Bihar: Sitamarhi, Supaul, and Kishanganj. Besides high leprosy prevalence rate—2.32 / 10,000 population as opposed to the national average of 0.57/ 10,000 population—some of these districts have a high share (up to 75%) of leprosy

multibacillary (MB) cases. Unlike paucibacillary (PB) cases, the MB patients have high bacterial load and are a major source of infection, leading to further transmission of mycobacterium leprae. The MB patients are also at greater risk of leprosy reactions and consequent nerve damage. The treatment is long-drawn and requires a more elaborate protocol for patients to follow.

It is to be noted that MB leprosy develops in patients with reduced or impaired cell-mediated immune reaction, which is caused due to protein-energy malnutrition. The three districts of the state, which have very high leprosy prevalence, also have a high percentage of people living in multidimensional poverty, ranging from 63% to 65%. This, of course, begs attention to the food security landscape in the state. About 80% (31 out of 38) of the districts in Bihar are among the top 25% most climate-vulnerable districts in the country. About 68.80 lakh hectares of the state's area (94.16 lakh hectare) is flood-prone, which covers 76% of north and 73% of south Bihar.⁷ Extended dry spells during summer, erratic monsoon rain, and abnormal rise and fall of temperature during planting season (Rabi crops) in winter cause high variability in yield of food grains, especially of diverse and nutritious crops, which can affect the intake of essential nutrients vital for health and immunity.

In neighbouring Uttar Pradesh, data on climate vulnerability, multidimensional poverty and leprosy prevalence demonstrate a similar cause-and-effect relationship. In 2020, Uttar Pradesh reported 15,484 new cases of leprosy, the third highest in the country. Districts with high prevalence of leprosy and other NTDs also have high multidimensional poverty. Over 74% of the population in Shravasti district and 71.8% of the population in Bahraich district are multidimensionally poor. The districts also report other neglected tropical diseases (NTDs) such as lymphatic filariasis and chikungunya.

The study analysed a report from the Council of Energy, Environment and Water (CEEW),⁸ which

stated that 69% of districts in Uttar Pradesh are exposed to compounded climate events such as floods and droughts. Over the last two decades, the state has experienced an increase in incidence of extremely high temperatures, torrential rain, and, in certain areas, devastating floods and droughts. Hence, it is hardly any surprise that the state's agricultural productivity is predicted to decline by up to 25% in irrigated areas and up to 50% in rain-fed areas.⁹ Inconsistent and erratic monsoons have already affected crop yields, cropped areas, and livestock in Bundelkhand region in the last few years.

In Odisha, 26 out of 30 districts are exposed to extreme climate events such as cyclones, floods, and droughts. The state has witnessed a three-fold increase in cyclones between 1970 and 2019. Storm surges, too, have tripled during this period. In fact, climate change is causing stress even in hitherto less vulnerable parts of Odisha. Let's consider Kendrapara. It had been a fertile and prosperous region, "but climate extremes, in the form of rapid onset events, have proven that even stable ecosystems and prosperous economies can erode," said a collaborative study.¹⁰ It went on to add that social protection mechanisms are not able to absorb climate shocks or efficiently cover all eligible households.

□ Discussion

The pattern that emerged in this study is true for other states such as Chhattisgarh, Maharashtra, and West Bengal. Be it Yavatmal district in the Vidarbha region of Maharashtra or Raigarh district of Chhattisgarh, the existence of multiple and simultaneous vulnerabilities is evident. The districts having high endemicity of leprosy and high proportion of tribal populations are shuttling between droughts and floods. This is having the greatest bearing on agriculture and allied sectors that provide income to the rural population, comprising marginal farmers and tribals who either rely on rain-fed monocrop agriculture or forest produce, making them most vulnerable to the impact of climate change.

Extreme climate events and food insecurity are major stressors for people in low-lying islands such as the Sundarbans in West Bengal that are facing a double whammy of climate hazards and chronic poverty. According to Future Health Systems—a research consortium—food insecurity level has a positive correlation with climatic vulnerability of households. “Recurrent climatic shocks and long-term climatic variability has downgraded all four dimensions of food security—availability, accessibility, utilisation and food system stability across the Indian Sundarbans,” says their research.¹¹ It also suggests that over 25% of households in the Sundarbans faced “extremely high losses to food resources during climatic emergencies in the last five years,” and 30% of children (0–6 years) in climatically vulnerable households face chronic malnourishment.

❑ Conclusion

Given the impact of extreme climate events on the social determinants or the non-medical risk factors for leprosy and other NTDs, India has to adopt a two-fold approach to meet the 2027 target of interrupting leprosy transmission. The study recommends implementing a holistic One Health approach towards leprosy elimination

that goes beyond only the clinical aspects of the disease and focuses on intersectoral co-ordination between departments of health, tribal affairs, agriculture, environment, etc. to plan interventions that will have co-benefits.

At the community level, the at-risk population needs awareness about disease transmission pathways and climatic factors (extreme rain, heat stress, and other extreme climate events) determining the persistence and spread of leprosy and ways to reduce the risk factors.

At the health systems level, there is a need for building institutional capacity in terms of analysing historical climate and epidemiological data, integrating climate information in health system planning, predicting disease outbreaks, and preparing the systems to serve people during climate emergencies. Similarly, the public health workforce at a sub-district level needs to be capacitated enough to interpret climate and health data and understand climate-sensitivity of diseases and changing seasonality of diseases.

At the policy level, local climate action plans, health action plans, ancillary policies, and schemes require a thorough review to ensure that they factor in emerging climate-related risks and changes in disease transmission patterns.

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❑ **Conflicts of Interest:** None.

States	Total districts	Number (%age) of highly and very highly climate vulnerable districts	Percentage of population who are multidimensionally poor	Leprosy Cases Reported in 2019-20
Bihar	38	38 (100%)	51.91	16595
Chhattisgarh	18	3 (16.67%)	29.91	8905
Jharkhand	24	23 (96%)	42.16	6160
Odisha	30	19 (63%)	29.35	10077
Uttar Pradesh	70	48 (69%)	37.79	15484
West Bengal	19	14 (74%)	21.43	6208
Maharashtra	35	19 (54%)	14.85	16572
Total	234	164 (70%)		80001

Table 1. Source: Central Leprosy Division, NITI Aayog MPI, and Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework

S. NO.	State	Districts	Leprosy Prevalence Rate	%age of population multidimensionally poor	Climate Vulnerability Rank
1	Bihar	Kishanganj	2.32	64.75	8
2		Supaul	1.11	64.1	53
3		Sitamarhi	0.95	63.46	36
4	Chhattisgarh	Surguja	0.99	47.37	419
5		Bastar	1.71	46.95	NA
6		Jashpur	1.10	45.85	NA
7		Bijapur	1.54	41.2	427
8		Kabirdham	1.94	39.6	474
9		Korba	1.52	31.86	413
10		Raigarh	4.40	30.82	263
11		Mahasamund	3.34	29.85	328
12		Bilaspur	1.99	25.66	273
13	Maharashtra	Nandurbar	2.46	52.12	50
14		Dhule	1.79	33.23	101
15		Yavatmal	1.4	23.54	167
16	Odisha	Nabarangapur	1.72	59.32	74
17		Malkangiri	0.45	58.71	100
18		Koraput	0.89	51.14	55
19		Kalahandi	1.22	47.28	NA
20		Mayurbhanj	1.05	44.90	NA
21		Nuapada	3.21	38	14
22	Uttar Pradesh	Shravasti	1.24	74.38	58
23		Bahraich	0.72	71.88	30
24		Kaushambi	0.61	56.06	358
25		Lakhimpur Kheri	0.98	59.95	109
26		Sitapur	0.98	56.83	188
27	West Bengal	Purulia	1.33	49.69	31
28		Birbhum	0.9	27.6	161
29		Bankura	0.8	27.4	146
30		Jhargram	1.45	23.82	57

Table 2. Source: Central Leprosy Division, NITI Aayog MPI, and Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework

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Need and scope for integrating climate change into medical education- towards preparing future healthcare professionals.

Sandeep Thaker

□ Abstract:

This article delves into the need to integrate comprehensive education on the social and health effects of anthropogenic climate change into medical curricula. The paper explores the profound impact of climate change on human health and argues that preparing future healthcare professionals through targeted medical education is essential for them to identify the effects of climate change and become confident in mitigating and adapting to these emerging challenges.

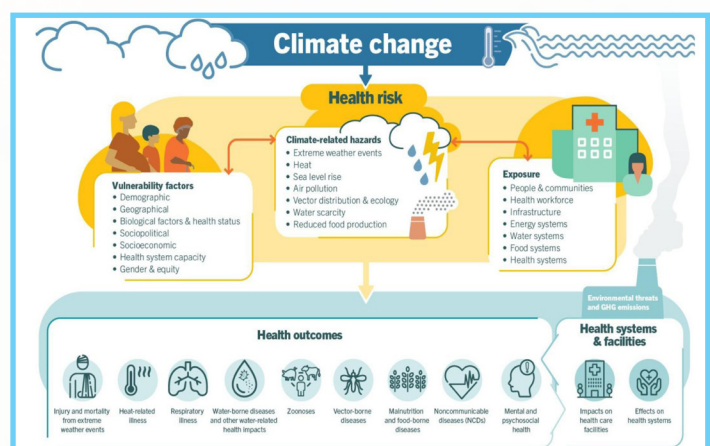
□ Background and Introduction:

Anthropogenic climate change, i.e., climate change due to human actions, poses unprecedented threats to global ecosystems, and its consequences increasingly affect human health. Mention of climate change by modern scientists was first made in the year 1896, and 128 years later, the world is facing extreme weather events, temperatures are reaching record high levels, and the effects of these are borne by all, with the most severely affected ones being those who had the most negligible role in climate change. While the earlier years saw a significant debate on climate change and its impact, over the past few decades, the economic, social, and medical effects are now well documented. Though the existence and extent of climate change continue to be debated by a few, this article reviews the direct health effects of climate change, including heat-related illnesses driven by record-breaking extreme temperatures, respiratory conditions, and cancers due to deteriorating air quality, changing vector-borne and infectious

disease patterns, extreme weather event related health suffering. [1] [2] [3] [4] Evidence of these effects in all parts of the world and the country is well documented, underscoring the urgency of educating medical students on these interconnections. This article also discusses the indirect effects of climate change on human health and the healthcare system through food and water security disruptions, displacement, and mental health issues. Medical education should prepare students to recognise and manage the multifaceted consequences of climate change on vulnerable populations.

□ Evidence on direct and indirect effect of climate change on human health

Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report (AR6) estimates that nearly 3.6 billion people already live in areas highly susceptible to climate change. [5] According to the World Health Organization, between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year from undernutrition, malaria, diarrhoea and heat stress alone. The direct damage costs to health are estimated to



be between US\$ 2–4 billion per year by 2030, and the areas with weak health infrastructure – mostly in developing countries – will be the least able to cope without assistance to prepare and respond. [6]

According to the 2023 report of the Lancet countdown on health and climate change, the past eight years were the warmest ever registered, and July 2023 was the hottest month ever recorded. [1] [7], [8] The frequency of heatwave days has increased twofold and is projected to increase soon. The direct health effect is the resultant mortality, especially in vulnerable populations and those at extremes of age. The projected mortality at mid-century due to heat-related illness is in the millions. India is among the top 5 nations likely to suffer the most due to rising temperatures. While mortality is something that the medical fraternity quickly understands and works towards, the indirect effect of increasing temperature on labour loss, economy and resultant mental illnesses and inequity is something that is affecting the medical ecosystem, too.

Over the past decades, globally and in India, the problem of malnutrition has been recognised, and significant progress in reducing morbidity and mortality is being made. This progress has been threatened because of climate change's impact on food systems, wherein droughts and resultant food insecurity are on the rise.[9], [10] The land area affected by droughts is projected to increase in the coming years, and the effects of these on human health will increase the need for medical treatment of micro and macro-nutrient deficiencies.

The changing temperature and rain patterns increase climate suitability for vector-borne diseases, and healthcare professionals have reported this nationwide. The number of months of high transmission of vector-borne diseases is changing. With this, we must adjust our preventive, promotive, and curative services planning and delivery.

❑ Role of medical professionals in preventing further environmental degradation and tackling effects on human health

Medical professionals have always played a pivotal role in understanding, preventing, and mitigating the health impacts of the environment, human behaviour, and external sources like vectors. Due to these efforts towards understanding human suffering and collaborative efforts to find solutions to health problems, tremendous progress has been made in reducing morbidity and mortality of diseases and conditions. However, these gains have not benefited all humans uniformly, and the country and the world are still battling inequity and human suffering.

❑ Status of climate change integration into the medical curriculum

A survey done in the year 2020 by the International Federation of Medical Students Association, spanning 2817 medical schools in 112 countries, found that climate change is taught in only 15% of medical schools worldwide and, in 12% of medical schools, climate health teaching activities are led by students and not faculty members.[11] Evidence shows that medical students wanted access to resources related to health and healthcare sustainability and guidance on how to make practical steps towards reducing environmental impact within clinical settings. [12] While the World Health Organization in 2018 recognised Climate change as the biggest threat to global health of the 21st century, the survey shows that future doctors aren't sufficiently trained to recognise the interdependence between health, ecosystems, and climate change, which leaves them unprepared to address the needs of their patients and communities.

❑ The case for enhanced incorporation of climate change in the medical curriculum

This article emphasises the importance of incorporating climate change education into medical training to equip future healthcare providers with the knowledge and skills necessary to address the complex challenges of a changing climate. While many of these issues might appear to be linked to social determinants of health at first glance, a deeper look reveals that these are also issues clinicians at all levels would face in their practice. For instance, while it is crucial for a doctor at the primary and secondary levels to take a history of heat and air pollution exposure, their competency also needs to be built on disease epidemiology and signs and symptoms for considering heatstroke in differential diagnoses and be equipped with evidence-based clinical protocols for management of heat-related illnesses.

To track the morbidity and mortality of diseases, one of the challenges faced worldwide is correctly recognising disease conditions and diagnosing them, documenting these diagnoses using standard ICD codes and preserving and analysing such records. While medical certification of cause of death has seen improvement over the years, climate change-related illnesses are not well documented. Towards this end, it is also vital to teach common diseases exacerbated by climate change during the pathology and clinical rotations in a way that students can recognise and report climate change-related diseases or conditions directly leading to death (for example, heat stroke or lung cancer in a non-smoker), report chain of events and underlying cause of death (example heat-related illness in patients of diabetes or stroke).

As one of the most trusted voices in the community, health professionals also have a role in setting an example by changing their attitudes and behaviours and acting on sustainable healthcare practices and sustainable, climate-

friendly healthcare delivery.[13] This will also enable them to discuss greenhouse gas emissions and sustainability measures with their patients and the community.

Globally, as well as in India, climate resilient and environmentally sustainable practices are being adopted in the health sector to reduce greenhouse gas emissions and make healthcare facilities more resilient and prepared for climate change-induced emergencies. Energy efficiency measures like solarisation of healthcare facilities, replacement of non-LED bulbs with energy-efficient LED bulbs and structural changes to reduce electricity consumption are being adopted on a large scale. Today's medical students are tomorrow's healthcare managers and practitioners, and they must be taught these upcoming measures in the formative years of their long medical careers to fulfil their crucial role in climate adaptation and mitigation.

❑ Approach to integration of climate change education in the medical curriculum.

Medical and allied paramedical curriculum boards and colleges can refer to various research studies, best practices, and experiences in integrating climate change into medical curriculum and frameworks developed by IFMSA and other organisations while creating a Climate Change and Medical Education Framework with core competencies and learning objectives for climate change- planetary health-related topics. Collaborative efforts between medical schools and environmental science departments can also be explored to enhance students' ability to address complex challenges at the intersection of health and the environment. Case examples from these collaborations and initiatives can inspire other institutions to adopt similar approaches. Experiential learning opportunities like disaster response simulations can improve adaptive capacity.

□ Conclusion

Through this paper, the authors make a case for the role of informed healthcare professionals in advocating for policies that address the root causes of climate change and promote resilience in healthcare systems.

The direct and indirect effects of climate change on human health and its implications on clinical and healthcare management practices thus underscore the critical role of medical education in preparing healthcare professionals to navigate the complex intersection of climate change and human health. The proactive integration of climate change topics into medical curricula is essential for fostering a generation of healthcare providers capable of addressing the evolving health challenges associated with anthropogenic climate change.

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Role of Medical Education in the Era of Anthropogenic Climate Change

Authors- Mukund Gupta (1), Pankaja Raghav⁽²⁾

Affiliations- (1) PhD Scholar, Department of Community Medicine and Family Medicine, ⁽²⁾

Professor and Head, Department of Community Medicine and Family Medicine

Corresponding Author: Prof Pankaja Raghav,

□ Abstract

This review delves into the indispensable role of medical education in addressing the complex challenges of anthropogenic climate change. The anthropogenic climate change, primarily driven by human activities, poses profound repercussions for public health. As the healthcare sector significantly contributes to environmental threats, incorporating climate change education into medical curricula is imperative. This review elucidates the multifaceted impacts of climate change on health, encompassing dangers such as heat-related illnesses, vector-borne diseases, injuries, psychological distress, and malnutrition. Vulnerable populations, including children, outdoor workers, and the geriatric age group, are at heightened risk in the face of a changing climate. Recognizing the pivotal role of medical education, the review underscores the imperative to integrate climate change topics across medical disciplines, equipping future healthcare professionals with the knowledge and skills to identify climate-related health issues and advocate for sustainable healthcare practices. An interdisciplinary approach and collaboration with environmental experts are crucial elements. Despite the challenges and barriers, medical schools, educators, and healthcare professionals are implored to take action by integrating climate change into curricula, addressing climate scepticism within the medical community,

and preparing for climate-resilient healthcare systems. This approach can positively impact public health and the environment, contributing to a healthier and more sustainable future.

Keywords

Medical Education

Anthropogenic climate change

Public health

Climate-related health issues

Climate-resilient healthcare systems

Introduction

Climate change is the long-term shifts in temperature and weather patterns. In earlier times, such shifts occurred due to natural causes like sun activity or large volcanic eruptions. Since the 1800s, there has been a sudden climate change, mainly due to human activities like burning fossil fuels. (1)

Even the necessary healthcare services have contributed to a threat to the environment and human health. (2) This footprint on the environment by healthcare services has a long-lasting impact on air, water and soil. Global healthcare accounts for about 1 to 5% of global environmental impacts, depending on the type of indicator. (2) The healthcare sector alone contributes to 4.4% of the greenhouse gas footprint. (2)

Given such implications of climate change and the impact of healthcare on climate change, it becomes fundamentally important to include and integrate climate change in the current medical education curriculum. (3) This will help future doctors to develop insights into their role as public health professionals in a climate-changing world. (3)

□ Understanding Climate Change and Health

Extreme heat events are dangerous and, at times, fatal. Such events lead to heat-related illness, even cardiovascular and respiratory disorders, heat stroke being the most serious.(4) Heat stroke requires emergency care, which, if not available, can cause permanent disability or death.(5)

Climate change also has made it conducive for various vector-borne diseases. There has been a rise in certain vector-borne diseases, including infectious diseases like Lymes, waterborne and mosquito-borne diseases like malaria and dengue. (6) There is also an increased burden of injury and psychological diseases due to extreme weather events.(7) Studies indicate a daily maximum temperature of more than 90°F is strongly associated with injury-related hospital visits.(8)

Climate change threatens to reverse the progress made so far in the fight against hunger and malnutrition. (9) Climate change affects food safety in varied ways. It causes grave social and economic consequences due to its impact on crops, livestock, and fisheries. Other than food availability, it impacts food access and absorption. (10)

Climatic factors like droughts can lead to stress and impaired mental health, including PTSD (posttraumatic stress disorder), adjustment disorders and depression. Increased rates of physical illness also lead to psychological distress. (11)

Climate migration is rising due to extreme weather events like floods, heat waves, and droughts. Slower and gradual events are rising sea levels, and its effects are also causing people to leave their homes. (12) Studies project much larger mass migrations if global efforts fail to address this climate crisis.(12)

Few individuals/groups are more likely to be affected due to climate change compared to others. (13) Children are more prone to airborne allergens due to their still-developing immune systems. Workers with their occupation in outdoor settings are at greater risk of heat-related illnesses. Geriatric people are less likely to adapt or respond to extreme weather events. (13)

□ The Role of Medical Education

Doctors are key stakeholders in climate change mitigation and health system adaptation. Incorporating such in the medical curriculum will help them prepare for emerging health threats. (3) They need to be trained in identifying climate-related health issues in patients, including respiratory and cardiovascular diseases, injuries and premature deaths, infectious diseases and threats related to mental health. (17)

A healthy environment is vital to “ensure healthy lives and promote well-being for all ages” (SDG Goal 3). There are several modifiable risk factors, like outdoor air pollution and household air pollution, which influence the risk of disease conditions. WHO estimates that 13-32% of the global disease burden is due to environmental determinants. (14)

There is a need to integrate climate change topics such as natural disasters, disease outbreaks, air quality, and heat stress across medical disciplines. The curriculum can be started with an introduction to the broad topic of climate change followed by a topic related to the health outcomes of climate change and the role of healthcare providers in responding to such threats. (16) Even the University Grants Commission (UGC)

guidelines in India recommend including climate change as a part of environmental education at the Undergraduate level as a global movement to safeguard our environment from the impacts of climate change. It includes comprehensive knowledge of climate change and its response measures and an overview of the efforts to address it through adaptation and mitigation.

This climate change affects the health and well-being of the people directly through specific events and indirectly by threatening the capacity of the healthcare system to care for the population. (18) These healthcare facilities sometimes cannot cope with extreme climate risks such as storms, floods and droughts. Such is often particularly true in healthcare facilities in developing countries due to the lack of adequate infrastructure and a trained workforce. (18) Also, due to improper management, the healthcare facility may contribute to climate change, either due to greenhouse gas emissions or a poor waste management system. (18) It is therefore necessary that healthcare facilities are environmentally sustainable with optimized use of resources.

❑ Challenges and Barriers

Climate change is well understood as a global reality and no longer a distant future threat. Even then, the educational systems do not address the climate crisis. There needs to be standardized climate education guidelines, even when medical students perceive and recognize the threat of climate change on human health and its need in medical education. (19)

There is a need to address the climate change scepticism within the medical community in relation to doubts about the perseverance of climate change as a scientific and physical problem and regarding the efficacy of action taken to address climate change. (20)

❑ Opportunities and Future Directions

Seeing the threats and long-term challenges climate change poses and considering its effect on human health, there exists a dire need to have a climate-informed healthcare workforce. They will play an essential role in informing and preparing the public regarding the health effects of climate change. (21) There is a need to prepare healthcare professionals for climate-resilient healthcare systems. This process must involve consideration of healthcare governance and implementation while also involving stakeholders to ensure safe and patient-oriented outcomes. (21)

❑ Conclusion

In conclusion, the role of medical education in addressing anthropogenic climate change must be considered. As we witness the ongoing shifts in temperature and weather patterns, primarily attributed to human activities like burning fossil fuels, the healthcare sector's contribution to environmental threats becomes apparent. Within the healthcare sector alone, it is clear that our practices contribute to climate change and pose a significant risk to public health. This realization underscores the importance of integrating climate change education into the current medical curriculum.

Understanding the intricate relationship between climate change and health is paramount. From the dangers of extreme heat events to the rise in vector-borne diseases, injuries, and psychological distress, the impacts of climate change on health are multifaceted. Furthermore, climate change threatens to undo progress in the fight against hunger and malnutrition, affecting food availability and access and causing stress and impaired mental health.

The role of medical education is clear: doctors are vital stakeholders in climate change mitigation and health system adaptation. Integrating climate change topics into medical curricula

allows future healthcare professionals to prepare for emerging health threats and understand their role as public health advocates in a changing climate. By identifying climate-related health issues, healthcare professionals can contribute to mitigating the impacts of climate change on public health.

By integrating climate change education into medical curricula, we can empower future healthcare professionals to advocate for sustainable healthcare practices, climate-resilient healthcare systems, and improved public health. This approach will benefit individual patients and contribute to a more sustainable and healthier future for the planet. The time for action is now, and the healthcare sector must embrace its role in addressing anthropogenic climate change.

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Impact of climate change on nutritional vulnerability of India and ways to mitigate it

Varun Kakde, Public Health Consultant

□ Abstract

Climate change poses a complex challenge to India's nutritional landscape, intertwining agriculture, public health, and socio-economic factors. This paper explores the intricate connections between climate change and nutritional vulnerability, emphasizing India's diverse agro-climatic zones and vulnerability due to its reliance on monsoon rains. The altering climate conditions disrupt agricultural productivity, impacting not only food quantity but also nutritional quality.

The paper navigates the impact on agriculture, emphasizing rising temperatures, erratic precipitation, and extreme events. It delves into water scarcity issues, shifts in food availability, and accessibility, underscoring climate-induced challenges in the production of diverse, nutrient-rich foods. Health implications, including the spread of diseases and compromised nutritional health, further amplify the complexity.

Mitigation strategies demand a holistic approach, encompassing climate-resilient agriculture, integrated water management, health interventions, community engagement, and research and innovation. Climate-resilient crop varieties, precision irrigation, and diversification emerge as crucial agricultural strategies. Integrated water management, health awareness campaigns, and early warning systems address water scarcity and health risks. Community engagement, especially empowering women and integrating indigenous knowledge, proves pivotal, while research and innovation focus on climate-smart technologies and biotechnological solutions.

Key Words:

1. Climate change
2. Nutritional vulnerability
3. India
4. Mitigation strategies
5. Public health

Introduction:

Climate change, recognized as one of the most pressing challenges of our time, transcends geographical boundaries, impacting ecosystems, economies, and, notably, human health. India, characterized by its diverse geography and climatic zones, is a microcosm of the global challenge posed by climate change. Agriculture, constituting a substantial portion of the nation's economy, plays a pivotal role in shaping the dietary habits and nutritional well-being of its population. As climate change manifests in altered weather patterns, rising temperatures, and more frequent extreme events, the repercussions on food systems and, subsequently, on nutrition become increasingly evident.

The Intergovernmental Panel on Climate Change (IPCC) highlights in its Fifth Assessment Report that climate change is unequivocal, and human activities are the dominant cause (IPCC, 2014). This global phenomenon manifests differently in various regions, and India's vulnerability stems from its dependence on monsoon rains, which irrigate most of its crops. Changes in precipitation patterns, a consequence of climate change, disrupt the delicate balance of water availability crucial for agriculture (Mishra et al., 2015). Agricultural productivity, the backbone of India's food security, faces the brunt of these changes.

The altered climate conditions lead to shifts in the distribution and cultivation of crops, impacting not only the quantity but also the nutritional quality of the produce. A study by Wheeler and von Braun (2013) emphasizes that climate change-induced alterations in ecosystems result in the changing availability and accessibility of diverse, nutrient-rich foods, contributing to imbalances in diets.

The consequences extend beyond crop yields, infiltrating the intricate web of nutrition and public health. Fanzo et al. (2018) underline the direct link between disruptions in food production and distribution and the exacerbation of existing challenges of malnutrition and undernutrition, particularly among vulnerable populations. Climate change-induced shifts in disease patterns further compound these challenges, as highlighted by Hales et al. (2014), who project an increased risk of vector-borne diseases due to changing climate conditions.

To comprehensively address the intricate challenges posed by climate change on nutrition in India, it is imperative to understand the interconnectedness of various factors. This includes not only the direct impact on agriculture and food systems but also the indirect consequences on health, sanitation, and socio-economic conditions. The complexities of this challenge necessitate an interdisciplinary approach, drawing from fields such as climatology, agriculture, public health, and policy studies.

As the global community grapples with the imperative to mitigate and adapt to climate change, India stands at a critical juncture, facing the dual challenge of securing its population against the adverse effects of climate change while ensuring sustainable and resilient food systems. Recognizing the urgency of this issue, this article aims to bridge gaps in understanding and pave the way for evidence-based mitigation and adaptation strategies that are not only effective but also contextually relevant to India's socio-economic and environmental landscape.

□ Climate Change and Nutritional Vulnerability:

The intricate interplay between climate change and nutritional vulnerability in India unfolds against the backdrop of a complex web, with agriculture at its epicenter. This relationship becomes increasingly significant as we navigate through the diverse agro-climatic zones and socio-economic disparities that characterize India.

- **Impact on Agriculture:** India's agriculture, highly dependent on monsoon rains, grapples with the dual challenges of rising temperatures and erratic precipitation patterns, outcomes of climate change. Recent studies by the Indian Ministry of Earth Sciences (MoES, 2018) highlight escalating temperature trends and their profound impact on crop growth cycles and yields. The Intergovernmental Panel on Climate Change (IPCC) reports that heightened temperatures exacerbate heat stress in crops, resulting in decreased yields and altered nutritional content (IPCC, 2014). Zampieri et al. (2019), underscore the ongoing changes in precipitation patterns, disrupting planting and harvesting seasons and directly impacting food production.

Extreme weather events, notably heatwaves and untimely rainfalls, have become more frequent. The vulnerability of crops to these extremes is highlighted in studies such as Deryng et al. (2016), which projects regional disparities in the impacts of climate change on crop water productivity. In the Indian context, research by the Indian Council of Agricultural Research (ICAR, 2019) indicates regional disparities in the impacts of climate change on crop water productivity, further threatening food security and nutritional diversity. The implications for nutritional vulnerability are twofold. First, the direct impact on crop yields threatens food security, particularly for

vulnerable populations. Second, the altered nutritional content of crops under stress conditions may compromise the quality of diets, contributing to hidden hunger.

- **Water Scarcity:** The synergy between climate change and water scarcity compounds the challenges faced by Indian agriculture. Altered precipitation patterns contribute to water scarcity, impacting irrigation and reducing agricultural productivity (Mishra et al., 2015). Recent studies, including those by Mishra et al. (2018), emphasize the increasing frequency and severity of droughts, intensifying water stress in both rain-fed and irrigated agricultural systems. Hence, sustainable water management practices are imperative to address nutritional insecurity in the context of climate change. Research from the Indian Institute of Technology (IIT), Mumbai, stresses the need for precision irrigation techniques and rainwater harvesting to mitigate the impact of water scarcity on crop production.

Beyond crop production, livestock, integral to India's agricultural system, also faces the brunt of reduced water availability. Studies by the National Institute of Animal Nutrition and Physiology (NIANP, 2020) draw attention to the nutritional implications of water scarcity for livestock, affecting the availability of animal-sourced foods rich in essential nutrients.

- **Shifts in Food Availability and Accessibility:** Climate-induced shifts in ecosystems have far-reaching consequences on the availability and accessibility of diverse, nutrient-rich foods. The changing climate impacts not only major crops but also horticultural and marine produce, a crucial source of essential vitamins, minerals and other important micronutrients.

Recent Indian study by the Indian Agricultural Research Institute (IARI, 2021), emphasizes the need for region-specific adaptation strategies as climate change alters the suitability of certain regions for specific crops. This shift has direct implications for the

availability of diverse foods and the overall nutritional quality of diets. Wheeler and von Braun (2013) stress the need for strategies that enhance the adaptive capacity of agriculture to these changes. Diversification of crops, promoting climate-resilient varieties, and investing in innovative agricultural practices are crucial components of such strategies (Lesk et al., 2016).

Marine ecosystems, a vital source of high-quality proteins and micronutrient likes iron folic acid and omega-3 fatty acids, are also affected. Cheung et al. (2010) highlight that climate change affects marine life, impacting the availability and nutritional content of fish, a crucial source of omega-3 fatty acids and high-quality proteins. Changes in sea surface temperatures and ocean acidification pose threats to marine biodiversity, affecting the composition of seafood (Cheung et al., 2010). Recent research from the National Institute of Oceanography (NIO, 2017) highlights the impact of climate change on marine biodiversity, influencing the composition and availability of seafood.

- **Health Implications:** Beyond its direct impact on agriculture, climate change poses significant health risks, further exacerbating nutritional vulnerabilities. The disruptions in food production and distribution, driven by climate change, pose a significant threat to addressing the existing challenges of malnutrition and undernutrition. Malnutrition and undernutrition become amplified challenges in the face of disrupted food production and distribution systems. Vulnerable populations, including children and pregnant women, are particularly at risk, emphasizing the need for targeted health interventions and nutritional support (Fanzo et al., 2018).

Recent studies, such as those conducted by the Indian Council of Medical Research (ICMR), delve into the specific health challenges faced by vulnerable populations due to climate change. The increased incidence of

waterborne diseases, malnutrition, and heat-related illnesses are notable outcomes (ICMR, 2022). The changing climate contributes to the spread of vector-borne diseases and contaminants, leading to a heightened risk of illness and compromised nutritional health (Hales et al., 2014).

Beyond traditional nutritional challenges, climate change introduces new health challenges. The changing climate contributes to the increase in spread of vector-borne diseases, water borne diseases and contaminants, leading to a heightened risk of illness, and compromised nutritional health (Hales et al, 2014). Thus, increase in the spread of vector-borne diseases, water borne diseases and contaminants contributed by climate change is further likely to compromise nutritional health.

In navigating the impacts of climate change on nutritional vulnerability in India, a holistic understanding of its impact on agriculture, food systems, and public health is essential. Recent scientific publications and Indian studies underscore the urgency of addressing the evolving challenges and highlight the need for context-specific solutions. As India strives towards a sustainable and climate-resilient future, integrating scientific insights and community engagement will shape the trajectory of nutritional security, ensuring a healthier and more resilient population in the face of an ever-changing climate.

❑ **Mitigation Strategies: A Holistic Approach to Addressing Climate-Induced Nutritional Vulnerability in India:**

Mitigating the complex interplay between climate change and nutritional vulnerability in India requires a comprehensive and context-specific approach that spans agriculture, public health, and socio-economic considerations. Developing and implementing policies that prioritize climate-smart agriculture and enhance the nutritional

quality of food can mitigate the impact of climate change (FAO, 2019). By prioritizing climate-resilient agriculture, water management, health interventions, community engagement, and research and innovation, India can build a more resilient and sustainable future, ensuring the well-being of its population in the face of an ever-changing climate.

- **Climate-Resilient Agriculture:** Adapting agricultural practices to the changing climate is foundational to mitigating the impact on food production. Research from the Indian Council of Agricultural Research (ICAR) and the Indian Institute of Technology (IIT), Mumbai, underscores the significance of climate-resilient crop varieties. These varieties, developed through advanced breeding techniques, exhibit tolerance to heat stress, changes in precipitation patterns, and increased pest pressures (ICAR, 2019; IIT Mumbai, 2021).

Diversification of crops emerges as a critical strategy for enhancing the resilience of agricultural systems. Promoting the cultivation of climate-resilient crops and adopting diversified farming systems enhance food security (Lipper et al., 2014). Integrating climate-resilient and nutrient-rich crops into traditional farming practices not only ensures food security but also contributes to improved dietary diversity. The National Mission on Sustainable Agriculture (NMSA) has been instrumental in promoting such practices, encouraging farmers to cultivate a variety of crops suited to their agro-climatic zones.

Precision irrigation techniques, highlighted in studies by Mishra et al. (2018) and IIT Mumbai (2021), play a pivotal role in water-use efficiency. Adopting these techniques ensures optimal water distribution, addressing the increasing water scarcity issues and promoting sustainable agricultural practices.

- **Integrated Water Management:** Water scarcity is a pressing challenge exacerbated

by climate change, necessitating robust water management strategies. Recent research by the Indian Agricultural Research Institute (IARI, 2021) underscores the importance of integrated water management approaches, combining traditional water harvesting methods with modern technologies. Capturing rainwater during monsoons can supplement irrigation needs during drier periods, contributing to sustained agricultural productivity. Implementing efficient water management practices, such as rainwater harvesting and precision irrigation, is crucial for sustainable agriculture (FAO, 2017)

Rainwater harvesting, promoted by the National Rural Livelihood Mission (NRLM), emerges as a viable strategy. Community-based water management initiatives empower local populations to actively participate in sustainable water practices. Leveraging indigenous knowledge, as demonstrated in studies by Mishra et al. (2018) and IARI (2021), ensures the relevance and effectiveness of water management strategies in diverse agro-climatic regions.

- **Health Interventions:** The health implications of climate change are profound, necessitating targeted interventions and robust healthcare systems. Recent research by the Indian Council of Medical Research (ICMR) emphasizes the importance of comprehensive health strategies to address climate-induced health risks including the impact of climate change on nutrition (ICMR, 2022). Strengthening healthcare systems to address emerging health challenges associated with climate change, including vector-borne and water-borne diseases are pivotal in formulating policies to protect population against health harms of changing climate (Haines et al., 2014)

1. **Capacity Building and Training:**

Strengthening the capacity of healthcare workers to address climate-related health risks is a crucial aspect. Targeted training

programs ensure that healthcare providers are equipped to recognize, manage, and prevent health issues exacerbated by climate change. Capacity building extends to local health workers and community leaders, creating a network of informed individuals capable of responding to emerging health challenges.

2. **Health Awareness Campaigns:**

Educational campaigns focused on nutrition and health awareness are vital in enhancing adaptive capacity. The National Health Mission (NHM) integrates climate change considerations into its health programs, recognizing the need for a holistic approach that addresses both climate-related health risks and nutritional deficiencies. These campaigns, conducted at the community level, disseminate information about climate-resilient dietary practices, disease prevention, and the importance of nutritional diversity.

3. **Early Warning Systems:**

Implementing early warning systems for disease outbreaks linked to climate variability is crucial. The establishment of climate-resilient health infrastructure ensures a proactive response to emerging health challenges. This includes the development of surveillance systems that monitor climate-sensitive diseases, allowing for timely interventions and resource allocation.

4. **Malnutrition and Vulnerable Populations:**

Malnutrition and undernutrition become amplified challenges in the face of disrupted food production and distribution systems. Vulnerable populations, including children and pregnant women, are particularly at risk. Fanzo et al. (2018) emphasize the need for targeted health interventions and nutritional support. Government-led programs, such as the Integrated Child

Development Services (ICDS) and the Mid-Day Meal Scheme, play a pivotal role in addressing nutritional deficiencies among vulnerable groups.

- **Community Engagement and Empowerment:**

Community-based approaches are pivotal in building resilience at the grassroots level. Fostering community-based initiatives for sustainable agriculture, nutrition education, and adaptation to climate-related challenges empowers local communities (Sovacool et al., 2017)

1. **Indigenous Knowledge Integration:**

Integrating traditional knowledge systems with scientific insights fosters community-led initiatives. Recent studies, including those by IARI (2021) and NIANP (2020), highlight the success of community-driven agricultural practices and livestock management, enhancing adaptive capacity and fostering sustainable livelihoods. Recognizing and incorporating indigenous knowledge ensures the relevance and effectiveness of adaptation strategies, creating a harmonious synergy between traditional practices and modern science.

2. **Women Empowerment:** The engagement of women in climate-resilient agricultural practices and nutritional programs is especially crucial. Research by the National Institute of Rural Development and Panchayati Raj (NIRDPR, 2021) emphasizes the pivotal role of women in climate adaptation, recognizing their unique insights and contributions to sustainable agricultural practices. Empowering women through skill development, access to resources, and participation in decision-making processes contributes not only to climate resilience but also to enhanced community well-being.

3. **Policy and Institutional Support:**

Policymakers and development agencies play a key role in facilitating community engagement. Initiatives like the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) focus on creating climate-resilient livelihood opportunities, reinforcing the linkages between economic development, climate adaptation, and nutritional security. Institutional support is critical in providing the necessary resources, infrastructure, and policy frameworks to enable community-led initiatives.

- **Research and Innovation:** The dynamic nature of climate change necessitates a continual focus on research and innovation. Collaborative efforts between research institutions, government agencies, and non-governmental organizations are crucial for developing context-specific solutions.

1. **Knowledge Platforms and Collaborations:**

Initiatives like the National Innovations in Climate Resilient Agriculture (NICRA) and the Indian Network on Climate Change Assessment (INCCA) foster a collaborative research ecosystem. These platforms facilitate the exchange of knowledge, promote innovation in sustainable agricultural practices, and contribute to evidence-based policymaking (NICRA; INCCA).

2. **Climate-Smart Technologies:** Investing in climate-smart technologies, such as remote sensing and precision agriculture, enhances the monitoring and management of agricultural systems. Recent studies, including those by the Indian Space Research Organisation (ISRO) and the Indian Institute of Science (IISc), showcase the potential of these technologies in optimizing resource use and improving agricultural resilience (ISRO; IISc).

3. **Biotechnological Innovations:**

Biotechnological innovations, including the development of genetically modified crops with enhanced resilience to climate stress, present a frontier for research. These crops, designed to withstand changing climatic conditions while maintaining nutritional content, offer a promising avenue for ensuring food security and nutritional diversity (Prakash et al., 2019).

proves instrumental in fostering adaptive capacity at the grassroots level. Success stories of community-driven agricultural practices and sustainable livelihoods underscore the potency of local solutions in building resilience.

As the paper delves into policy implications, it emphasizes the crucial role of research and innovation. Collaborative endeavors, climate-smart technologies, and biotechnological innovations illuminate the path towards a sustainable future.

□ **Conclusion:**

The nutritional vulnerability exacerbated by climate change in India necessitates urgent and coordinated action. This exploration reveals a complex landscape that necessitates holistic mitigation strategies. The dynamic connections between climate change, agriculture, and public health underscore the need for a comprehensive approach, intertwining scientific insights, community engagement, and innovative solutions.

In conclusion, the convergence of climate change and nutritional vulnerability demands a unified and proactive response. By weaving together, the threads of climate-resilient agriculture, health interventions, community empowerment, and research and innovation, India can navigate the challenges ahead and craft a narrative of resilience, ensuring the well-being of its populace in the face of an ever-changing climate.

Climate-resilient agriculture stands as a cornerstone for securing food production amid evolving climatic patterns. Diversification of crops, precision irrigation, and the integration of traditional and modern farming practices serve as critical bulwarks against the threats posed by climate change. However, the journey towards resilience extends beyond fields to encompass the health and well-being of communities.

Health interventions, detailed in this paper, take center stage in addressing the intricate web of climate-induced health risks and nutritional deficiencies. Capacity building, health awareness campaigns, and early warning systems form a robust framework for mitigating the health implications of climate change. Prioritizing vulnerable populations and incorporating gender-sensitive approaches ensures equitable health outcomes in the face of evolving challenges.

Community engagement, particularly empowering women and integrating indigenous knowledge,

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Impact of Climate Change in India with reference to Human Health

Mrutyunjay Mohapatra, Akhil Srivastava, R. Chattopadhyay, Praveen Kumar, O. P. Sreejith, Monica Sharma, Soma Sen Roy, India Meteorological Department, Ministry of Earth Sciences, Government of India.

□ Abstract:

Climate change poses a significant risk to human health, by acting as a threat multiplier, impacting not only the physical environment but also all aspects of natural and human systems. It affects social, economic as well as physiological functioning of health systems. With continuous shifts in climatic conditions, there is a noticeable increase in the frequency and intensity of weather and climate events, such as heat waves cold waves, tropical cyclones, precipitation, thunderstorm, lightning etc. These weather and climate-related hazards have direct and indirect implications for health, amplifying the risks of mortality, noncommunicable diseases, the emergence and spread of infectious diseases, and health emergencies. In view of these exigencies, the effective, efficient and skilled early weather warning system can play an important role in reducing the harm caused by these events by alerting general public, disaster managers, stakeholders and healthcare sector with sufficient lead time and actionable forecasts & warnings.

Keywords: - Climate-Change, Heat Wave, Cold Wave, Early Warning System, Impact based forecasting, Weather Extreme.

Introduction:

Climate, Weather and Health are interrelated in different facets. Weather and climate have direct and indirect effects on health in any place. The people over any region have adapted to these weather and climatic conditions after many years of evolution customizing their social, economic, customary and food habits. However, in the present times these practices are under stress due to climate change and global warming. Different weather phenomenon is getting affected in terms of their occurrence (temporal & spatial), intensity and impact under these changing scenarios. These are also adversely impacting the human being through different direct and indirect ways.

Numerous researches have studied the relationship between disease/human health and weather, and it has long been acknowledged and proven. Seasonal occurrences of diseases have also been documented in traditional literature and knowledge systems [1]. The abundance and behavior of vectors that spread diseases such as mosquitoes and ticks are influenced by temperature, humidity, and precipitation. Warmer temperatures and increased rainfall promote vector (mosquito) reproduction, which can lead to higher transmission rates of diseases such as malaria, dengue fever, Chikungunya, Japanese encephalitis, and Zika virus, among others [2][3].

Cold and dry weather have been linked to an increase in the transmission of respiratory viruses,

including influenza. Low humidity levels can cause mucous membranes to dry up, rendering people more susceptible to respiratory illnesses. Extreme weather events such as excessive rainfall, floods, and storms can contaminate water supplies and spread waterborne infections [4]. Furthermore, stagnant weather patterns might contribute to increased levels of air pollution, worsening respiratory disorders. The integration of weather forecast and weather warning in the context of health impact is in need of the day. Over the past few decades, vector borne diseases have been steadily increasing due to reasons such as climatic variability and change, increased international travel and trade, urbanization, and population development. These all provide an ideal breeding ground for dengue vectors and viruses [5].

An increasingly warm global climate can contribute to more severe heat waves by raising the likelihood of exceptionally hot days and nights. The warming climate also intensifies the evaporation of water from land, potentially worsening drought and creating conditions more prone to wildfires, consequently leading to an extended wildfire season. Moreover, a warmer atmosphere is associated with heightened occurrences of intense precipitation events, including heavier rain and snowstorms, owing to the air's increased capacity to retain moisture. El Niño phenomena typically induce drought in many tropical and subtropical regions, whereas La Niña events promote wetter conditions in various locations. These short-term and regional fluctuations are expected to become more significant in a warming climate. The Earth's warmer and more humid atmosphere, in conjunction with warmer oceans, increases the likelihood that the most powerful cyclones will become more vigorous, produce more rainfall, affect new regions, and potentially become larger and longer-lasting. Additionally, the rise in sea levels results in more seawater being pushed onto shore during coastal storms, which,

in combination with the increased rainfall from the storms, can lead to more destructive storm surges and flooding. This impactful weather brings the risk and hazard of direct and indirect health impacts.

In view of the multifaceted challenges of climate change with respect to health in India, the following sections cover the evolution of important disastrous weather events with climate change and their impacts on human health.

□ Evolution of major weather events with climate change

a) Heat Wave

Climate change has led to an increase in frequency of heatwave and hot days, and the days where temperature are remaining above normal have also increased. Sometimes, beyond the period of summer season, many places realize heat wave like condition and meeting the criteria. Heatwaves are becoming more intense, with record-breaking temperatures being observed in many regions and also lasting long, and mainly caused due to global warming with addition to anthropogenic activities and natural disaster (forest fires, War, volcanic eruptions etc.). Temperatures during heat waves are regularly surpassing those formerly considered rare or extreme. Heat islands are being created as a result of rapid and unplanned urbanization, which has established a new maximum temperature normal. This exacerbates the health risks associated with weather exposure, given that a significant portion of the population in India depends on outdoor activities for their means of livelihood. Significant health consequences result from heatwaves, high temperatures, and hot days, including heat-related illnesses, heat stress, and even death, especially among vulnerable populations such as the elderly, infants, and those with preexisting conditions. The association between climate change

and the increase of heatwave occurrences emphasizes the essential importance of adaptation strategies, such as public health interventions, heatwave early warning systems, and measures aimed at lowering greenhouse gas emissions in order to prevent further warming.

A significant increase was noticed in the frequency, persistency and spatial coverage of high frequency temperature extreme events (heat waves) during the decade (1991-2000) [6][7]. In their 2022 study, [8] examined the impact of human activity on the shifting trends of heat waves in India, utilizing the Heat Wave Magnitude Index daily (HWMId). Their research revealed that anthropogenic influences have doubled the likelihood of severe heat waves occurring in central and central-southern India throughout the twentieth century. According to the findings of a study, it is proposed that forthcoming climate warming will result in a notable surge in heat-related fatalities, particularly in lower-latitude developing nations such as India, where the occurrence of heat waves is expected to be more recurrent, and the population is especially susceptible to these extreme temperatures [9]. The study further demonstrates that even a slight elevation in average temperatures could result in a significant increase in heat-related mortality, underscoring the importance of initiatives required to mitigate these effects. Based on the analysis of CMIP data in a study [10] indicated that heat waves are anticipated to become more severe, persist for longer durations, and manifest more frequently and earlier in the year. Additionally, it is projected that by the conclusion of the 21st century, Southern India, presently unaffected by heat waves, will be significantly impacted. Projections suggest that a considerable portion of India will encounter heat stress conditions in the years to come. A study regarding escalating trends in temperature and moisture-induced heat index, and its potential impact on human health within the context of climate change across the Indian subcontinent found that on average across the country, Heat Index (considering cumulative impact of temperatures and relative humidity) is increasing during the summer and monsoon seasons at rates of $+0.560^{\circ}\text{C}$ per decade and $+0.320^{\circ}\text{C}$ per decade, respectively [11]. This is indicating increasing effect of discomfort. The overall situation considering the observed heat waves from 1961 onwards indicate increase in heat wave frequency and heat wave days as shown in Fig 1 (a) & 1 (b) respectively.

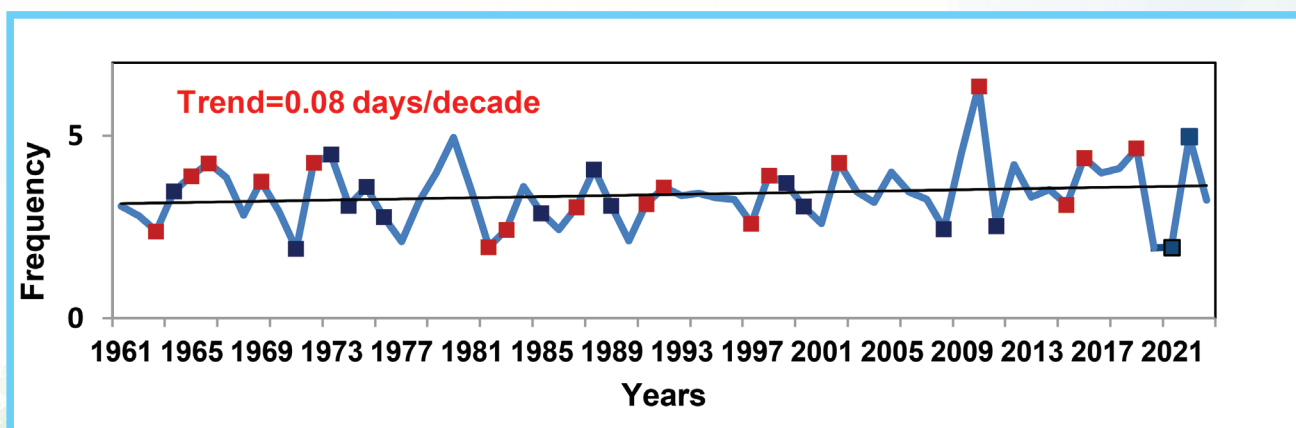


Fig. 1 (a) Heat wave Frequency since 1961

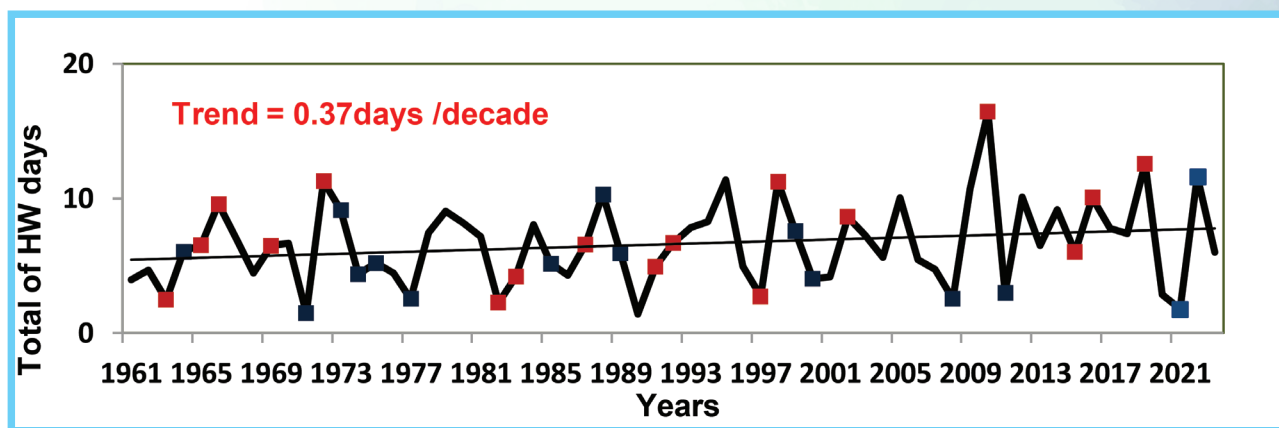


Fig. 1 (b) Heat wave days since 1961

b) Cold Wave

The information sourced from the annual reports of the India Meteorological Department, “Disastrous Weather Events” for a period of 37 years (1978-2014), shows that total 606 cold wave events have resulted in a cumulative 8520 fatalities, or an annual average of 230 fatalities during this period. Bihar and Uttar Pradesh account for only 24% and 31%, respectively, of the total cold wave mortalities. Between the years 1978 and 1999, a total of 3264 fatalities were reported due to cold waves in the northern parts of India [12]. As per a report (NDMA 2021) cold wave has caused 4,712 deaths from 2001 to 2019 across various states. A survey assessing the influence of cold waves on Rabi crops revealed economic losses amounting to 6230 million Indian rupees in the state of Rajasthan during the 2005-2006 Rabi season alone. The impact of cold waves affects agriculture and extends to the Rabi crops, which are sown in winter and harvested the following spring in the northern regions of India.

Cold waves and frost represent significant factors that exert a notable influence on the growth and productivity of crops, horticultural plantations, and orchards, consequently bearing a substantial impact on agriculture and the livelihoods of people. The degree of impairment caused by a cold wave is contingent upon various factors such as temperature, duration of exposure, humidity levels, and the rate at which freezing temperatures are reached. Numerous crops and orchards in the northern and northeastern regions of the country have experienced the detrimental consequences of cold waves and frost. Lower temperatures lead to two types of harm to plants. The first type is chilling injury, which occurs within the temperature range of 2°C to 0°C. The second type is freezing injury, which arises when the external temperature falls below the freezing point of water.

The recent study highlights a noticeable decline in the number of cold wave days at various stations across the northern regions of India [13]. Conversely, only a limited number of stations in the central and eastern parts of the country exhibit an upward trend. The overall situation considering the observed cold waves from 1971 onwards indicate decrease in cold wave frequency and cold wave days as shown in Fig 2 (a) & 2 (b) respectively. However, still the lower temperatures and associated impact are one of the major threats for survivability of human beings in terms of their health impact, impact on agriculture, horticulture, transportation etc.

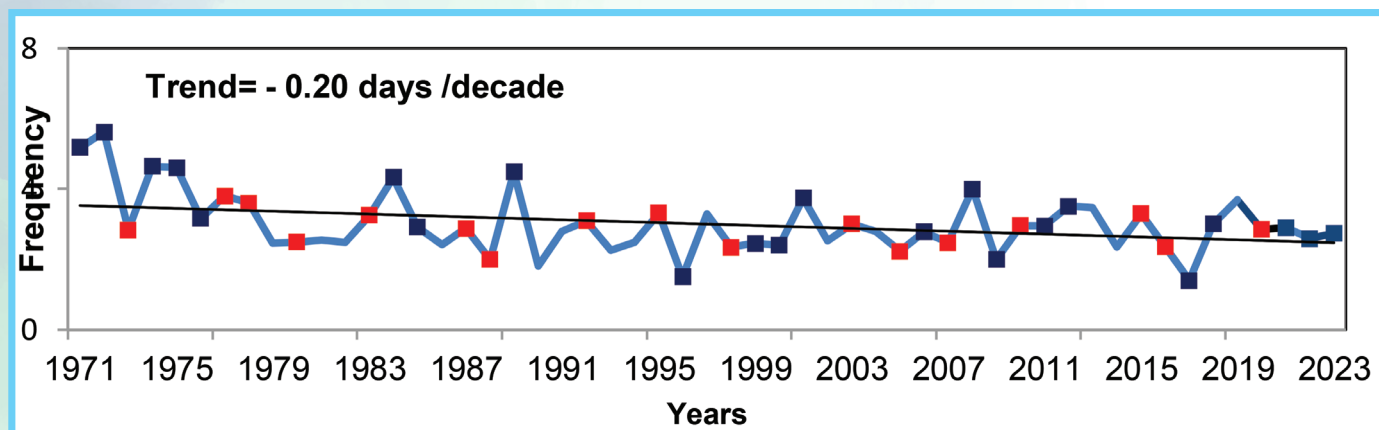


Fig. 2 (a) Cold wave Frequency since 1971

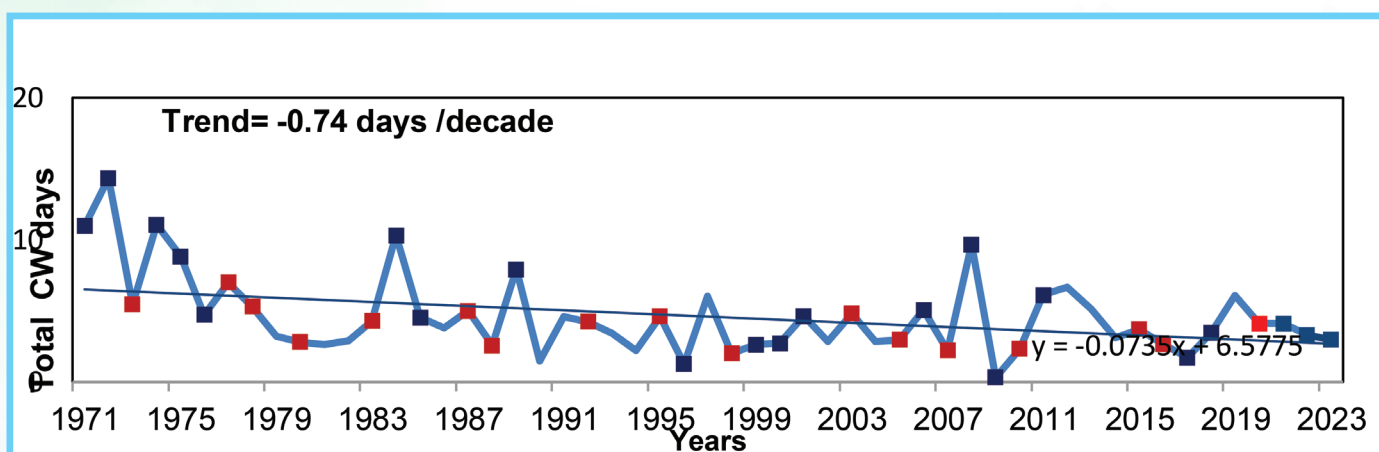


Fig. 2 (b) Cold wave days since 1971

c) Tropical Cyclones

The impact of the shifting climate on extreme phenomena like tropical cyclones stands as a significant societal and scientific concern. Various studies have demonstrated an upward trend in the occurrence of intense tropical cyclones (TCs) in the Northern Indian Ocean (NIO), particularly during the months of heightened TC activity, namely November and May [14][15][16]. Traditionally, the Bay of Bengal (BoB) has experienced a higher frequency of tropical cyclones (TCs) compared to the Arabian Sea (ARB). However, recent years have seen a greater number of TCs forming in the ARB than in the BoB. As per a study the frequency of tropical cyclones indicates a declining trend in recent decades compared to earlier decades however, the frequency of intense cyclones has escalated in the North Indian Ocean (NIO) region, posing substantial risks and vulnerabilities to coastal areas [17]. In a study for period from 1982 to 2019, a noteworthy upward trend in the intensity, frequency, and duration of cyclonic storms (CS) and very severe cyclonic storms (VSCS) has been observed over the ARB [18]. Specifically, there has been a 52% increase in the frequency of cyclonic storm during the recent epoch (2001–2019) in the Arabian sea, while there has been an 8% decrease in the Bay of Bengal [18]. This study also pointed out that over the Arabian Sea, there has been an 80% increment in cyclonic storm duration and a nearly threefold increase in very severe cyclonic storm during the recent epoch compared to the earlier period (1982–2000). Additionally, both the lifetime maximum intensity and accumulated cyclone energy have shown an increase over the Arabian Sea, indicating a strengthening of tropical cyclones in this region. Detailed analysis distinctly indicated a notable upward trend of approximately 16.75%

in the intensity of severe cyclonic storms that developed over the North Indian Ocean in the preceding four decades [19]. According to the sixth assessment report by the Intergovernmental Panel on Climate Change (IPCC), there is a highlighted emphasis on the heightened occurrence of more powerful tropical cyclones (TC, falling within categories 3–5) during the past four decades. The Northern Indian Ocean displays similar trends in this regard and is a cause of concern for human health and safety.

The analysis of data during 1965-2022 as shown in Fig.3, indicate that there is decreasing trend in frequency of genesis of all categories of cyclonic storms over Bay of Bengal and North Indian Ocean except extremely severe cyclonic storm (ESCS) category. There is no significant change in frequency of ESCS category over the Bay of Bengal and NIO. Similarly, there is no significant change in different categories of cyclonic storms over the Arabian Sea except ESCS category. ESCS category shows significant increasing trend over the Arabian Sea. The analysis of data during 1965-2022 as shown in Fig. 4, indicate that there is decreasing trend in cumulative frequency of genesis of all categories of cyclonic storms & above over the Bay of Bengal and NIO except the ESCS & above category. The ESCS & above category shows no significant trend over the Bay of Bengal and NIO. Over the Arabian Sea, all categories show increasing trend, being significantly increasing trend for ESCS & above.

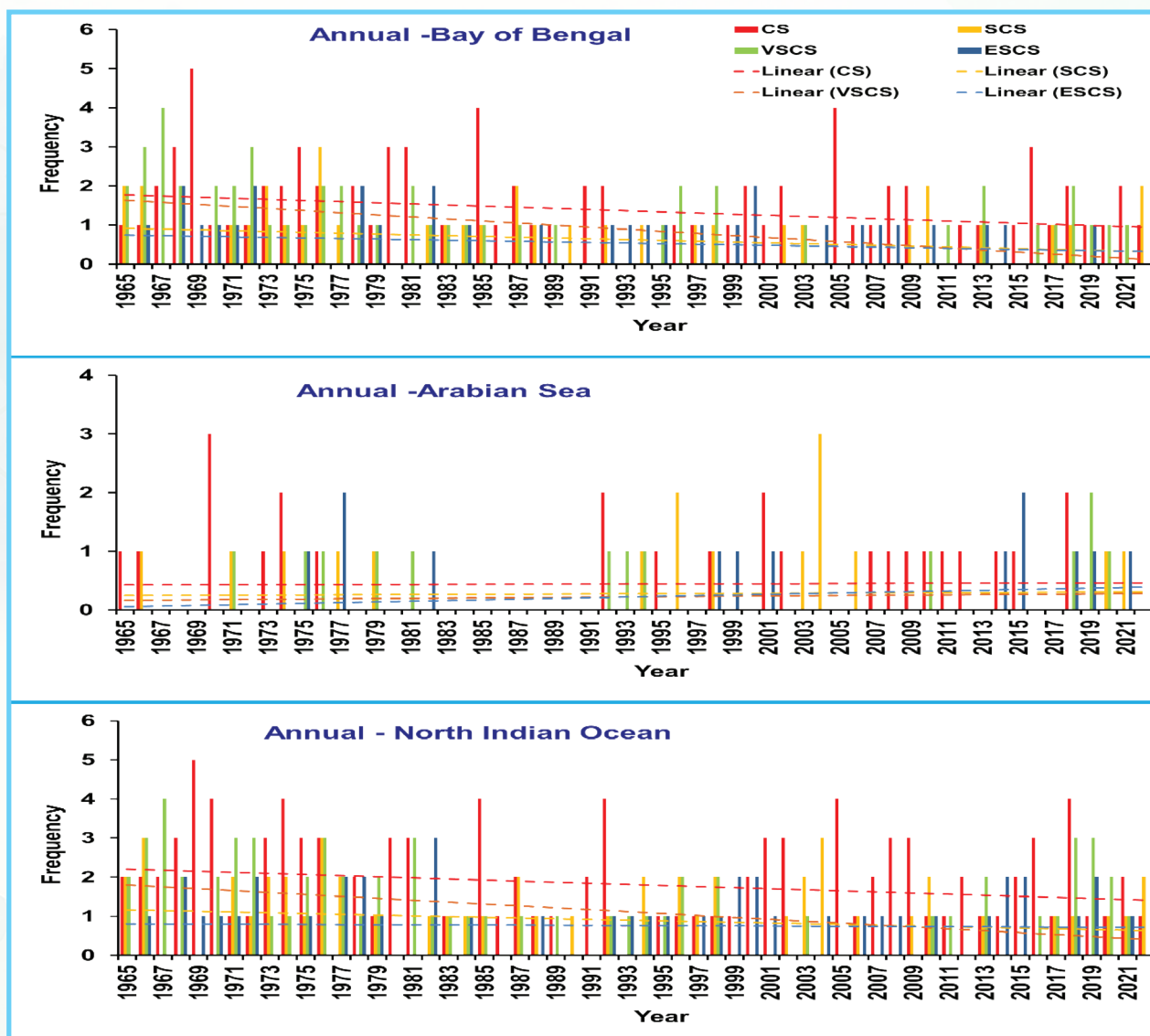


Fig. 3 Annual Frequency (individual category) of genesis of cyclonic storm and above category (≥ 34 knots) over (a) Bay of Bengal, (b) Arabian Sea and (c) North Indian Ocean.

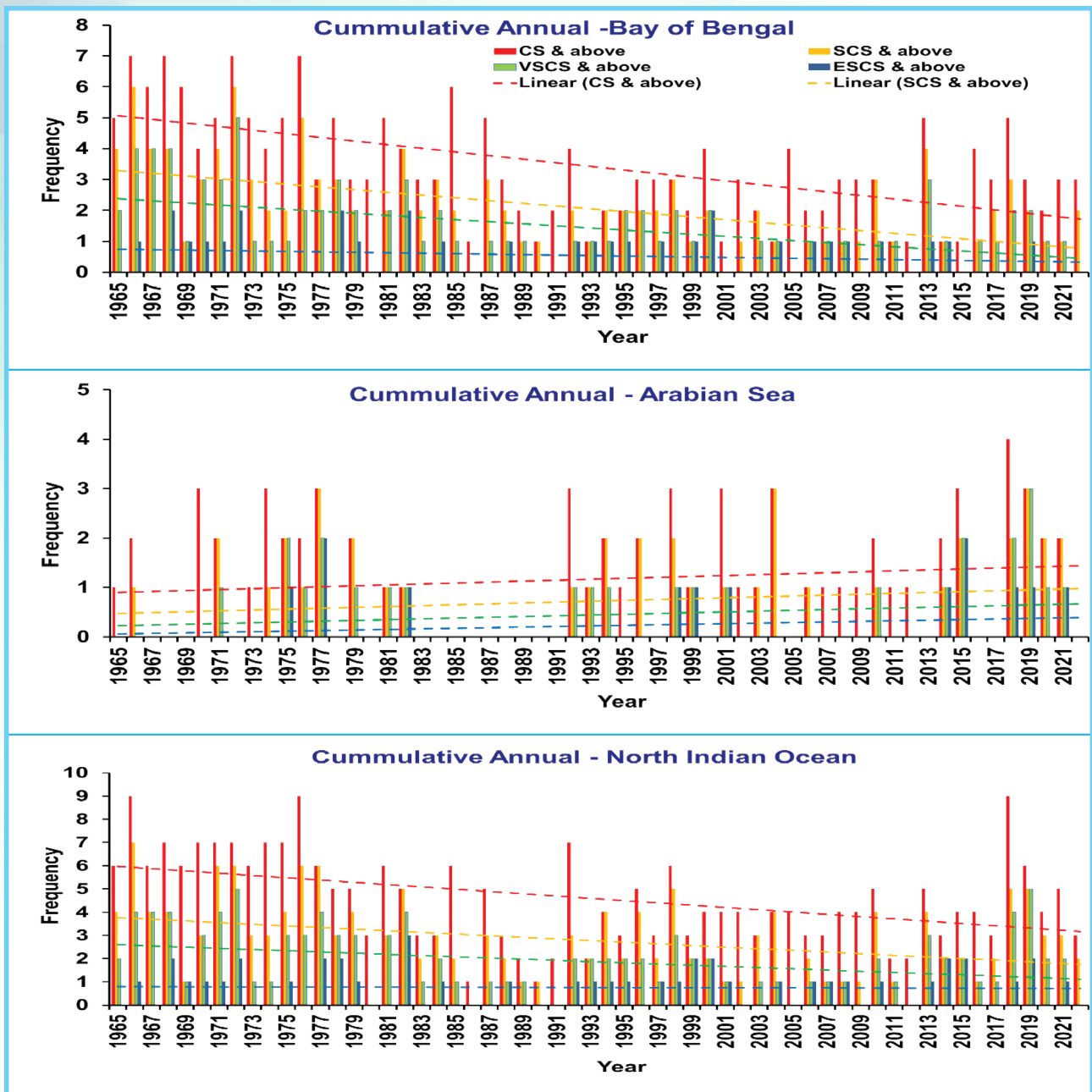


Fig. 4 Cumulative Annual frequency of genesis of cyclonic storm & above category (≥ 34 knots), severe cyclonic storm & above (≥ 50 knots), very severe cyclonic storm & above (≥ 64 knots) and extremely severe cyclonic storm & above (≥ 120 knots) over (a) Bay of Bengal, (b) Arabian Sea and (c) North Indian Ocean during 1965-2022

These extreme and hazardous weather events pose direct and indirect risks to human health in terms of accidents due to flying objects, snake bites in the coastal flooded regions and different other tertiary health impacts due to improper maintenance of hygiene during these natural calamities. Epidemiological research relates cyclones to mortality, noncommunicable diseases, adverse birth outcomes, infectious diseases, and mental health issues. Cyclones can displace communities, causing a major health problem. The overcrowded temporary shelters can spread respiratory, cutaneous, vector-borne and other epidemiological diseases. Diseases might spread faster in these settings due to poor sanitation and hygiene. Mental health issues are also vital as post-traumatic stress disorder, anxiety, and depression can result from cyclones. Losing homes, livelihoods, and loved ones can have long-term mental health impacts.

d) Thunderstorms & Lightning

Thunderstorm along with Lightning activity represents a significant destructive element of force of nature across India. Moreover, the intensity of these lightning strikes is notably pronounced along the coastal regions and in the Bay of Bengal. Thunderstorm is also seen to be changing its characteristics in terms of spatial and temporal displacements thereby beating the adaptability capabilities of human being and bringing more damage to human health. It is found in a study based on 50 years of data (1967-2016) that there is a decreasing trend in thunderstorm activity over the thunderstorm maximum region in east and northeast India in the monthly as well as annual scale, and a corresponding increasing trend over west central India, where thunderstorm frequency is less [20]. A study found that during the period from 1998 to 2014, lightning exhibited a significant intensification, growing annually by approximately 1% to 2.5% across all Indian regions, with the most pronounced trends observed along the coasts [21]. Rising surface temperatures have led to increased instability and subsequent stronger moisture transport to the upper-troposphere and lower-stratosphere regions, particularly along the coasts. This transported moisture contributes to a reduction in ozone concentration, resulting in decreased temperatures and heightened equilibrium levels, ultimately leading to more robust and frequent lightning events, as confirmed by trend analysis [21]. This study also predicts that the lightning frequency and intensity across the Indian region will increase by approximately 10% to 25% and 15% to 50%, respectively, by the end of the century, with the highest risks anticipated along the coasts, necessitating immediate attention from disaster managers and healthcare professionals. Long-term trends in the frequency of thunderstorm days, investigated using fifty years of data

during 1967-2016, as recorded by weather observatories throughout India, indicates that there are spatially cohesive trends in thunderstorm activity. Fig. 5 (a) displays three separate boxes for analysing the trends over three specific regions: East Central Indian region (outlined as “A” in Figure 5 (a)), west central Indian region (outlined as “B” in Figure 5 (a)) and northeast Indian region, (outlined as “C” in Figure 5 (a)). The trends of thunderstorm day occurrence over these regions is displayed in fig 5 (b). The data indicates that, annually, in the areas of east central and northeast India where the climatological frequency of thunderstorm activity is most pronounced, there was initially a cohesive spatial decline, succeeded by a subsequent increase in recent years. In east central India, the minimum was observed in 1991, followed by a subsequent upward trend. In northeast India, the frequency of thunderstorm days declined until 2001 before exhibiting an upward trajectory

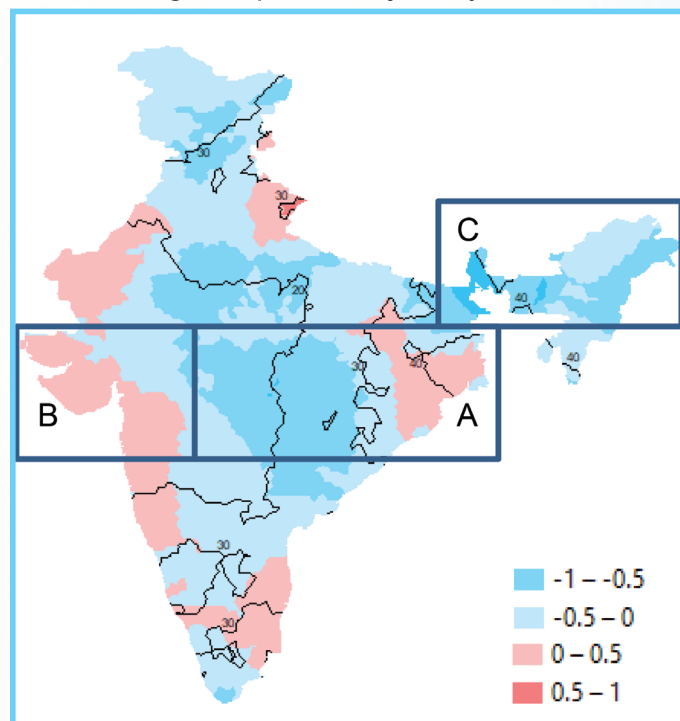


Figure 5 (a): Climatology of average number of thunderstorm days per year over the Indian region (black contours). Boxes demarcate sub regions for detailed analysis.

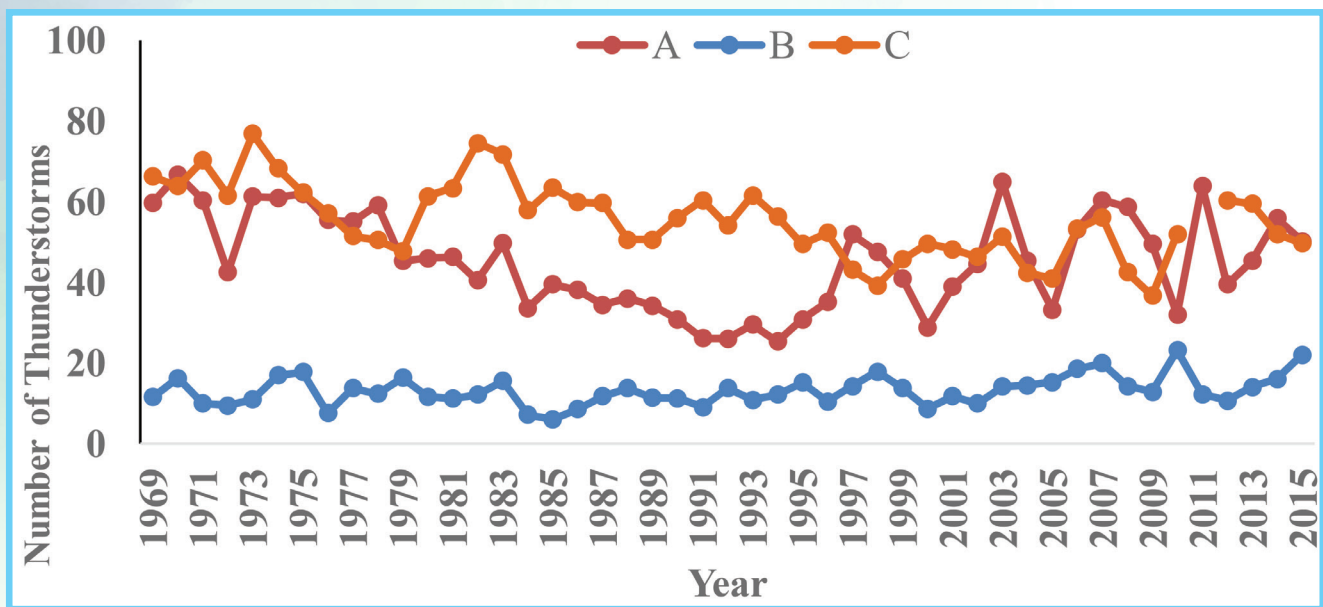


Figure 5 (b): Annual variations in frequency of thunderstorms for all stations of the subregions inside each box

e) Precipitation

Precipitation plays a vital role in the global water cycle and economy [22]. In the case of India, the monsoon rains during the June-September period, which account for over 75% of the yearly rainfall are crucial for the nation's agriculture and economy [23][24]. The Indian monsoon precipitation has been seeing abrupt variations over decades and centuries [25][26]. The all-India annual and summer monsoon mean rainfall have displayed a declining trend from 1951 to 2015, particularly evident in regions across the Indo-Gangetic Plains and the Western Ghats [27]. Over the last 15 years, beginning in 2005 and concluding in 2020, there has been a temporary decline in the temporal frequency of monsoonal precipitation extremes specifically over Central India [28]. Meanwhile, the occurrences of low and moderate precipitation events have displayed upward trends during this period [28]. These alterations seem to be influenced by amplified levels of human-generated aerosols over the northern hemisphere [27]. Between 1951 and 2015, there has been a notable rise in the frequency of localized heavy rain occurrences across India. It is probable that this increase is influenced by urbanization, other land-use changes, and aerosols, which collectively contribute to the occurrence of localized heavy rainfall [27]. The fig 6 (a) and fig 6 (b) are also depicting the declining trend in the annual and southwest monsoon rainfall during 1901 to 2021. It is also indicated in few reports that the Dry years are expected to be drier and wet years wetter (<https://www.worldbank.org/en/news/feature/2013/06/19/india-climate-change-impacts>). Not only the amount of precipitation is shifting but studies are also suggesting shifting nature of precipitation activities for instance west coast of India largely dominated by stratiform rainfall saw more of convective rainfall activity during monsoon 2019 [29].

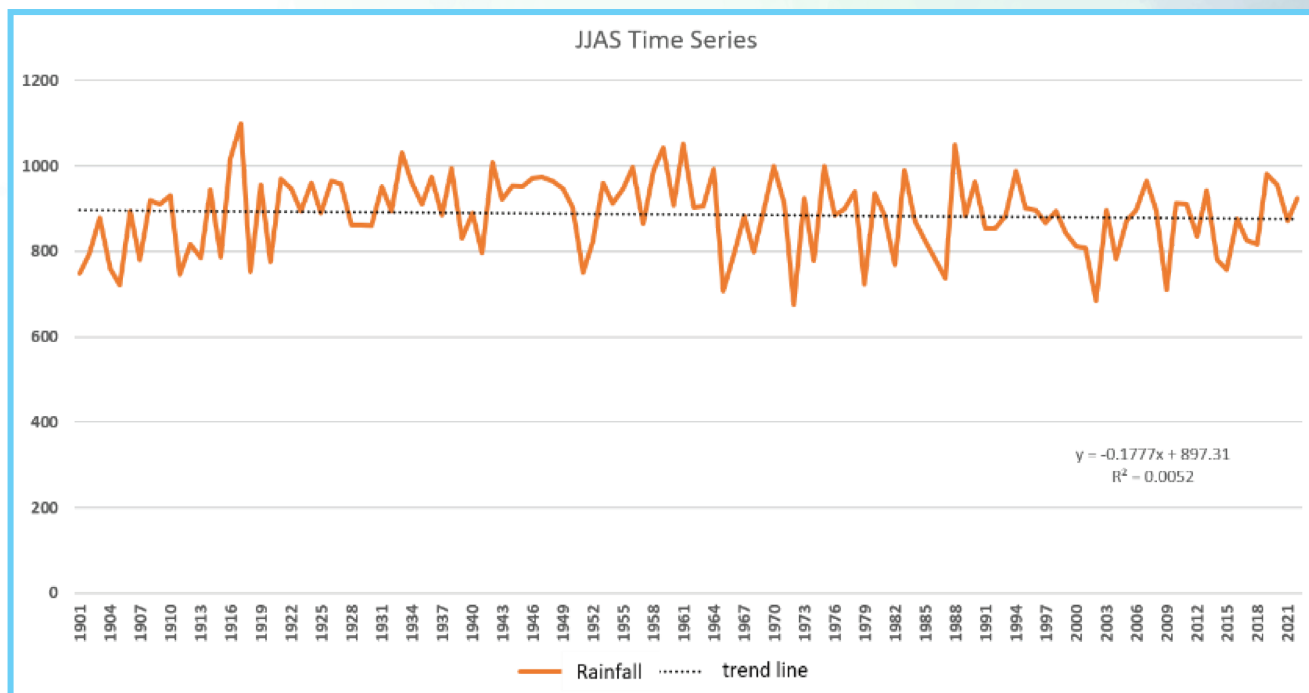


Figure 6 (a): All India Rainfall annual time series and trendline.

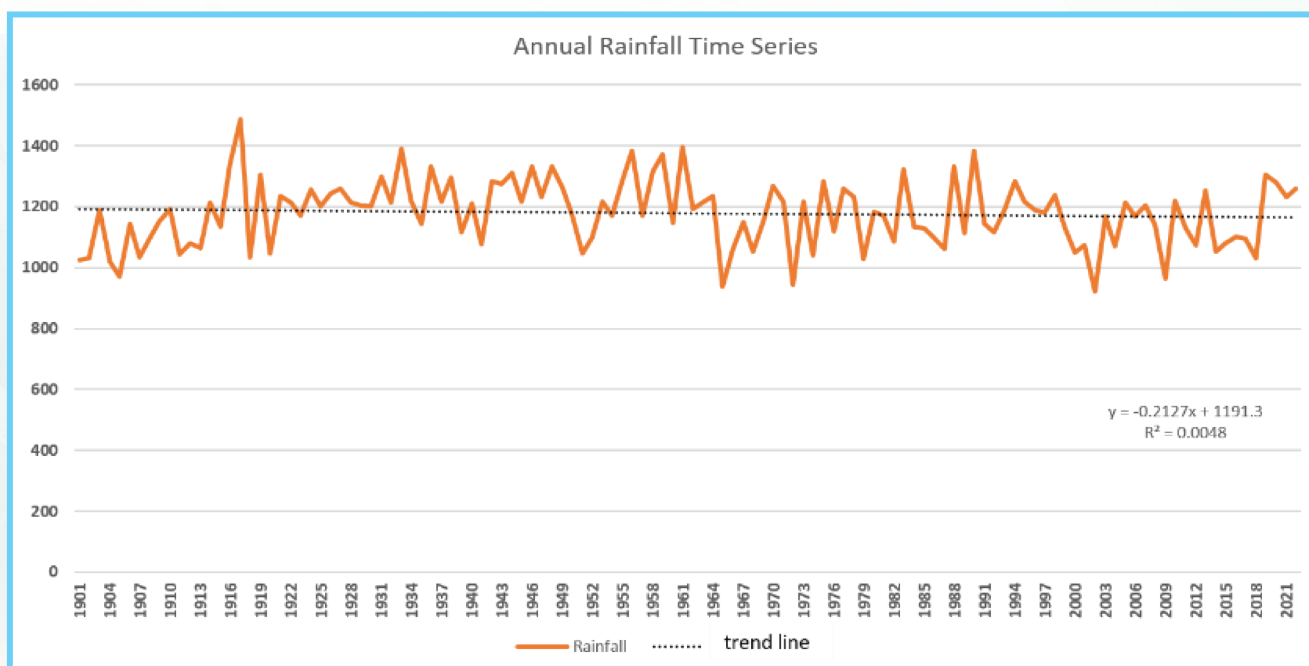


Figure 6 (b): All India Rainfall time series and trendline during monsoon (Jun-Sep).

Rainstorm is a storm characterized by substantial heavy rainfall. It is an extreme rainfall event experienced over a particular area for a particular period, in association with various weather systems of different spatial scales. Many times, it has been observed that rainstorms lead to floods and landslides. India Meteorological Department has classified the rainfall events into different categories based on the intensity of the rainfall. The fig 7 (a) illustrates the patterns of station-specific rainfall events categorized as heavy (64.5 to 115.5mm), very heavy (115.6 to 204.4mm), and extremely heavy (greater than 204.4mm) for the South-West Monsoon season (JJAS) and fig 7 (b) for the annual rainfall from 1951 to 2022. Only trends with a statistical significance exceeding 95% for the period 1951-2022 are considered here. Blue arrows indicate a notably negative trend, while red arrows signify a significantly increasing trend. Between 1951

and 2022, it has been noted that for Southwest monsoon season 1215 stations exhibit a significant rise in heavy rainfall, 974 stations in very heavy rainfall, and 511 stations in extremely heavy rainfall. Conversely, 1492 stations show a statistically insignificant decrease in heavy rainfall, 1171 stations in very heavy rainfall, and 514 stations in extremely heavy rainfall. Whereas, with respect to annual rainfall consideration it is observed that 1303 stations experienced a significant increase in heavy rainfall, 1056 stations in very heavy rainfall, and 534 stations in extremely heavy rainfall. Conversely, 1722 stations displayed a statistically insignificant decrease in heavy rainfall, 1259 stations in very heavy rainfall, and 578 stations in extremely heavy rainfall over the same period. Thereby indicating statistically significant increasing trend in heavy, very heavy and extremely heavy rainfall during southwest monsoon as well as during entire year.

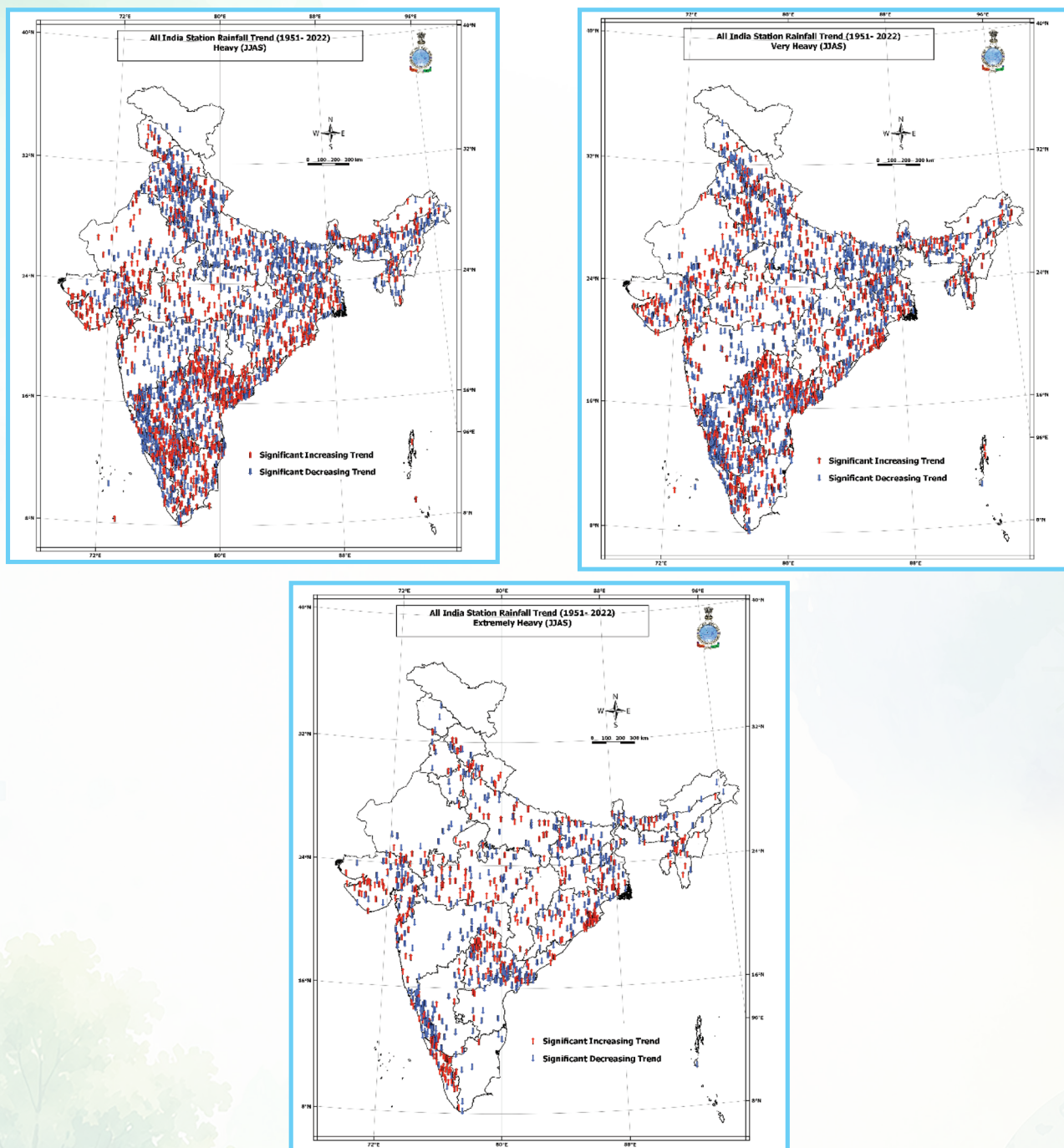


Fig 7 (a): Patterns of station-specific rainfall events categorized as heavy (64.5 to 115.5 mm), very heavy (115.6 to 204.4 mm), and extremely heavy (greater than 204.4 mm) for the South-West Monsoon season (June to September).

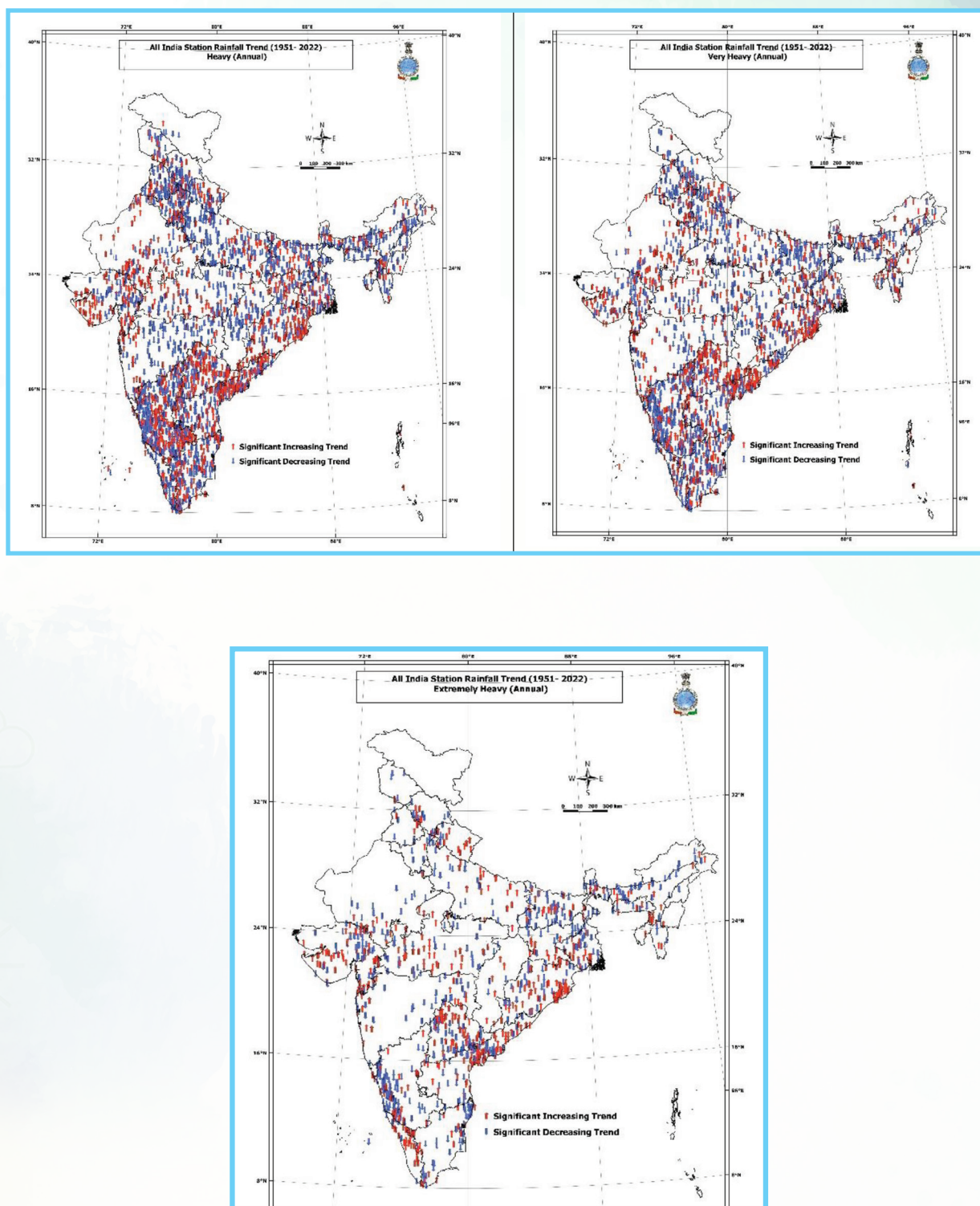


Fig 7 (b): Patterns of station-specific rainfall events categorized as heavy (64.5 to 115.5 mm), very heavy (115.6 to 204.4 mm), and extremely heavy (greater than 204.4 mm) for entire year (January to December)

In future also, different climate projections are indicating variation in precipitation activities. Anticipated projections indicate a potential escalation in the frequency and intensity of events, characterized by an average daily rainfall exceeding 20 mm [30]. As a whole, this study suggests that water-related disasters, including flooding and landslides, may considerably exacerbate in India due to the effects of climate warming. In a study which examined 90 climate models from four consortium CMIP5, CMIP6, NEX-GDDP, and CORDEX suggested increased precipitation over central eastern

and north-eastern India in the monsoon season, and over peninsular India during post-monsoon months [31]. A growing consensus, supported by numerous datasets and simulations from climate models, indicates that the radiative impact of human-induced aerosol forcing across the Northern Hemisphere has substantially counteracted the anticipated rise in precipitation resulting from greenhouse gas (GHG) warming. This counteraction has contributed significantly to the observed reduction in summer monsoon precipitation. Based on CMIP5 models and the expectation of ongoing global warming along with predicted decreases in anthropogenic aerosol emissions in the future, projections indicate a likely surge in both the average and variability of monsoon precipitation by the conclusion of the twenty-first century. Moreover, these models also suggest significant amplification in the occurrences of extreme daily precipitation events.

□ Impact of changing weather characteristics on health

i. Mortality and Morbidity in association with different weather events

The changing weather patterns are also bringing up different direct and indirect tertiary hazards. These threats with respect to health, life and wellbeing of human beings have been a major concern while dealing with the changing climate. The impacts of climate change on health, encompassing heightened exposure to heat, compromised air quality, extreme weather occurrences, altered transmission of vector-borne diseases, diminished water quality, and compromised food security, affect men and women, children and aged differentially. Within India, where rapid environmental shifts are occurring, climate change poses a threat to exacerbating pre-existing gender-based health inequalities [32]. Increasing frequency of extreme heat events and rising average

seasonal temperatures leads to increased morbidity and mortality. Annually, a significant number of hospitalizations are linked to exposure to extreme ambient temperatures, particularly in the context of heatwaves and cold spells [33][34][35][36]. The elderly is more susceptible to both heat- and cold-related health issues, as indicated by research [37][38][39][40]. Additionally, urban residents are often exposed to higher temperatures compared to those living in suburban and rural areas due to the “heat island effect.” This phenomenon is caused by various factors, including increased heat absorption by dark surfaces, heat emissions from vehicles and air conditioning units, a lack of vegetation and trees, and poor ventilation [41][42][43]. As a result, people in urban areas face an increased risk of health problems due to heightened ambient heat exposure [43]. The findings by few studies indicate that forthcoming climate warming is likely to result in significant upsurges in heat-related mortality, particularly in developing nations situated at lower latitudes, like India. This prediction is primarily attributed to the projected increase in the frequency of heatwaves and the heightened vulnerability of populations in these regions to extreme temperatures [9]. These impacts of temperatures are getting amplified in view of the global rise in temperatures.

Tropical cyclones are also witnessing increased intensity over North Indian Ocean. The torrential rain and high windspeed accompanying the cyclone cause lot of damage to life and property. There has been considerable reduction in the deaths directly associated with the tropical cyclones due to improved accuracy in the forecast and lead times [44][45]. However, still the tertiary health conditions are a challenge for the healthcare sector. The global recognition of an elevation in diarrheal diseases following various types of natural disasters highlights a concerning

trend [46]. Significant natural calamities, including floods, tsunamis, earthquakes, tropical cyclones, and tornadoes, can intensify the risk factors for the spread of infectious diseases [47]. This exacerbation is primarily due to the disruption of already inadequate water, sanitation, and sewage systems [48]. During a cyclone, the breakdown of the water distribution system, coupled with insufficient hygiene, sanitation, and limited access to healthcare services, notably elevates the likelihood of cholera outbreaks within affected areas [49][50]. Similar results were found with respect to cholera outbreak in Puducherry aftermath of Severe cyclonic storm “Thane” making landfall from Bay of Bengal on 30th December 2011[51].

The impact of cyclonic storms on waterborne diseases can vary, depending on the specific characteristics of the storm that dictate the level of flooding and destruction [52]. Storms are typically characterized by their wind speed and rainfall, which are often weakly correlated upon making landfall and can result in differing conditions within affected regions [53]. Slower-moving storms tend to bring about a significant accumulation of rainfall and more extensive flooding, while tropical cyclones with higher wind speeds might lead to less precipitation but cause property or infrastructure damage due to strong winds [54]. The type of storm can also influence decisions related to disaster management and individual-level responses, including the ability to comply with evacuation orders. Furthermore, the severity of the storm impacts healthcare-seeking behavior and healthcare infrastructure. Storm-related disturbances might deter individuals with mild or moderate conditions from seeking medical attention [55], whereas catastrophic storms can hinder those with urgent medical needs from accessing healthcare systems [56].

The projected escalation in storm severity

owing to atmospheric warming underscores the critical need for a thorough understanding of the impact of storms on waterborne diseases, offering valuable insights for the development of effective climate change adaptation strategies and public health policies [52]. Apart from communicable diseases, there is substantial evidence supporting the concept that high-intensity cyclones could notably elevate the risks of mental disorders, particularly post-traumatic stress disorder (PTSD), alongside heightened mortality rates and hospitalizations. However, the evidence pertaining to other health outcomes, such as chronic diseases (e.g., cardiovascular diseases, cancer, diabetes) and adverse birth outcomes, remains either limited or inconsistent [57]. In view of climate change more research focused on storms, outbreaks, general gastrointestinal illnesses, comprehensive investigations encompassing multiple storm seasons are required in the Indian setup to formulate public health plans and interventions aimed at mitigating the adverse health consequences stemming from tropical cyclones.

Lightning, often coupled with severe weather phenomena such as thunderstorms and hailstorms, stands as one of the most fatal localized natural occurrences. It represents the primary cause of injury and fatality compared to other natural hazards [58]. The combination of hot weather and humidity fosters the optimal environment for the development of thunderstorms. Climate change, resulting in localized heating of the Earth's surface and an influx of moisture, contributing to a notable surge in the frequency of large-scale lightning occurrences. The increased incidence of lightning brings with it increased risk of deaths and injuries to humans as well as livestock's. While a direct strike is frequently perceived as the most prevalent cause of injury, it is relatively uncommon. In contrast, ground current, side

flash, upward leader, and direct contact are more frequently observed mechanisms of injury [59]. Lightning not only is fatal to human beings but in case of survivals may bring permanent damages to the human beings requiring long-term medical interventions. When a large amount of energy in form of lightning enters human body, it can disrupt the electric signals that govern the functioning of the heart, lungs, and nervous system. This disruption can lead to several potential consequences, including: cardiac arrest, brain injury, seizures, spinal cord damage and amnesia etc. In developed countries, lightning tends to result in neurological injuries rather than substantial burn injuries in the majority of cases. However, in developing nations, it can lead to notable burn injuries under specific conditions, in addition to causing neurological and long-term harm [59]. In view of the increasing incidences of lightning attributed to climate change increased burden on health care sector with respect to injuries and fatalities due to lightning could be a reality in coming years.

Thunderstorm on the other hand in conjunction with lightning are fatal but also generates different medical requirements. Thunderstorm asthma pertains to an observed surge in cases of acute bronchospasm subsequent to the occurrence of thunderstorms within the local vicinity [22]. While rainfall can alleviate symptoms for individuals with asthma and allergies by cleansing the environment of dust and pollen, the occurrence of thunderstorms can trigger what is commonly referred to as 'thunder fever.' This phenomenon arises when the downward-moving cold air currents, typically associated with warm weather and thunderstorms, lead to the concentration of mold or pollen. Subsequently, these air particles are lifted up to the clouds, where the interplay of wind, moisture, and lightning breaks them down into smaller particles. These

smaller allergens are then dispersed by gusty winds during the thunderstorm, intensifying the severity of asthma attacks and allergic reactions. While there is no precise definition based on the extent of the increase in asthma cases, thunderstorm asthma epidemics are infrequent and occur only when specific factors related to the population, meteorology, and environment align [60]. Individuals affected by this phenomenon typically present with characteristic symptoms of acute asthma, including coughing, wheezing, and shortness of breath [60]. The substantial number of people affected has the potential to overwhelm locally available healthcare services and in rare cases, thunderstorm asthma can result in fatalities [61]. In a study based on the data from 1990 to 2016 an increase of 8.6% is seen in the prevalence of respiratory conditions, including asthma [62]. Thereby, making the thunderstorm and their shifting patterns in view of climate change a concern for the healthcare sector with respect to respiratory diseases in general and asthma in particular.

The frequency of intense precipitation events has increased and climate projections indicate that it is expected to continue in the future. This rise in both extreme precipitation and overall precipitation has significantly contributed to the occurrence of severe flooding events in different areas [63]. Furthermore, the acceleration in the rate of multi-day flood events is anticipated to surpass that of single-day events in the future, carrying significant implications for both agriculture, infrastructure and healthcare sector [63]. Different studies have indicated a surge in outbreaks of waterborne diseases in the weeks following heavy rainfall, although various factors may influence these connections. Water seepage into buildings can lead to mold contamination later on, exacerbating indoor air quality issues. Structures damaged

during hurricanes are particularly vulnerable to water intrusion. Individuals living in damp indoor environments are more susceptible to an increased prevalence of asthma and other upper respiratory tract symptoms, such as coughing and wheezing, as well as lower respiratory tract infections, including pneumonia and respiratory syncytial virus (RSV) infections and RSV pneumonia [64]. Conversely, at the other end of the spectrum, drought conditions also pose significant risks to public health and safety. Droughts can increase exposure to various health hazards, including wildfires, dust storms, extreme heat events, flash flooding, degraded water quality, and reduced water availability. Dust storms associated with drought conditions contribute to compromised air quality due to particulate matter and have been linked to an increased incidence of coccidioidomycosis (valley fever), a fungal pathogen etc. [64]. Between 1951 and 2015, there has been a marked increase in the frequency and geographical coverage of droughts across India [84]. The severity of droughts has particularly intensified in the central regions of the country, encompassing sections of the Indo-Gangetic Plains [65]. On the other hand, the heightened occurrence of localized heavy rainfall at sub-daily and daily intervals has notably amplified the risk of flooding throughout India, particularly within urban regions [65]. According to climate model projections, there is a forecasted rise in the frequency, geographical coverage, and severity of droughts across India during the twenty-first century. Simultaneously, there is a high level of confidence in the projection that the susceptibility to flooding will intensify in the major Himalayan River basins, including the Indus, Ganga, and Brahmaputra, in the coming years [65]. Thereby, making a complex challenge for the healthcare sector to deal with the flood as well as droughts related medical complications.

ii. Vector Borne Diseases: (Dengue, Malaria, Japanese encephalitis etc.)

Outbreaks of Vector borne disease (VBD) pose a serious challenge to healthcare professionals in terms of managing disease mortality, controlling disease transmission, and preventing financial loss. The World Health Organization identifies a list of major vectors borne diseases such as malaria, dengue, chikungunya, yellow fever, Zika virus disease, lymphatic filariasis, schistosomiasis, onchocerciasis, Chagas disease, leishmaniasis, and Japanese encephalitis [66]. Among all these diseases, the mosquito borne diseases (MBD) such as dengue pose a serious threat in different parts of India as shown in data from National Center for Vector Borne Disease Control (Table-1). India shows marked regional, spatial and temporal variations in terms of number of malaria and dengue cases [67][68][69]. Most of these incidents are localized in urban or rural areas. Prevention of such localized MBD outbreaks such as malaria and dengue and timely intervention to reduce the disease burden is important from community health practice perspective. Even though several intervention techniques are available, sometimes predictive outlooks can be useful for preparation against such outbreaks. There are several reasons for MBD outbreaks. Epidemiological modeling and simulation studies often relate the MBD outbreaks to vector growth and proliferation on different spatial and temporal scales, which are known to be related to the ambient weather and climatic factors like temperature, humidity, rainfall, etc. [69][70]. These studies showed that the temporal evolution of these climate factors act as “environmental drivers” for temporal evolution dynamics [71]. Several studies also assume environmental forcing as a driving factor for a near future estimation/outlooks of such outbreaks using linear, non-linear, dynamical as well as statistical forecasting models [72][73][74].

Table 1. Dengue Cases and Deaths in the Country since 2018

(Source: <https://ncvbdc.mohfw.gov.in/index4.php?lang=1&level=0&linkid=431&lid=3715>)

Sl. No.	Affected States/UTs	2018		2019		2020		2021		2022		2023*	
		C	D	C	D	C	D	C	D	C	D	C	D
1	Andhra Pradesh	4011	0	5286	0	925	0	4760	0	6391	0	3926	0
2	Arunachal Pradesh	1	0	123	0	1	0	7	0	114	0	17	0
3	Assam	166	0	196	0	33	0	103	0	1826	2	5604	6
4	Bihar	2142	0	6712	0	493	2	633	2	13972	32	2515	7
5	Chattisgarh	2674	10	722	0	57	0	1086	0	2679	10	733	0
6	Goa	335	1	992	0	376	0	649	0	443	1	264	0
7	Gujarat	7579	5	18219	17	1564	2	10983	14	6682	7	3334	1
8	Haryana	1898	0	1207	0	1377	0	11835	13	8996	18	2892	4
9	Himachal Pradesh	4672	7	344	2	21	0	349	0	3326	1	596	0
10	J & K	214	0	439	0	53	0	1709	4	8269	18	1192	0
11	Jharkhand	463	1	825	0	79	0	220	1	290	0	958	2
12	Karnataka	4427	4	16986	13	3823	0	7393	7	9889	9	9185	0
13	Kerala	4083	32	4652	16	4399	5	3251	27	4432	29	9770	37
14	Lakshadweep	0	0	0	0	0	0	1	0	67	0	286	0
15	Madhya Pradesh	4506	5	4189	2	806	0	15592	11	3318	2	1544	0
16	Meghalaya	44	0	82	0	4	0	129	0	26	0	59	0
17	Maharashtra	11011	55	14907	29	3356	10	12720	42	8578	27	8496	2
18	Manipur	14	0	359	0	37	0	203	0	503	4	521	0
19	Mizoram	68	0	42	0	67	0	83	0	1868	5	821	1
20	Nagaland	369	0	8	0	1	0	24	0	154	0	400	0
21	Odisha	5198	5	3758	4	496	0	7548	0	7063	0	6563	0
22	Punjab	14980	9	10289	14	8435	22	23389	55	11030	41	4246	0
23	Rajasthan	9587	10	13706	17	2023	7	20749	96	13491	10	5094	6
24	Sikkim	320	0	444	0	11	0	243	1	264	0	163	0
25	Tamil Nadu	4486	13	8527	5	2410	0	6039	8	6430	8	4148	3
26	Tripura	100	0	114	0	24	0	349	0	56	0	744	0
27	Telangana	4592	2	13331	7	2173	0	7135	0	8972	0	5138	0
28	Uttar Pradesh	3829	4	10557	26	3715	6	29750	29	19821	33	5742	5
29	Uttarakhand	689	3	10622	8	76	1	738	2	2337	0	1588	14
30	West Bengal			NR	NR	5166	0	8264	7	67271	30	NR	NR
31	A& N Island	49	0	168	0	98	0	175	0	1014	3	540	0
32	Chandigarh	301	0	286	0	265	0	1596	3	910	1	93	0
33	Delhi	7136	4	5077	0	1269	0	13089	23	10183	9	5221	1
34	D&N Haveli	493	0	1491	2	248	0	547	0	685	0	478	0
35	Daman & Diu	163	0	625	2	71	0	279	0	228	0	94	0
36	Puduchery	592	2	2030	2	633	1	1625	1	1673	3	1233	2
	Total	101192	172	157315	166	44585	56	193245	346	233251	303	94198	9

Although the epidemiological model of malaria and dengue outbreaks relates several external factors to the growth of the parasite/mosquito, temperature and other climate-derived factors are known to be important driving factors for the growth of both the parasite and mosquito. This is shown in Fig. 8 for the malaria and dengue cases and rainfall interannual variability over the state of Kerala. Fig. 9 shows the monthly distribution of outbreaks. Outbreaks are defined to occur when the numbers of cases cross above a threshold value for a particular month (Fig. 9). For the state of Kerala, the panel shows that the outbreak peaks during the monsoon months indicating a relationship with rainfall.

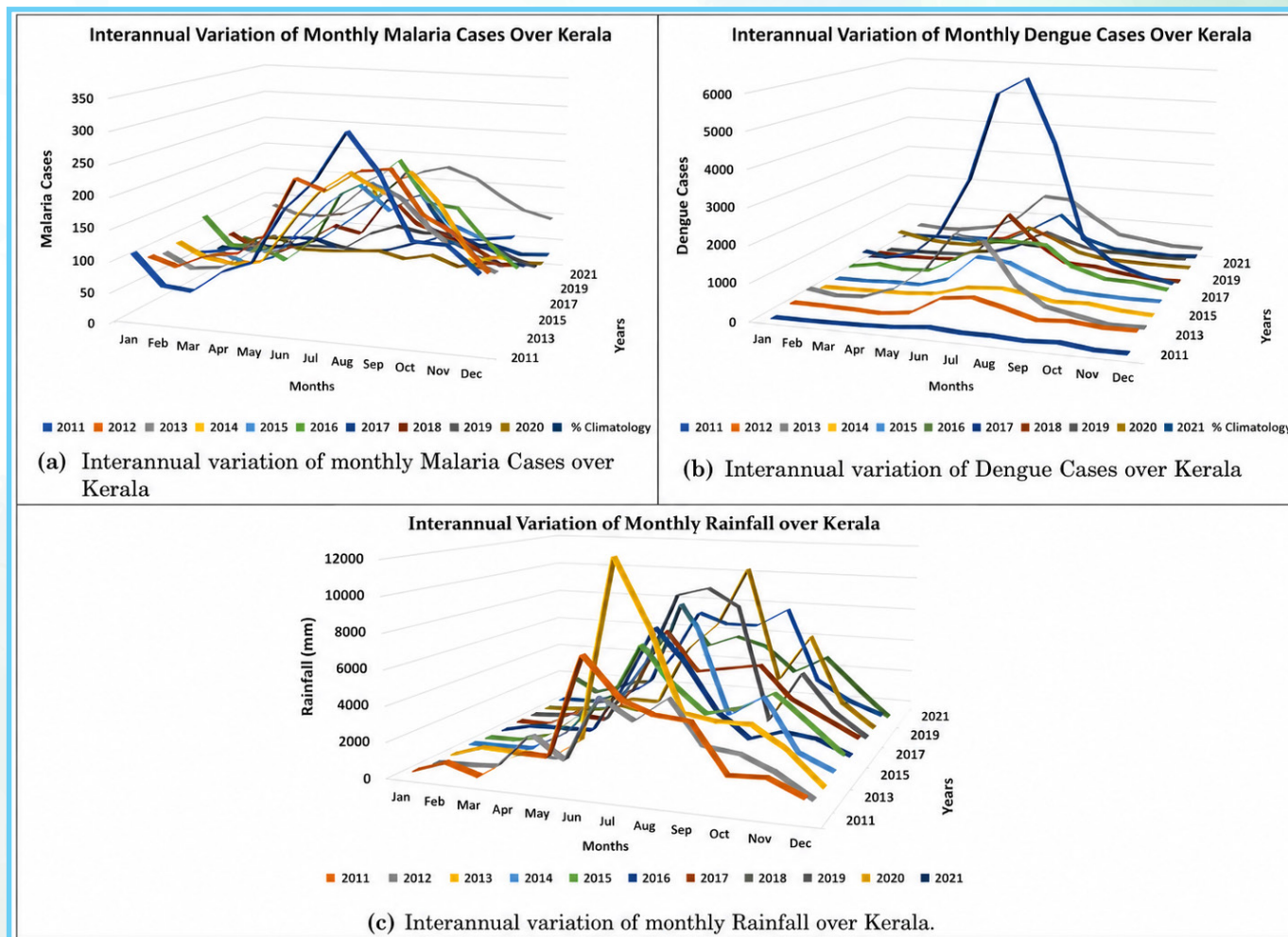


Fig 8: Interannual variation of Malaria cases, Dengue Cases and monthly Rainfall over Kerala.

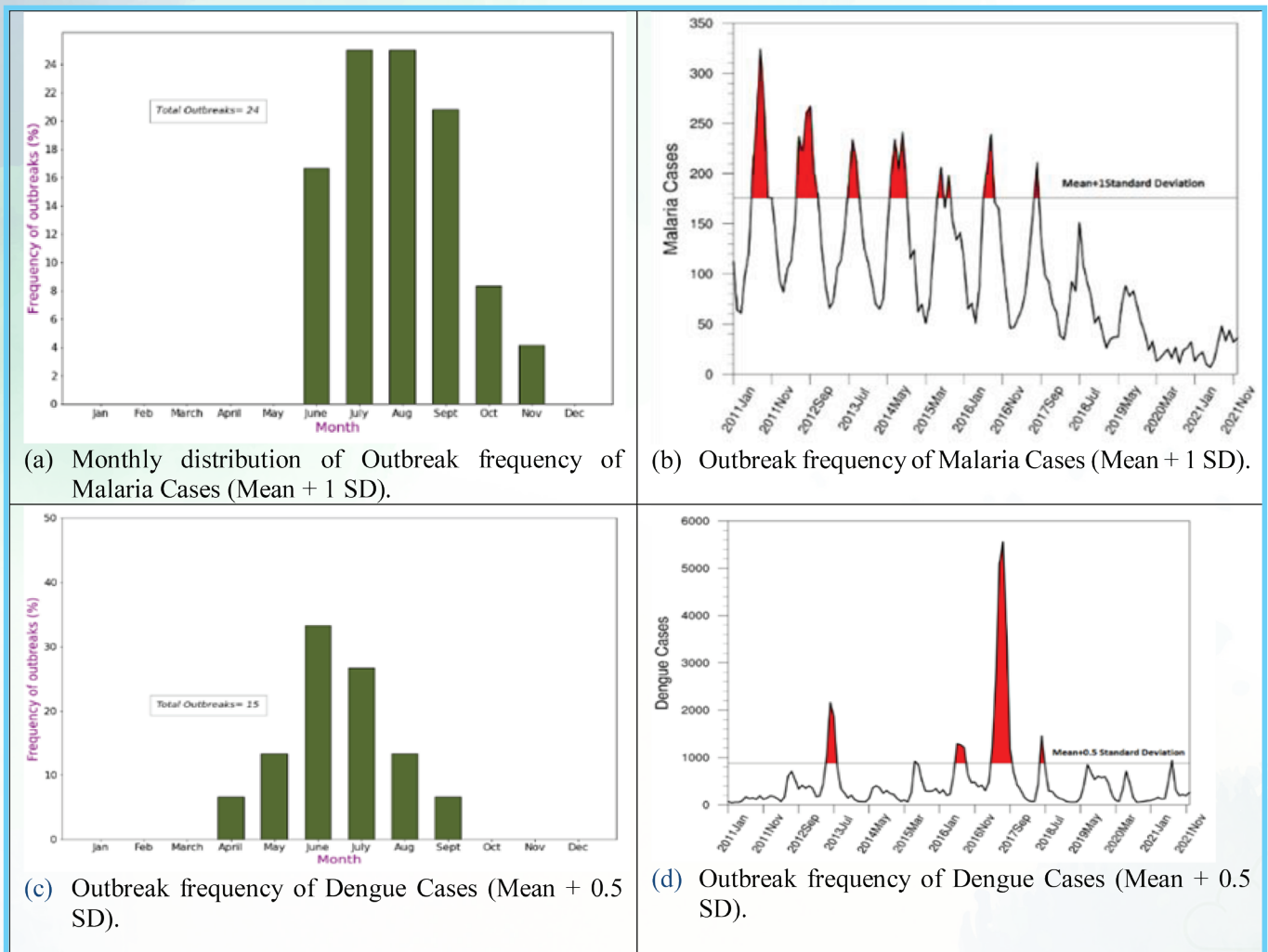


Fig 9: Monthly distribution and outbreak frequency of Dengue and Malaria over Kerala.

The life cycle of malaria and dengue viruses involves two hosts: humans and mosquitoes. The viruses spread through bites from female *Anopheles* and *Aedes* mosquitoes, respectively, on infected people. The viruses undergo multiple developmental stages within the mosquito before being transmitted to another human. Both viruses are transmitted by mosquitoes, and their life cycle is closely linked to climatic factors. Since mosquitoes are ectotherms, temperature heavily affects the development of malaria and dengue viruses in mosquitoes. Elevated temperatures expedite the virus's growth, whereas lower temperatures decelerate it. Similarly, increased humidity levels likewise promote its progression. However, extreme temperatures can have a negative impact on virus transmission [75]. The extrinsic incubation period (EIP) is the time it takes for the pathogen to develop inside the mosquito before it can be transmitted to a human host. The EIP of malaria varies depending on the species of mosquito vector and the temperature. It typically ranges from 10 to 21 days. Dengue has an EIP of around 8 to 12 days, but similar to malaria, this can vary depending on temperature and other environmental factors. For both diseases, higher temperatures shorten the EIP, while lower temperatures lengthen it. Climate forcing can affect the transmission of both diseases by changing the distribution and abundance of mosquito vectors, which can impact their life cycle and the extrinsic incubation period [76]. Hence, such studies conclude that climatic factors are extremely important for MBD outbreaks.

In the context of climate change scenario and rise in global mean temperature, studies report frequent proliferation of MBD outbreaks [77][78][79]. In a study the sensitivity of extrinsic incubation

period (EIP) with respect to temperature was studied and found to be consequent upon the temperature fluctuations [80]. In the context of climate change scenarios, the result suggests the sensitivity of EIP with temperatures. It is clear that climate change can affect the incubation period thereby changing the malarial infection rate. In India, several studies suggest the development of favorable conditions for malaria transmission in a warming scenario in different regions where microclimates are affected by climate change. In a study related to the climatic trends in the state of Mizoram and adjoining areas near the Bangladesh border from 1981 to 2021 a statistically significant increasing trend in minimum temperature, relative humidity, rainfall, and the associated shift of regional climatic patterns from temperate to tropical monsoon, which could facilitate an increase in malaria transmission in this region was seen [81]. Similarly, analysis of near and far future temperature, humidity and rainfall trend suggest changes in the transmission pattern [82][83]. Utilising models one of the studies suggested that climate change may significantly increase the spatial spread of *P. vivax* (Pv) and *P. falciparum* (Pf) malaria with an increase in the transmission window's month and a shift in the pattern of the mean monthly cycle of transmission [83]. The study also pointed out regions of increase and decrease in transmission. For example, some areas in the western Himalaya are likely to have a new epicenter of Pv malaria transmission. Interior parts of some southern and eastern states are likely to become more suitable for Pf malaria. Study has also identified regions with a reduction in transmission months by the 2030s, leading to unstable malaria and a higher potential for malaria outbreaks. Similarly, another study over state of Odisha suggested that malaria transmission during the summer and winter monsoon seasons may decrease in the future due to climate change, except in a few districts with high elevations and dense

forest regions, such as Kandhamal, Koraput, Raygada, and Mayurbhanj districts, where an increase in malaria transmission is found [84]. Thus, climate change projects the appearance of newer hotspots and a reduction in the transmission of malaria in some new hotspots. For policymakers and public health planners, this indicates the development of dynamic strategies of risk reduction depending on risk profiles and hotspots.

□ Role of weather forecasting in mitigating impact of climate change on health.

India Meteorological Department (IMD) being a nodal agency, provides the weather forecast and weather warning in different spatial and temporal scale. The lead time for weather forecast and warning varies from nowcast (next few hours), very short range (next 12 hours), short range (up to 01-03 days), medium range (04-07 days), extended range (07-14 days), monthly (up to one month) and long range (1-3 months). IMD issues forecast and warning at block level, district level, city level, location-specific, sectoral, sub-divisional and national level. All these forecasts are disseminated to stakeholders including to healthcare sectors too. The skill for forecast and warning has been improving and is being effectively utilized in mitigation activities. As the extreme weather events (heavy rainfall, heat wave, cold wave, floods, etc.) have increased in both frequency and severity as a result of climate change. Hence, accurate weather forecast helps in predicting those extreme well, in advance with an actionable lead time thereby playing a crucial role in mitigating their impact on human health.

Weather forecasting helps in the development and implementation of early warning systems for extreme weather events like heat waves, cold waves, flash floods etc. These systems with proper health advisories may allow the public to prepare and take necessary precautions to minimize health risks. Similarly, the air quality is impacted by climate change, which results in

the accumulation of air pollutants like ozone and particulate matter. The ability to predict air quality conditions through the use of weather forecasting allows public health agencies to issue advisories regarding air quality and implement preventative measures to mitigate exposure to pollutants in the air. This entails providing guidance on mask usage and instructing susceptible demographics to remain indoors throughout episodes of increased pollution, and follow other measures as possible.

Concurrently, climate change has increased the occurrence and severity of weather-related natural disasters, such as flash floods, landslides, dust storms, and wildfires, among others. Weather forecasting plays a crucial role in the anticipation of the extent of such disasters, enabling authorities to issue evacuation directives and effectively coordinate disaster response attempts. Furthermore, the utilization of weather forecasts plays a crucial role in the evaluation of potential health risks that may arise following a disaster, such as the presence of contaminated water, and the occurrence of waterborne disease outbreaks, etc. There early warning services could be effectively utilized in the strategy ensuring the adequate availability of health care professionals, infrastructure and pharmaceutical interventions.

□ Summary

The impacts of climate change on health are varied and far-reaching, resulting in fatalities and illnesses stemming from more frequent extreme weather events such as heatwaves, storms, and floods. Additionally, climate change disrupts food systems and contributes to the rise of zoonotic, food-, water-, and vector-borne diseases, while also fostering mental health issues. Moreover, climate change undermines several critical social determinants for good health, such as livelihoods, equality, and access to healthcare and social support structures. These health risks sensitive to climate disproportionately

affect the most vulnerable and disadvantaged populations, including women, children, ethnic minorities, impoverished communities, migrants or displaced individuals, the elderly, and those with preexisting health conditions.

Current efforts aimed at tackling global warming primarily emphasize the mitigation of climate change. However, considering the projected implications such as increased temperatures, lightning intensity, varying precipitation levels, and evolving disease patterns in India, there is an urgent need for heightened scientific research and the development of strategies focused on climate adaptation and mitigation, especially concerning public health for the most vulnerable populations. Addressing climate risks necessitates collaborative efforts across multiple sectors, enhanced data collection, monitoring of gender-specific objectives, and inclusive stakeholder involvement. The role of efficient and effective early weather warning system for all is the cogwheel while transitioning towards climate change ready India.

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Mental Health Impacts of Climate Change - The Silent Crisis

Authors: Chandana Sabbella¹, Sourabh Joshi¹, Prakyath Ravindranath Hegde², Channaveerachari Naveen Kumar³

□ Affiliation:

- 1 Senior Resident of Psychiatry, GS-NIMHANS Mental Health Programme, National Institute of Mental health and Neurosciences, Bangalore.
- 2 Assistant Professor of Psychiatry, GS-NIMHANS Mental Health Programme, National Institute of Mental health and Neurosciences, Bangalore.
- 3 Professor of Psychiatry, Head Community Psychiatry at National Institute of Mental health and Neurosciences, Bangalore and the Officer In Charge of COE in Mental Health under the National Program of Climate Change and Human Health, Govt. of India.

Introduction:

In discussions about climate change, we often focus on its visible impacts like rising global temperatures, increasing sea levels, melting of glaciers, and increase in the frequency or severity of extreme weather events and their physical impacts, which are apparent. However, its impact on mental health often goes unnoticed or underestimated. The mental health consequences of climate change are complex, ranging from acute distress triggered by natural disasters to chronic conditions such as anxiety or depression resulting from environmental uncertainty. This article explores climate change's immediate and long-term impacts on mental health and the intersection between climate change and psychological well-being.

The impacts of climate change on mental health can manifest in multiple ways. Climate change might have direct impacts on mental health or indirect effects through factors such as loss of livelihood, migration, unemployment, and crop failure.

□ Table: Overview of Subclinical and Clinical Mental Health Impacts of Climate Change

Subclinical Mental health impact	Clinical Mental health impact
Shock	Depression
Despair	Anxiety
Helplessness	Adjustment disorder
Grief	Substance abuse or dependence
Fear	Post-Traumatic Stress Disorder
Irritability	Suicidal ideation.
	Loss of personal identity

A scoping review conducted in 2021 highlighted the increased incidence of major depressive disorder, heightened rates of hospital admissions and psychological distress during heat waves.[1] The review also identified a reduction in positive emotions, such as happiness, and an increase in negative emotions, like anger, stress, and fatigue. Furthermore, the review underscored

a concerning increase in aggression, domestic violence, and self-harm attempts, indicating the profound and varied effects of climate change on mental well-being

In a remote coastal region of the Solomon Islands, the rising sea levels were linked to an increase in mental health morbidities, illustrating how worries about sea-level rise have influenced the thoughts and behaviours of individuals, as well as those of their families and communities[2]. Chronic exposure to ozone is associated with increased cognitive decline rates in the elderly[3]. Long-term exposure to air pollution correlates with an increased likelihood of developing depression as various air pollutants rise, which suggests that the effects of air pollution on depression may persist over time [4].

Meta-analyses on air pollution revealed significant associations with adverse health outcomes. Exposure to particulate matter during pregnancy increases the risk of adverse outcomes, including infants with low birth weight, preterm deliveries, and neurodevelopmental conditions like autism spectrum disorders. [5] Another meta-analysis revealed a connection between extended inhalation of fine particulate matter (PM_{2.5}) and nitrogen dioxide (NO₂) and an increased risk of depression.[6].

Studies from India have explored the intersection of climate change and mental health. A study conducted in the Sundarbans Delta, India, explored the intersection of eco-psychiatry and environmental conservation. The study included 178 individuals attending community mental health clinics. In them, the prevalence of various mental morbidity is higher than the national average of the NMHS (National Mental Health Survey) 2016. Findings showed that Major Depressive Disorder was the most common condition (14.6%), succeeded by Somatoform Pain Disorder (14%), PTSD related to animal attacks (9.6%), adjustment disorder (9%), and

self-harm attempts of 11.2%. [7]

A study in Kodagu district of Karnataka explored the prevalence of psychiatric symptoms among residents following a flood event. The findings indicated a high prevalence of psychiatric issues, with over two-thirds (66.7%) of residents experiencing symptoms. Depression emerged as the most common issue, affecting roughly one-third (33%) of the population. Anxiety disorders (31%) were also prevalent, followed by somatic disorders (28.7%), insomnia (35.7%), and substance abuse (15.8%). Notably, the study identified factors like displacement during the disaster and damage to homes as significant contributors to the development of psychiatric issues among these residents.[8].

Crop-damaging temperatures in India were associated with increased suicide rates, particularly during the primary agricultural growing season. The elevated temperatures during this period substantially elevated annual suicide rates. For temperatures surpassing 20°C, a 1°C rise in daily temperature correlates with an average of 67 additional deaths across India, equating to a 3.5% increase in the suicide rate per standard deviation of temperature increase. Over the last three decades, the warming climate has been linked to an estimated 59,300 farmer suicides in India, accounting for 6.8% of the overall increase in suicides.[9]

Approximately a year following a super-cyclone in Orissa, higher proportions of adolescents exhibited PTSD symptom[10]. Specifically, the prevalence of PTSD was 26.9%, major depression was 17.6%, and generalized anxiety disorder was 12%, surpassing the rates reported in the NMHS-2016. Additionally, the affected population experienced impaired performance in school, indicating the enduring impact on mental health and academic functioning.

In conclusion, the discussion surrounding climate change must expand beyond its ecological and

physical consequences to its profound effects on mental health. As this article has highlighted, climate change poses a wide array of mental health challenges. As temperatures rise and natural disasters become more frequent and severe, the mental health impacts ripple across societies, disrupting lives and livelihoods and affecting the marginalized communities the most.

However, amidst these challenges lies an opportunity for collective action. By acknowledging and addressing the mental health dimensions of climate change, policymakers can foster adaptive strategies that promote well-being and sustainability. Investing in mental health resources to better explore these phenomena, creating social support networks, building resilience, and improving community awareness can mitigate the adverse effects of climate change on mental health.

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Adolescents at the Forefront for Urban Climate and Health Resilience: The Lessons Learnt from Surat, India

Anuj Ghanekar¹ Dr Vikas Desai² Dr Pradip Umrigar³ Dr Ashish Naik⁴

□ Abstract

Cities in India are witnessing resilience initiatives to promote climate-smart and health-conscious development. On another front, cities are also envisioning the status of child-friendly cities by adopting a range of measures that prioritise the needs of children in urban planning and development. The “Resilient cities” and “Child-friendly cities” visions overlap with their long-term goals. Indian cities aim to create sustainable settlements that nurture and inspire children today so that they can grow to create and protect the city’s resilience in the future.

The authors of this paper facilitated two unique development sector projects pertaining to both of these visions, in Surat City of India. Based on the shared traits and complementary factors of the two projects, this paper suggests that adolescents (10-19 age group) can be focus points in developing climate-resilient health systems.

The four specific advocacy lessons for health systems in this regard were learnt: i) Health systems have a scope to identify the vulnerabilities of adolescents by utilizing multiple sources of evidence that overlap. ii) The health system can also locate and address contextual climate and health vulnerabilities in conjunction with adolescent issues. iii) The health system can consider high-priority focus areas to reduce the vulnerability iv) Adolescents’ potential can be explored to act as “change agents” in promoting climate and health resilience.

Currently, a separate policy for “climate and health resilience” or “adolescent health” is absent in India. The present research generated information “for policy” where the research audience will be stakeholders involved in policy planning and implementation.

Keywords: Adolescents, Child-Friendly Cities, Climate Change, Health System, Resilience, Surat city, Urban Health

Introduction

Cities in India are currently facing multiple climate and health challenges. (1-4) They are experiencing frequent and intense urban floods, cyclones, harsh winters, and heat waves, which have detrimental effects on municipal infrastructure, livelihoods, and the economic well-being of the cities. Climate change worsens urban issues such as air pollution, water scarcity, and social inequality, leading to greater health vulnerabilities with new and resurgent infections, changing patterns of vector and water-borne diseases, respiratory diseases, and heat-related illnesses on the rise. The situation is further complicated by socio-economic stressors like rampant urbanization, disruption of livelihoods, migration, family displacement, food insecurity, and unsafe neighbourhoods. India’s urban population is proliferating, with the National Commission on Population (NCP) predicting that by 2036, about 38.6% of Indians (600 million) will live in urban areas. (5)

Despite these challenges, several initiatives are being implemented to promote the climate-

smart and health-conscious development of cities. These include government activities under the National Program on Climate Change and Human Health (for example 6,7), and activities under Public Private Partnerships such as the “100 Resilient Cities” program. (8).

On the other front, urban administrators are also envisioning the status of child-friendly cities by adopting a range of measures that prioritise the needs of children in urban planning and development. For example, the Child-Friendly Smart Cities (CFSC) initiative within the urban agenda of building smart cities. (9) Such initiatives seek to create healthier and safer urban neighbourhoods for children including adolescents, considering the future of a nation.

The “Resilient cities” and “Child-friendly cities” visions overlap with their long-term goals. By focusing on the needs of children, Indian cities can create sustainable settlements that nurture and inspire children today so that they can grow to create and protect the city’s resilience in the future. This vision is also in alignment with the broader Sustainable Development Goal 11 which aims to make cities and human settlements inclusive, safe, resilient, and sustainable. (10). The present paper is based on the advocacy lessons learnt in this dual context.

The authors of this paper facilitated two unique research, training, and advocacy projects in Surat City India. The first project was the “Urban Health and Climate Resilience Centre,” which was conducted under the Asian Cities Climate Change Resilience Network (ACCCRN) initiative of the Rockefeller Foundation between 2013-2016 (11). The second project consisted of several initiatives with adolescents aged between 10 to 19 years, which were conducted under the “Child Friendly Smart City Knowledge Centre” umbrella initiative of Surat Municipal Corporation and UNICEF between 2016-2023.

Based on their shared traits and complementary

factors with two projects, this paper suggests that adolescents (10-19 age group) can play a key role in developing climate-resilient health systems. There are two main reasons for this argument. Firstly, urban adolescents are particularly vulnerable to the long-lasting impacts of climate change on health in their adulthood. Secondly, adolescents can be trained, empowered, and given opportunities to contribute significantly to building climate-resilient health systems. This is indeed an opportune time to do so, as urban health and climate resilience are new arenas for urban agenda in the nation. This paper also attempts to expand the understanding already generated on this topic by the organization in relevant academic contributions like (12-14).

2 Methodology

2.1 The setting

Both the UHCRCE projects were carried out in Surat, a coastal city located in the Gujarat state of India. The city is vulnerable to multiple climate and health stressors. According to the World Bank Sustainable Development Network, Surat is one of the cities most affected by climate change. (15) Surat has experienced river floods since 1914, with 25 floods recorded to date. Creek and urban flooding during monsoons are also common. As a coastal city, Surat faces the impacts of climate change such as increased temperature and humidity (16), urban heat island effects when combined with urbanization, and heat stress-associated health effects (17). With long summers, the city’s water requirements are rapidly increasing. The geographical and socio-demographic environment of Surat is conducive to vector breeding and vector-borne infections. Plague (1994) and leptospirosis (2006) have long-lasting footprints, as flood-linked health consequences.

Surat is recognized as the fourth fastest-growing

city globally (18), with a growth rate of 55.29% over the last decade. The city has a population density of 13,680 people per square km. From 1951 to 2011, the city's sprawl increased by 326 square km, with a buffer effect of neighbourhood village space, and the population grew by 4.1 million. Given that 30% of the city's population are migrants, with 60% of them residing in slums, Surat is known as a city of migrants. The migrant population have been settling in slums and informal settlements along the floodplain of the river since the 1950s, which makes them more vulnerable to health and climate impacts. As of 2018, the mid-census estimated total population of the city is 6,078,457, with around 37% of the population residing in slums and slum-like areas. According to the Family Health Survey of 2018, Surat has a total adolescent population of 646,459, which represents 10.6% of the total population.

2.2 Research question

With this background, the specific research question for this paper posed was: What lessons the health system in Surat can learn to develop climate and health resilience keeping adolescents as a focal point?

The research question is primarily explanatory in nature with implicit “Why” and “How” questions into it. In the research question, the term “health system” implied not just service providers or administrators but the community including adolescents, when viewed from a holistic perspective. The starting point for this research question assumes the positionality that the health system is a learning organization and is in the constant ongoing process of developing climate and health resilience. Currently, a separate policy for “climate and health resilience” or “adolescent health” is absent in India. The present paper intends to generate information “for policy” where the research audience will be stakeholders involved in policy planning and implementation.

2.3 Data analysis

For this paper, the existing data set was used to convince health systems about the utilisation of local data for local policy design. The same was complimented by findings derived from various studies and activities conducted under past UHCRCE projects (2013-2023). The project insights were organized into a matrix of activity, finding, and interpretation. The commonalities between the two sets of findings and interpretations (from both projects) were grouped into qualitative themes and sub-themes. These were ultimately described as the lessons learned in the given context, supported by relevant examples. Consensus coding was reached through the discussions between all the authors.

3 Findings and Discussion

The lessons for the health system to develop urban climate and health resilience can be categorized into two main themes if we prioritize adolescents. The first theme focuses on adolescents as a vulnerable population subgroup and highlights the role that the health system can play in attending to their needs. The recent national and state-level health programs like Rashtriya Kishor Swasthya Karyakram (RKSK) are also focusing on the needs of adolescents. (19) The second theme focuses on adolescents as valuable contributors to the health system, showcasing the various ways they can make a positive impact.

This section presents evidence supporting two themes, with the first three lessons under theme 1 and the fourth under theme 2.

Lesson 1 Health systems have a scope to identify the vulnerabilities of adolescents by utilizing multiple sources of evidence that overlap.

Although some primary and secondary studies conducted under UHCRCE projects belong to different timeframes, when combined, they provided a broad understanding of the vulnerabilities of adolescents.

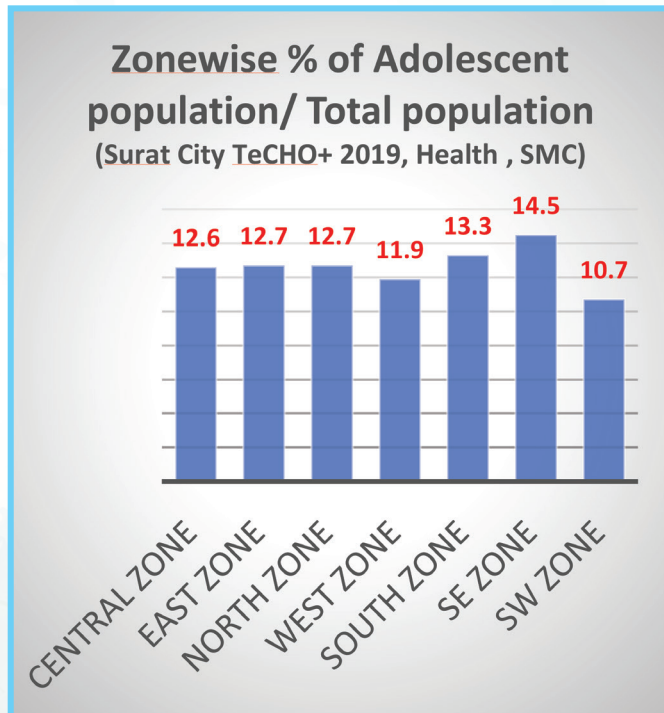


Fig. 1 The highest share of adolescents in the South and southeast zones ⁱⁱ

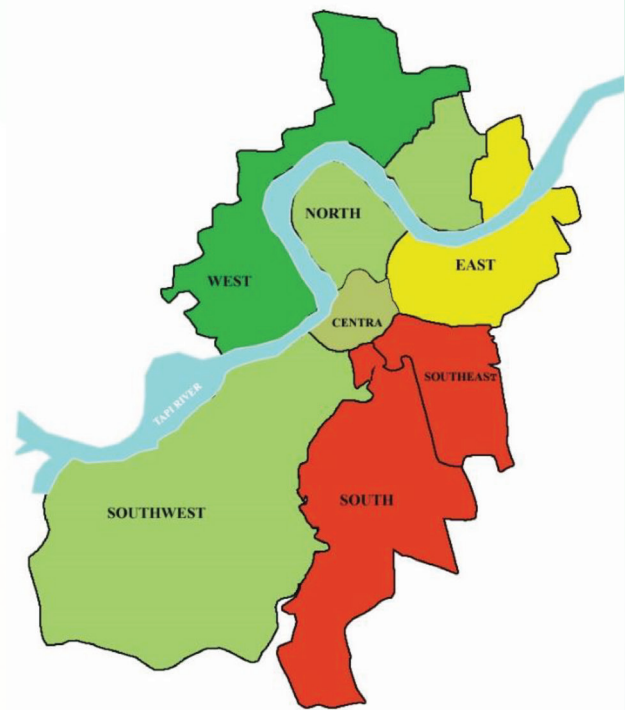


Fig. 2 Public health and climate vulnerability analysis by UHCRCE: Most vulnerable South & South East zones ⁱⁱⁱ

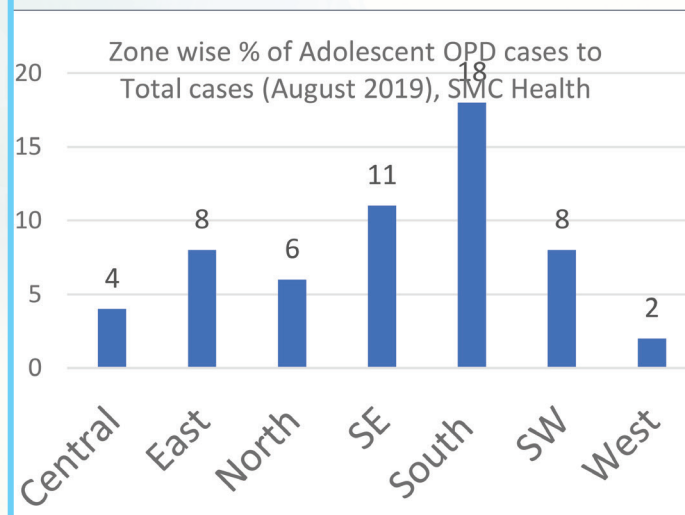


Fig. 3 Health burden study of adolescents: majority cases from South & South East zones ^{iv}

Intra-city variability (Highest record in Summer 2014)

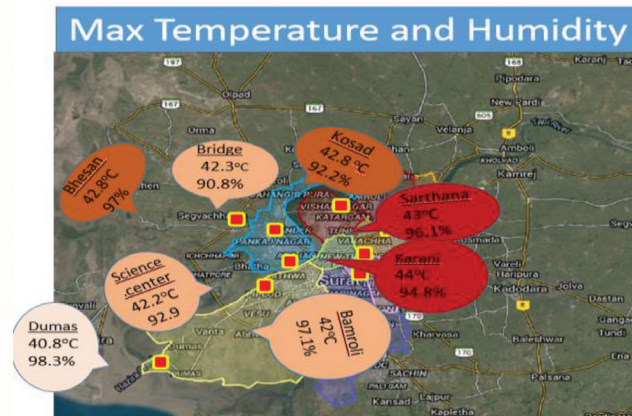


Fig. 4 Sample climate indicator as heat stress: Vulnerable South & Southeast zones (in red and orange weather stations) ^v

Surat City is mainly divided into seven administrative zones, which have recently been expanded. According to studies from UHCRCE, adolescents in the South and Southeast administrative zones are particularly vulnerable to climate as well as health concerns. These two zones have the highest number of adolescents in the city (as shown in Figure 1). The public health and climate vulnerability assessment revealed that these zones experience socio-demographic stressors, making them fall into the red category in general (as shown in Figure 2). Furthermore, the health burden among adolescents is also highest in these two zones, as indicated by their share of daily OPDs at the primary health centres (as shown in Figure 3). Climate indicators, like heat stress, put these zones in a vulnerable category due to reasons such as overcrowding, housing, the presence of industries, and the urban heat island effect (as shown in Figure 4).

South and Southeast zones is to be of priority if the health system intends to plan adolescent-specific actions. It is possible to create maps of climate and health risks for adolescents by combining age-segregated and spatial studies. Routine data analysis can be utilized during emergencies. The importance of evidence generation in climate and health resilience has already been highlighted in the literature. (2, 20)

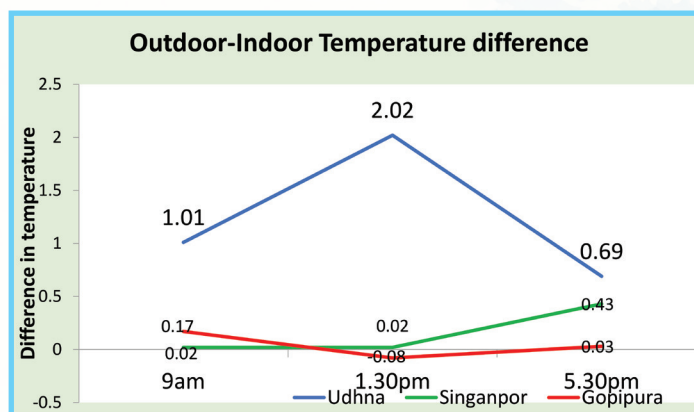
Lesson 2 The health system can also locate and address contextual climate and health vulnerabilities in conjunction with adolescent issues.

Urban adolescents, as a sub-group, are vulnerable to specific health risks that are unique to urban areas. These vulnerabilities are further exacerbated by the impacts of climate change. The “Children’s Charter of Demands (2018)”^{vi} process conducted throughout Surat compiled qualitative narratives by adolescents, demonstrating the human impact behind the statistical understanding of climate indicators.

For instance, 13-year-old Khushi from the low-income settlement of Southeast zone narrated her experience of the urban flooding:

“The uncertainty of rainfall has increased over the last few years, making floods more frequent. If there is drainage water stagnation, it’s even more problematic. Waterlogging makes our lives difficult for those few days. There is water everywhere, we are trapped in the house, unable to go to school or play. I am scared of waterlogging now when monsoon signs start.”

Such experiences of vulnerability can be different for different sub-groups within the adolescents. During interactions with out-of-school girls in the South zone, it was revealed that many drop out of school after 8th standard due to financial constraints (13). Parents often prevent them



from leaving the house due to an increase in gender-based harassment cases. As a result, the daily lives of these girls are limited to intra-domestic activities household chores, taking care of siblings, and watching television. This was the same geographical area where one of the UHCRCE climate studies^{vii} found high levels of intra-domestic discomfort, especially during afternoons as shown in Fig. 5. Taken together, these findings suggest that girls are one of the potential groups at risk of experiencing intra-domestic discomfort and the resulting health impacts.

Lesson 3 The health system can consider high-priority focus areas to reduce the vulnerability

Eight thematic workshops were held within two projects (2013-2023) involving 215 participants from various departments of urban local bodies, academic institutions within the city, and non-profit sector organizations. *(Some of the participants were common in workshops.)* During these workshops, stakeholders identified high-priority focus areas that are common for both “climate and health resilience” and “adolescent health” concerns. They also shared examples and UHCRCE also piloted some innovations, which can serve both agendas.

No.	Suggested focus area	Examples provided by stakeholders/ emerged during projects which apply to both agendas
1	Intersectoral coordination across the government departments	The education department working in collaboration with the Swachh Bharat Mission (Pan India Initiative for Cleanliness)
2	Urban local bodies actively work with the local academic ecosystem	Micro-scale evidence generation, identifying technological climate interventions, preparing a local team/ observatory for children-focused climate actions
3	Enhanced public-private partnership models	Private doctors contribute to child morbidity surveillance, contractors and urban planners contributing to child-friendly and climate-sensitive spaces, NGOs' role in disaster relief operations
4	Technology based innovations	Upgrading existing technology-based innovations like Urban Service Monitoring System (UrSMS) to capture adolescent health records as well as climate-induced health outcomes
5	Innovations in Education	Life skills education (LSE) integration with environment education: In 2018-19, a pilot model for LSE was demonstrated for children and adolescents in the context of climate change education. The model was executed as a joint action between schools, AWCs, health centres and NGOs in the most vulnerable zone of the city. The programme was implemented by creating a local pool of 30 master trainers and 170 teacher trainers. The programme impacted 5000 children. One of the components was- Relating abstract life skills with real-life climate change issues for children, for example, Decision-making for pre-monsoon flood preparedness, critical thinking for waste segregation and creative thinking (Fancy dress, posters) for climate change communication. More about this program can be read in (14)
6	Innovations in healthcare service provision	UHCRCE attempted some innovations in the Adolescent Responsive Healthcare Services Program like systematic holistic screening of adolescents who visit primary health centre OPD, exposure visit of adolescents to primary health centre for demand generation etc.

7	Capacity building of caregivers of adolescents	The caregivers like parents, families, and teachers are immediate contact points for the adolescents. The health system need to understand the importance of these stakeholders as “interconnecting links” when adolescents are to be reached for climate action. Some suggestions provided in this regard were: Systematic capacity building of caregivers with climate change-associated knowledge and skills, inter-generational dialogue between parents and adolescents, Social Behavior Change Communication (SBCC) strategies, supportive supervision of caregivers, and Promotion of traditional health and nutrition behaviour in the life-style.
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Lesson 4 Adolescents’ potential can be explored to act as “change agents” in promoting climate and health resilience.

It is unjust for adolescents to suffer the consequences of human-induced climate change caused by adults around them. Today’s adolescents will become tomorrow’s citizens, and their teenage years are a crucial time for promoting both healthy behaviour and climate action. This period presents a unique opportunity to instil a lifestyle that prioritizes climate and health resilience. Adolescents are in an emotional and energetic phase where they are receptive to appeals and are more likely to adopt new behaviours. By empowering and educating adolescents, we can create change-makers who will make a positive impact on society. Schools offer an ideal platform for reaching out to large numbers of adolescents, who are also tech-savvy. Therefore, including adolescents in efforts to promote climate and health resilience is a cost-effective approach.

Some experimental initiatives under two projects demonstrated this argument. For example, on the occasion of World Children’s Day 2018, CFSCKC released the “Children’s Charter of Demand”. The charter was prepared after 30 empirical participatory interactions with 450 children (the majority were adolescents). Adolescents were found to have a voice for climate and health resilience demands such as Better green spaces

that provide comfort during heat stress, Pollution monitoring and measures for cleanliness, Promotion of Rainwater harvesting systems, Flood Risk Management, Disaster warning systems, Systematic waste disposal, Water logging management and effective drainage systems.

Another example was the Climate Smart Healthy Children model^{viii} where the Peer education (adolescent buddies) approach was used in three schools. The peer educator in-school students imparted the knowledge, skills and attitudes of “climate and health resilience actions” to out-of-school adolescents in creative ways. The “Adolescent to Adolescent” model created more interest and dialogue among recipient peers. Heat stress, flood resilience, Malaria-dengue fight, action against swine-flu, insist on motorbike pooling, food safety, healthy diet practices, green Surat, saving electricity – such resilience messages were discussed, demonstrated and acted upon by youngsters. “Earth leaders” were formed in schools, who exhibited enthusiasm for monitoring the climate indicators like heat index and air pollution using technology-based applications. Making the program more inclusive, 55 Students from the School for Deaf and Mute Children, were trained on Environment

Monitoring Kit. They were involved in weather monitoring assembling toolkits, noting the readings, and learning about air pollution and heat stress. The entire workshop happened in sign language with the help of interpreters. Students actively shared about air pollution causes and impacts. They talked about health impacts like respiratory problems, sneezing, coughing, irritation of eyes, skin problems etc. The reasons listed by them included factory gases, coal burning, tree cutting, and vehicular pollution. Noise pollution with high decibel frequency was another concern raised by them. They also shared how they are differentially vulnerable to these problems because of hearing and speech disabilities



Fig. 6 Adolescents handing over "Children's Charter of Demands" to city officials



Fig. 7 Adolescents learning to monitor vector-borne disease control activities in school

There are many existing programs under the urban local body system which already view adolescents as change agents. Desk research and stakeholder consultations under both projects resulted mapping of some existing programs which can be viewed as an avenue for adolescents' participation in climate and health resilience.

S. No.	Policy/Program Name	Description of the existing role of adolescents
1	Rashtriya Kishor Swasthya Karyakram (RKSK)	Peer Educators who are expected to play a role in the Knowledge dissemination to fellow in and out-of-school peers on 6 RKSK themes, information regarding existing adolescent-friendly health services, facilitation of Adolescent Health days and participation in the Adolescent Friendly Club meetings.
2	Mamata Taruni Abhiyaan	Mamta Taruni Peer Educators in ICDS Anganwadi centres are adolescent girls who are supposed to educate and bring adolescent girls to the Mamta Taruni Anganwadi health and nutrition education sessions and health care facilities for treatment.
3	School Health & Wellness Programme	Health and Wellness Ambassadors: Students force is created with the help of teachers to educate about health and wellness-11 thematic areas.
4	Swachh Bharat Abhiyaan	Swachhta Ambassadors: Celebrities who are responsible for creating awareness, participating in events, and sensitizing the public)

5	Integrated Child Protection Scheme (ICPS)	Nodal Organizations: They are academic institutes that volunteer their resources to develop Child Line Services (1098). Child volunteers are recruited for awareness campaigns and assisting in project management. They also research issues related to child protection.
6	National Health Mission	Mahila Arogya Samiti (MAS) works to organize local collective action for Health promotion, health resource mapping, and monitoring and facilitating access to public services. MAS can take the help of adolescent girls in their work.

The existing role of adolescents in these programs can be expanded to incorporate a “climate change associated health” lens in their topics of discussion, communication, capacity-building agendas, syllabus, and overall approach.

4 Conclusion

Human health is under serious threat from climate change, which affects the spread and severity of diseases. Urban areas are especially vulnerable, as they vary in their climate conditions, social factors and health impacts. While long-term solutions are needed to reduce greenhouse gas emissions, short-term actions are also necessary to adapt to the changing climate and build resilience. Urban adolescents are a group that faces high risks from climate change but also have great potential to contribute to adaptation and resilience. This paper shares key lessons for urban health systems to develop climate and health resilience with a focus on adolescents, based on experiences from Surat city of India. These lessons can be useful for other city administrators and policymakers working on this subject.

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Promoting Advocacy and Partnership in India to Protect Human Health from Climate Change

Dr Ranjan Das, Dr Monalisha Sahu,

Abstract:

Climate change poses a significant threat to global public health, with vulnerable regions like India experiencing substantial impacts. India, with its vast population and diverse ecosystems, is particularly vulnerable to the adverse effects of shifting climate patterns. Advocacy serves as a powerful catalyst for policy change and increased awareness. Promoting advocacy and partnership in India is imperative in safeguarding human health from the escalating impacts of climate change. Through targeted advocacy efforts, these entities mobilize communities and influence policymakers, driving effective adaptation and mitigation strategies. Partnerships, both public and private, are equally crucial. Collaboration among stakeholders such as the government, health sector, civil society, media, and international organizations is essential. These partnerships facilitate the pooling of resources, knowledge, and expertise. They also aid in formulating and implementing robust policies and governance structures, as well as in strengthening health systems to better adapt to and mitigate the impacts of climate change. Within the health sector, advocacy and partnership assume critical roles. Advocating for health considerations across various sectors including energy, transport, agriculture, urban planning, and disaster management is essential. Additionally, the health sector must lead in strengthening the resilience of healthcare systems to cope with the evolving challenges

brought on by climate change. This includes implementing early warning systems for climate-sensitive diseases and preparing contingency plans for emergencies. In conclusion, promoting advocacy and partnership in India is pivotal in protecting human health from the adverse effects of climate change. By fostering collaboration among diverse stakeholders and advocating for health-centric policies, India can build a more resilient future, ensuring the well-being of its citizens in the face of this pressing global challenge.

Full Text

Climate change is one of the greatest threats to human health in the 21st century. Rising temperatures, extreme weather events, and altered disease dynamics pose significant threats to public health(1). It affects the social and environmental determinants of health, such as clean air, safe drinking water, food security and shelter(2). It also increases the risk of infectious diseases, heat stress, malnutrition, injuries and mental health problems. India is particularly vulnerable to the impacts of climate change due to its large population, high dependence on agriculture, diverse ecosystems and low adaptive-capacity(3). Rising temperatures, extreme weather events, and changing disease patterns have grave consequences for human well-being(3). To mitigate these effects, it is imperative to foster advocacy and forge partnerships in India.

□ Current Climate and Health Scenario in India:

India faces a mounting health crisis due to climate change. Heatwaves, floods, and droughts are becoming more frequent and severe. Diseases like malaria and dengue are spreading to new regions. Vulnerable populations, including those in coastal areas and urban slums, bear the brunt of these changes. Furthermore, strained healthcare systems struggle to cope with the escalating demands. While tourism is a crucial driver of economic growth and cultural exchange, it also exerts a significant impact on climate change. The travel industry, particularly aviation and accommodation, accounts for a substantial portion of global greenhouse gas emissions. Air travel, characterized by its reliance on fossil fuels, releases substantial amounts of carbon dioxide into the atmosphere. Furthermore, the construction and operation of hotels, resorts, and other tourism-related infrastructure can lead to deforestation, habitat degradation, and increased energy consumption. Additionally, the influx of tourists often places strain on local resources, leading to increased waste generation and higher energy demands. In ecologically sensitive regions, unregulated tourism can result in damage to fragile ecosystems and disruption of wildlife habitats. These collective factors emphasize the urgent need for sustainable tourism practices that minimize environmental impact while still providing meaningful experiences for travelers. To effectively address these challenges, it is crucial to implement advocacy and form partnerships in India.

□ The Role of Advocacy in Climate Change Mitigation to Protect Human Health:

Advocacy serves as a potent tool for driving climate policy changes and raising public awareness. It creates greater understanding of the climate risks to health which facilitates Socio behavioral change thereby improving health and reducing vulnerability(4). By

mobilizing communities and influencing policy makers, advocacy efforts can lead to effective adaptation and mitigation strategies. To protect human health from climate change, India needs to promote advocacy and partnership among various stakeholders, including the health sector, the government, the civil society, the media and the international community.

Advocacy and partnership can help to raise awareness, mobilize resources, strengthen policies and governance, enhance scientific evidence and support health systems to adapt and mitigate.

The health sector has a crucial role to play in advocacy and partnership for climate action in India(5). The health sector can:

- 1 Advocate for health in all policies and sectors, such as energy, transport, agriculture, urban planning and disaster management. The health sector can highlight the co-benefits of low-carbon development for health, such as reduced air pollution, improved physical activity and nutrition, and increased access to clean energy sources(6). The Climate Resilient Agriculture project stands as a testament to the potential impact of strategic collaborations. This joint endeavor between the Indian government and the World Bank aims to enhance agricultural practices for better climate resilience. By promoting water conservation techniques, drought-tolerant crops, and crop diversification, this project not only safeguards livelihoods but also fortifies communities against the agricultural disruptions wrought by climate change. Moreover, the Solar Electrification in Rural Health Centers initiative underscores the transformative power of decentralized, community-driven solutions. By providing renewable energy to remote health facilities, this initiative not only ensures consistent healthcare access but also exemplifies the dual benefits of sustainable energy adoption and improved public health outcomes. These

initiatives serve as illuminating models, illustrating how targeted interventions can address both climate vulnerabilities and public health needs in tandem.

2 Strengthen the resilience of health systems to cope with the current and future impacts of climate change(7). The health sector plays a pivotal role in safeguarding the well-being of the population and can strengthen climate resilience by:

- a) **Implementing Surveillance and Early Warning Systems:** The health sector would establish a robust surveillance system to monitor climate-sensitive diseases prevalent in the region, such as malaria, dengue, cholera, and heat-related illnesses. For instance, by utilizing advanced technology and data analytics, health authorities can track disease trends and identify potential outbreaks well in advance.
- b) **Preparing Contingency Plans for Emergencies:** Recognizing the heightened risk of disasters like floods and cyclones, the health sector would formulate comprehensive contingency plans. These plans would outline step-by-step procedures for evacuations, provision of medical care in emergency shelters, and coordination with other response agencies. This could involve conducting regular drills to ensure efficient response during actual emergencies.
- c) **Enhancing Capacity of Health Workers and Facilities:** Training programs would be conducted for healthcare workers to equip them with the skills and knowledge needed to handle climate-related health challenges. This might include specialized training in treating injuries from extreme weather events, managing waterborne diseases after floods, and recognizing and addressing heat-related illnesses.

Additionally, health facilities would be equipped with necessary resources, such as medical supplies, backup power, and communication systems, to ensure uninterrupted healthcare delivery during adverse climate events.

In this way, the health sector's proactive measures not only directly protect the health of the population but also contribute to overall community resilience. By anticipating and preparing for climate-related health risks, the sector ensures that healthcare services remain accessible and effective even in the face of significant environmental challenges. This approach not only saves lives but also mitigates the long-term impact of climate change on public health (6).

3 Building Partnerships for Climate Health Resilience: Collaboration between various stakeholders is critical in addressing climate-related health challenges. Public-private partnerships, involving government agencies, non-profit organizations, and the private sector, have shown promising results. For instance, initiatives like the Climate Resilient Agriculture project, jointly undertaken by the Indian government and the World Bank, aim to enhance agricultural practices for better climate resilience(10). Partnership between government and civil society organizations to promote climate-resilient agriculture. Climate change is already having a negative impact on agriculture in India, which is a major source of employment and income for the rural population. It is important to build partnerships between government and civil society organizations to promote climate-resilient agricultural practices, such as water conservation techniques, drought-tolerant crops, and crop diversification. Partnership between businesses and academia to develop new technologies to protect human health from climate change. Businesses and academia can work together to develop new

technologies to protect human health from climate change. For example, they could develop new vaccines and treatments for climate-sensitive diseases, or develop new air purification technologies to reduce air pollution.

4 Strengthen the regulatory, monitoring and stewardship roles of the environmental and social determinants of health. The health sector can enforce standards and regulations for environmental quality, such as air quality, water quality and waste management. The health sector can also monitor and report on the health impacts of climate change and the effectiveness of interventions(5). The health sector can also advocate for the protection of vulnerable groups, such as women, children, elderly and indigenous people.

5 Catalyze multisectoral interventions and mobilize support for health and climate action. The health sector can collaborate with other sectors and stakeholders to implement integrated solutions that address both climate change and health issues(8). For example, the health sector can partner with the energy sector to promote renewable energy sources that reduce greenhouse gas emissions and improve air quality(9). The health sector can also partner with the media to disseminate information and raise awareness on climate change and health among the public. The health sector can also partner with the international community to access financial and technical assistance for climate action.

6 Policy Frameworks and Regulations: India's National Action Plan on Climate Change (NAPCC) provides a comprehensive framework for addressing climate impacts(11). However, there is a need for stricter enforcement and targeted policies focusing on health. By integrating health considerations into climate policies, India can effectively safeguard its population from climate-related health risks. Advocacy for a national climate change adaptation plan that includes health.

India does not currently have a national climate change adaptation plan that specifically addresses health. It is important to advocate for the development and implementation of such a plan. The plan should include measures to reduce the health risks of climate change, such as strengthening early warning systems for extreme weather events, improving access to clean water and sanitation, and developing heat stress prevention programs.

7 Community Engagement and Grassroots Advocacy: Raising awareness of the health risks of climate change. Many people in India are not aware of the links between climate change and health. It is important to raise awareness of these links among the public, policymakers, and healthcare professionals. This can be done through public education campaigns, media outreach, and training programs. Empowering local communities is essential in building climate resilience. Projects like the Solar Electrification in Rural Health Centers initiative demonstrate the potential of decentralized, community-driven solutions(12). Additionally, educational campaigns and capacity-building programs can enhance climate awareness and preparedness at the grassroots level.

8 Technological Innovations and Climate-Resilient Healthcare: Innovative technologies play a crucial role in climate-resilient healthcare. Innovative technologies are integral to creating a healthcare system that is both resilient to climate challenges and environmentally sustainable. These technologies encompass a range of solutions that not only enhance healthcare delivery but also minimize the sector's environmental footprint. By incorporating green practices and leveraging cutting-edge tools, healthcare facilities can not only adapt to climate change but also lead the way in sustainable development (13).

a) Green Healthcare Infrastructure: Climate-resilient healthcare starts with the physical

infrastructure. Green building practices, such as the use of renewable materials, energy-efficient design, and eco-friendly construction methods, can significantly reduce a healthcare facility's environmental impact. For instance, the adoption of passive design principles, which optimize natural lighting and ventilation, can lead to substantial energy savings. Additionally, green roofs and rainwater harvesting systems can mitigate water runoff and contribute to local biodiversity.

- b) **Energy-Efficient Practices:** Implementing energy-efficient technologies is a cornerstone of climate-resilient healthcare. This includes the adoption of renewable energy sources, such as solar and wind power, to meet energy needs. Advanced HVAC systems with smart controls can optimize heating, cooling, and ventilation, minimizing energy consumption. Additionally, energy-efficient lighting, appliances, and equipment contribute to a more sustainable and cost-effective healthcare facility.
- c) **Telemedicine Solutions:** Telemedicine has emerged as a transformative technology, particularly in the context of climate resilience. By leveraging digital platforms and telecommunications, healthcare services can be delivered remotely, reducing the need for physical travel to healthcare facilities. This not only enhances accessibility, especially in remote or disaster-affected areas, but also mitigates the carbon footprint associated with transportation.
- d) **Health Information Technology (HIT):** Robust HIT systems play a critical role in climate-resilient healthcare. Electronic health records (EHRs) and digital health platforms streamline healthcare delivery, improve patient outcomes, and reduce

paper waste. Additionally, data analytics and predictive modeling can enhance disease surveillance and early warning systems for climate-sensitive illnesses.

- e) **Medical Waste Management Technologies:** Proper disposal of medical waste is essential for both public health and environmental protection. Advanced waste management technologies, including autoclaves, incinerators, and sterilization systems, ensure safe and environmentally responsible handling of healthcare waste.
- f) **Green Procurement Practices:** Climate-resilient healthcare extends to the procurement process. Adopting green purchasing practices involves selecting eco-friendly products, materials, and equipment. For instance, choosing energy-efficient medical devices and sourcing sustainable, low-impact supplies can significantly reduce the environmental footprint of healthcare operations.
- g) **Water Conservation and Management:** Implementing water-saving technologies, such as low-flow fixtures and efficient irrigation systems, can help healthcare facilities manage water resources more sustainably. Additionally, advanced water treatment technologies ensure the safety and purity of water supplies, particularly in regions vulnerable to waterborne diseases due to climate impacts.
- h) **Renewable Energy Integration:** Embracing renewable energy sources like solar panels, wind turbines, and geothermal systems not only reduces carbon emissions but also enhances the resilience of healthcare facilities. By generating on-site, reliable energy, healthcare facilities can maintain critical operations during power outages or disruptions caused by extreme weather events.

By harnessing these technological innovations, healthcare facilities can lead by example in climate-conscious development. Through green infrastructure, energy-efficient practices, telemedicine solutions, and other cutting-edge technologies, healthcare systems can become more resilient to climate impacts while simultaneously contributing to a sustainable and environmentally responsible future. These innovations not only enhance the quality of care but also demonstrate the potential for climate-resilient solutions across various sectors.

9 Financing Climate Health Initiatives:

Sustainable financing mechanisms are vital for implementing climate health projects. Implementing climate health projects requires sustainable and robust financing mechanisms. Without adequate funding, the ambitious goals of climate-resilient healthcare infrastructure and services may remain unrealized. India has a range of options to explore, each with its unique benefits and considerations.

- a) *Climate Funds:* Dedicated climate funds, both at the national and international levels, offer a significant source of financial support. These funds are specifically earmarked for initiatives aimed at combating climate change and its impacts. India can tap into existing climate funds, like the Green Climate Fund, which provides financial assistance to developing countries for climate-related projects. By aligning healthcare initiatives with climate goals, India can access these funds to bolster its climate health endeavors.
- b) *International Partnerships:* Collaborative efforts with international organizations, governments, and non-governmental entities provide another avenue for financial support. Bilateral or multilateral partnerships can facilitate knowledge

exchange, technical expertise, and, importantly, financial assistance. These partnerships can lead to joint funding arrangements for climate-resilient healthcare projects. For instance, India could work closely with international health organizations or donor countries to secure grants, concessional loans, or technical assistance for specific initiatives.

- c) *Private Sector Investments:* Engaging the private sector is instrumental in mobilizing additional resources for climate health projects. Private investors, including healthcare providers, pharmaceutical companies, and technology firms, have a vested interest in a healthy and sustainable future. Public-private partnerships can be established to leverage the financial capabilities, technical expertise, and innovation capacity of the private sector. For example, a private healthcare provider might invest in the development of climate-resilient healthcare facilities in exchange for a stake in the project or a share of the revenue generated.
- d) *Innovative Financing Models:* India can explore innovative financing models tailored to climate health initiatives. These could include green bonds, where investors fund projects with clear environmental benefits, or social impact bonds, which involve private investors providing upfront capital for projects and receiving returns based on the achievement of specified social and environmental outcomes. Such models align financial incentives with climate health goals, making them attractive to a range of investors.
- e) *Carbon Pricing and Taxation:* Implementing carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems, can generate revenue that can be earmarked for climate health initiatives.

By putting a price on carbon emissions, industries are incentivized to reduce their environmental impact. The revenue generated from these mechanisms can be channeled into healthcare projects that enhance resilience to climate change.

By diversifying its financing strategies and engaging multiple stakeholders, India can build a robust financial framework to support climate health initiatives. These efforts not only ensure the sustainability of healthcare services in the face of climate change but also stimulate economic growth and enhance overall public health outcomes. It's a strategic investment in a resilient and prosperous future for the nation.

10. Monitoring, Evaluation, and Reporting:

Establishing robust monitoring and evaluation mechanisms is crucial in assessing the effectiveness of climate health initiatives(14). Transparent reporting and accountability mechanisms ensure that resources are allocated efficiently and that progress is tracked effectively. Establishing robust monitoring and evaluation (M&E) mechanisms is paramount in ensuring the success and impact of climate health initiatives. This process involves systematic data collection, analysis, and assessment of the outcomes and effectiveness of projects and programs.

- a) **Comprehensive Data Collection:** A crucial first step in M&E is the collection of comprehensive and accurate data. This may include health indicators, climate-related data (such as temperature trends, extreme weather events, and disease patterns), as well as information on project implementation, resource utilization, and population health status. For example, in a climate-resilient healthcare initiative, data might be collected on the number of patients treated for climate-related illnesses, the

effectiveness of early warning systems, and the utilization of climate-adaptive technologies.

- b) **Performance Metrics and Benchmarks:** Clear performance metrics and benchmarks are established to measure progress and achievement against predefined goals and targets. These metrics should be specific, measurable, achievable, relevant, and time-bound (SMART) to provide a clear framework for assessment. For instance, a climate health initiative might aim to reduce the incidence of heat-related illnesses by a certain percentage over a specified period.
- c) **Impact Assessment:** M&E efforts should go beyond outputs and activities to assess the actual impact on public health and climate resilience. This involves evaluating changes in health outcomes, such as reductions in climate-related diseases or improvements in community health preparedness. It also includes assessing the overall resilience of healthcare systems in the face of climate challenges.
- d) **Stakeholder Engagement:** Engaging stakeholders, including communities, healthcare providers, policymakers, and experts, is vital in ensuring a comprehensive and accurate assessment. Their input provides valuable insights into the ground-level realities and the effectiveness of interventions. This can be achieved through surveys, focus group discussions, and consultations.
- e) **Transparent Reporting and Accountability:** Transparent reporting mechanisms are established to communicate findings and progress to relevant stakeholders. This includes regular updates, progress reports, and, where applicable, public disclosures. Additionally, accountability mechanisms hold responsible parties to

task for achieving stated objectives and efficiently allocating resources.

- f) **Iterative Learning and Adaptation:** The M&E process is not static; it allows for learning and adaptation. Findings from evaluations inform decision-making, allowing for adjustments in strategies, resource allocation, and implementation approaches. This iterative process ensures that initiatives remain responsive to changing circumstances and emerging challenges.
- g) **Knowledge Sharing and Best Practices:** The insights gained from M&E activities should be shared both within the organization and with the wider community. Documenting and disseminating best practices, lessons learned, and successful strategies can inform future initiatives and contribute to the broader body of knowledge in climate health resilience.

By establishing a rigorous M&E framework, climate health initiatives can be continuously assessed for their impact, allowing for evidence-based decision-making and the

refinement of strategies to ensure the most effective allocation of resources. This transparency and accountability ultimately lead to more resilient and sustainable healthcare systems in the face of climate change.

In conclusion, advocacy and partnership are essential for protecting human health from climate change in India. The health sector has a vital role to play in this process by advocating for health in all policies and sectors, strengthening the resilience of health systems, strengthening the regulatory, monitoring and stewardship roles of the environmental and social determinants of health, and catalyzing multisectoral interventions and mobilizing support for health and climate action. By promoting advocacy and partnership, India can build a more resilient future for its people and protect human health from the impacts of climate change.



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Towards healthy public policy for heat health: Making a case for a paradigm shift

Rajib Dasgupta

Abstract

Policies around heat health in India have evolved rapidly over the last decade and the National Programme on Climate Change and Human Health has emerged as a flagship programme. Management of heat related illnesses, a continuum from mild symptoms to fatalities, involve collaboration across multiple agencies. The prerogative of preventing mortality has led to an acute response in the disaster framework. Recognising heat health as a slow disaster or a long complex crisis, there is a need to evolve to more decentralised and community-centric approach.

India has taken several important and constructive steps over the last decade and the National Programme on Climate Change and Human Health (NPCCHH) has emerged as a flagship health programme on climate change and health.¹ The case of heat health, pursued with the NPCCHH is a case in point.

It is important to recount a brief history of the evolution.² Responding to the challenges in connection with climate change, the Government of India launched the National Action Plan for Climate Change (NAPCC) in 2008 to mitigate and adapt to the adverse impacts. Four new Missions were subsequently introduced in 2015: promoting wind energy, building preparedness to deal with impacts on human health, more effective management of coastal resources and harnessing energy from waste. The National Action Plan for Climate Change and Human Health (NAPCCHH) was thus prepared in 2018.

The overarching goal is to reduce morbidity, mortality, injuries, and health vulnerability due to climate variability and extreme weathers and the core objective is to strengthen health care services against adverse impact of climate change on health. The conceptualisation on heat related illnesses (HRI) rightly identifies that the outcomes can be both a direct effect of exposure to heat or a worsening of underlying respiratory, cardiovascular, and renal morbidities. It was thus explicitly stated that HRIs constitute a continuum from mild symptoms to fatalities.

As with all intersections of climate change and health, heat health entails the collaboration and synergy of two streams – the meteorological and the public health including medical care. In the Indian context however, the National Disaster Management Authority (NDMA) is the nodal agency for heat risk reduction and have been tasked with preparing heat action plans. The Ministry of Health and Family Welfare (MoH&FW) is the nodal agency for the health aspects of heat wave and preparing guidelines on prevention and management of heat related illnesses and the National Centre for Disease Control (NCDC) is the implementation agency.

Heat Index is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature. The India Meteorological Department (IMD) and the National Disaster Management Authority (NDMA) jointly issue colour code impact-based heat warnings. The Indian classification was introduced experimentally on 20 July 2023: Green (Heat Index less than 35 degrees Celsius), normal day; Yellow Alert (36 to 45 degrees Celsius), heat

alert; Orange Alert (46 to 55 degrees Celsius), severe heat alert for the day; to, Red Alert (higher than 55 degrees Celsius), extreme heat alert for the day.³ It was revised to higher temperature categories on 4 April 2024: Green (less than 40 degrees Celsius); Yellow (40 to 50 degrees Celsius); Orange (50 to 60 degrees Celsius); and, Red (higher than 60 degrees Celsius).⁴

Interestingly, at about the same time, the US National Weather Service (NWS) and the Centers for Disease Control and Prevention (CDC) introduced a new category of heat risk on 22 April, Earth Day – Magenta, a category above Red.⁵ It is a new online heat risk system that combines meteorological and medical risk factors with a seven-day forecast. It factors in three parameters: how unusual the heat is for the time of the year; the duration of the heat including both daytime and nighttime temperatures; and if those temperatures pose an elevated risk of heat-related impacts (based on data from the CDC). Magenta is categorised as ‘extreme’ - a level of rare and/or long-duration extreme heat with little to no overnight relief affects anyone without effective cooling and/or adequate hydration. The US Magenta begins at about 53 degrees Celsius and therefore corresponds to the Indian Red.

The NDMA has been assigned the role of the nodal agency for heat health (and for air pollution and health conditions), presumably for the associated risks of mortality. This has led to framing of policies and practice through an acute disaster management lens, from a standpoint of the precautionary principle. The notion of a health emergency inevitably leads to a response framework that is too immediate and the spotlight moves away from the gradual effects and impacts. The concept of slow disaster, a long complex crisis, has emerged from a more nuanced understanding of the COVID-19 response and may help build a more sensitive climate resilient health system that India needs.⁶ Magenta of the NWS-CDC classification characteristically deals

with “long-duration heat” rather than a single day’s temperature, and that is a refinement India may need to consider.

Heat health response plans in India have not yet factored in the social determinants of vulnerability to heat. Recent sensitive analyses have revealed higher ambient temperatures among communities and neighbourhoods that have lower income and are under-resourced, including densely populated urban dwellings, housing characteristics, lack of access to air cooling or air conditioning.⁷ Vulnerable individuals living in these disproportionately hotter settings such as the elderly, infants and young children, pregnant women, those with chronic morbidities and outdoor workers are at higher risk for HRIs.

While national, state or city level plans provide overall guidance and lay down the foundations, the last-mile challenges lie in identifying and locating communities at high risk for heat-health hazards.⁸ Heat vulnerability is increasingly being mapped to construct micro-climatic zones by capturing indicators of environmental and sociodemographic characteristics associated with adverse health outcomes during extreme heat events. These are overlaid with vulnerability information obtained through health surveys, analysis of mortality data, chronic disease databases if available and records of ambulance calls.

The way forward is to make a paradigmatic shift shifting from the current disaster management approach to a more decentralised one. The National Health Mission (NHM) provides ample space through its planning and communitisation models that should leverage community-derived knowledge about practices among the most at-risk individuals and strengthen local health systems to effectively respond to heat health challenges.

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Climate Change and Human Health: Identifying Critical Research Gaps

Authors: Gauri S Mullerpattan¹, Sahana Nujella¹, Prakyath Ravindranath Hegde², Channaveerachari Naveen Kumar³

Affiliation:

1 Psychologist, GS-NIMHANS Mental Health Programme, National Institute of Mental health and Neurosciences, Bangalore.

2 Assistant Professor of Psychiatry, GS-NIMHANS Mental Health Programme, National Institute of Mental health and Neurosciences, Bangalore.

3 Professor of Psychiatry, Head Community Psychiatry at National Institute of Mental health and Neurosciences, Bangalore and the Officer In Charge of COE in Mental Health under the National Program of Climate Change and Human Health, Govt. of India.

Introduction:

Climate change significantly affects human health through increased exposure to extreme weather, changes in vector-borne disease distribution, and worsening air quality. Heatwaves, for example, exacerbate cardiovascular and respiratory conditions, especially in the elderly, while shifts in climate affect mosquito habitats, influencing the spread of diseases like malaria and dengue fever. Furthermore, climate-induced alterations in agriculture and water sources aggravate malnutrition and water-borne illnesses[1][2].

There are significant research gaps in our understanding of the health impacts of climate change, particularly regarding the long-term health consequences of climate-related events, diseases with lower prevalence, and specific population vulnerabilities. These gaps limit

our ability to develop effective strategies for adaptation and mitigation. Addressing these gaps is imperative to improve public health outcomes and policy guidance, thereby enhancing preparedness and resilience against climate change's health threats.

□ Identification of Research Gaps:

I. Emerging Health Threats:

Emerging health threats, such as the rise in vector-borne diseases and mental health issues, illustrate our evolving understanding of how climate change affects health. The migration of disease vectors to new regions poses significant risks for the spread of illnesses like Zika and Lyme disease. The relationship between climate variables and disease transmission highlights the need for comprehensive research to predict and manage future disease patterns[3]. Additionally, climate change's psychological impacts, including eco-anxiety and solastalgia, represent critical yet understudied areas. These conditions, driven by environmental degradation and loss, necessitate focused research to develop effective interventions and support systems[4][5].

II. Population-Specific Vulnerabilities:

Certain groups, including children, the elderly, and indigenous communities, face heightened risks from climate change due to socio-economic, geographic, and health-related factors. Children are particularly susceptible to malnutrition and heat-related illnesses, while extreme weather and temperature fluctuations may exacerbate the elderly's pre-existing conditions.[6] Indigenous communities,

whose livelihoods and cultures are closely tied to the environment, experience direct impacts on their well-being and traditions.[7] Additionally, individuals with pre-existing health conditions are at increased risk from polluted air and climate-induced psychological stress, underscoring the importance of targeted health policies and interventions. [8]

III. Long-Term Health Outcomes:

The chronic health conditions resulting from long-term exposure to air pollution and extreme temperatures are a significant concern for future generations. Pollution-linked respiratory and cardiovascular diseases, alongside mental health disorders, stemming from climate-related stress and disasters, illustrate the need for robust public health strategies.[9][10] Understanding these long-term outcomes is crucial for societal adaptation and resilience, emphasizing the need for improved air quality, urban design, and mental health support[11][12]

IV. Mitigation and Adaptation Strategies

Mitigation strategies aim to reduce greenhouse gas emissions, limiting climate change's pace and health impacts. Transitioning to renewable energy and promoting sustainable practices curbs emissions and offers immediate health benefits, such as reduced air pollution and enhanced physical activity[13]. Adaptation efforts focus on modifying infrastructure and policies to minimize unavoidable climate impacts. This includes strengthening healthcare, improving food and water security, and urban planning to mitigate heat effects. Such strategies, while addressing climate change, can also potentially improve public health outcomes, demonstrating the value of integration [14].

Conclusion

In conclusion, addressing the identified research gaps requires a collaborative, interdisciplinary effort encompassing climatology, health, and policy to navigate the health challenges of climate change effectively. The urgency of this task cannot be overstated, as accelerating climate change threatens global health and well-being. The concerted action supported by robust research and policy commitment is crucial for safeguarding populations and ensuring equitable health outcomes in the face of climate change's far-reaching effects.

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Emerging Concepts in Mental Health in the Context of Climate Change

Authors: Sahana Nujella¹, Gauri S Mullerpattan¹, Prakyath Ravindranath Hegde², Channaveerachari Naveen Kumar³

□ Affiliation:

- 1 Psychologist, GS-NIMHANS Mental Health Programme, National Institute of Mental health and Neurosciences, Bangalore.
- 2 Assistant Professor of Psychiatry, GS-NIMHANS Mental Health Programme, National Institute of Mental health and Neurosciences, Bangalore.
- 3 Professor of Psychiatry, Head Community Psychiatry at National Institute of Mental health and Neurosciences, Bangalore and the Officer In Charge of COE in Mental Health under the National Program of Climate Change and Human Health, Govt. of India.

Introduction:

The devastating sweep of climate change in recent years has highlighted the urgent need for climate action. Beyond the evident impacts on infrastructure, economy and physical health, climate change has implications for the mental well-being of individuals and communities. Direct impacts of climate change may result from abruptly occurring extreme weather events like floods or gradual environmental changes like a rise in temperature and changing rainfall patterns. These mental health effects include distress as well as clinical disorders like depression, anxiety, post-traumatic stress disorder (PTSD), substance abuse, increased risk of suicide, and self-harm, among others. Further, climate change is known to have detrimental effects on prenatal and child development that may result in neural deficits and genetic mental disorders. However, it is important to recognize that mental health implications are not restricted to those who directly experience floods or other forms of climate change; it can also result from a sense of connection to the environment and the mere awareness and anticipation of the scale and impact of climate change. Albrecht (2005) noted that changes in the ecosystem and a changing relationship with one's environment are likely to produce stress in humans and termed the range of mental health impacts/syndromes as psychoterratic syndromes. [1] Today, the emotions or mental states one experiences in response to the degradation of the environment have broadly been termed "ecological emotions" or simply "eco-emotions", which comprise experiences of eco-anxiety, ecological grief, solastalgia, eco-guilt and many others.

Some of the commonly discussed concepts are discussed below:

I. Eco-anxiety:

Eco-anxiety, a psychological phenomenon increasingly prevalent in the face of climate change, manifests as distress, fear, and apprehension regarding environmental degradation and its consequences[2]. This anxiety-like response is rooted in the awareness of the enormity of ecological threats and the anticipation of adverse outcomes, reflecting a future orientation of worry and a broader societal unease about the rapidly changing climate[3].

Kurth and Pinkala (2022) conceptualize eco-anxiety as a spectrum of a range of emotions brought and not simply that of typically defined anxiety[4]. Individuals experiencing eco-anxiety harbour a combination of existential, social, and practical anxiety, indicating the pervasive impact on the person's well-being. The broader focus of the literature lies in the nearly pathological and sporadic instances of eco-anxiety, where high levels can result in pathological outcomes like sleep disturbance, rumination, and other features of diagnosable conditions.

More recently, several researchers have noted that eco-anxiety can be a continuous experience that may not always manifest as a pathology and may even be considered a normal response to the ongoing crisis[5][6]. Such an experience can stem from being confronted with unexpected, difficult choices or practical anxiety[4]. While eco-anxiety can lead to feelings of paralysis and disengagement in response to the perceived magnitude of the environmental crisis[2], it may spur individuals to adopt pro-environmental behaviours and advocate for climate action.

II. Solastalgia

Solastalgia, a term coined by Glenn Albrecht in 2005, describes a deep and persistent distress experienced by individuals due to the gradual loss or degradation of their cherished environment or home [1]. The distress is caused by the lived experience of the physical degradation of one's home environment and territory, whether due to climate change consequences, natural events, or human activities. The word originates in the concepts of nostalgia, solace, and desolation. Research by Doherty and Clayton (2011) further explores the psychological impact of solastalgia, highlighting its existential consequences. Unlike nostalgia, where there may be a longing for a past home or environment, solastalgia occurs when the home still exists, but its comforting qualities are diminishing. This existential distress arises from the fading sense of belonging and identity associated with the home environment [7].

While both solastalgia and eco-anxiety involve emotional responses to environmental changes, solastalgia is rooted in the tangible loss of a familiar environment. In contrast, eco-anxiety is characterized by worry and apprehension about the potential consequences of environmental degradation.

III. Ecological Grief

Ecological grief, as conceptualized by Cunsolo and Ellis (2018), refers to the profound emotional response elicited by the anticipated or experienced loss of significant environments, ecosystems, and species due to climate change. This grief can arise from both chronic and acute environmental changes, encompassing various forms of loss. One aspect of ecological grief stems from landscapes and ecosystems' physical deterioration or disappearance, representing a tangible and visible loss [8]. Additionally, the loss of personal and cultural identities intertwined with specific environments can evoke grief, as individuals may mourn the erosion of their connections to these places[9]. Moreover, ecological grief may arise from anticipating future losses, including the potential destruction of ecosystems essential for livelihoods and well-being. These multifaceted experiences of loss contribute to the complex emotional landscape of ecological grief, highlighting the interconnectedness between humans and the natural world. As individuals grapple with the reality of environmental degradation and biodiversity loss, the emotional toll of ecological grief underscores the urgent need for action to address climate change and protect ecosystems for future generations.

❑ Intervention

Numerous mental health experts advocate for heightened awareness and training concerning eco-anxiety[10]. Despite the growing need for therapeutic assistance and the recognition that climate change will increasingly impact collective consciousness, there needs to be more literature addressing tailored therapeutic interventions for eco-anxiety. Some professionals and support groups are now providing treatment for those with eco-anxiety and related experiences. They focus on fostering resilience through cognitive, existential, emotion-focused, and self-care interventions[11]. Additionally, helping clients strengthen social connections through support groups, encouraging climate action, and connecting with nature have been identified as therapeutic measures to be implemented. Existing literature thus strongly advocates for increased awareness and implementation of targeted approaches among mental health practitioners and other stakeholders in these times of need.

❑ Future Directions

To effectively address the mental health implications of climate change, stakeholders must prioritize the development and implementation of evidence-based interventions tailored to individuals experiencing eco-anxiety, solastalgia, and ecological grief. This requires investment in research to understand the underlying mechanisms of these phenomena better and identify effective therapeutic modalities. Policymakers must integrate mental health considerations into climate change policies, allocating resources for mental health services and programs aimed at building resilience and fostering community support networks. Additionally, prioritizing climate justice and equity is essential to ensure that vulnerable populations disproportionately affected by climate change receive adequate mental health support. Community stakeholders should collaborate to create safe spaces for individuals to express their eco-emotions, access mental health resources, and participate in collective action. By empowering communities and fostering collaboration across sectors, stakeholders can pave the way for a more resilient and mentally healthy future in the face of environmental uncertainty.

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Heat Health Action Plans: Lessons from Ahmedabad

By Dr Dileep Mavalankar 1, Dr Vijay S. Limaye 2, Abhiyant Tiwari 3, Dr Tejas Shah 4.

1. History of Heatwave in India and Ahmedabad.

Ahmedabad is a 600 year old city in the western part of India. It is the main economic centre of state of Gujarat. Its population is about 7 million. Summer in Ahmedabad is from April to June. Ahmedabad city has been historically one of the very hot cities of India where summer temperatures regularly go up to 44 or 45 °C. As the city is fairly away from main Arabian sea hence the summer months are hot and dry. Temperatures peak in third or fourth week of May. From June temperatures start declining with increasing humidity due to south-west monsoon which sets in by third or fourth week of June in Ahmedabad. Ahmedabad's weather station is located at the Ahmedabad airport campus, and it has weather records available for more than one hundred years.

Every 2-3 years Ahmedabad faces high temperatures crossing 45 °C and heat waves. Over the years the hot days have increased and the temperature has been going up gradually with milder winters and hotter summers. In 2010 a major heat wave struck Ahmedabad with temperature reached 46.8 °C on 21st May which was a record. On 27th May 2016 another major heat wave was recorded in Ahmedabad with temperature reaching 47.8 °C which was highest in 100 years¹. On 11th May 2022 Ahmedabad recorded temperature of 45.8 °C. And from 1st April 2022 to 12 May Ahmedabad continuously recorded maximum temperature of 40 °C or above for almost consecutive 40 years except one day². India Meteorological Department (IMD) data shows that temperatures are going

up in Gujarat with less cold waves and more heat waves³. Such increase in heat waves is seen world over due to climate change. Many parts of India are also recording increasing temperatures over the years with increasing frequency of heat waves. After major heat wave in Chicago in 1995 and heat wave in Europe in 2003, USA and many European countries developed heat action plans to protect the population from heat wave related health damage and mortality. These plans have been effective in reducing mortality over the years during heat waves.

2. Heat wave of 2010 and sharp rise in mortality in Ahmedabad

Ahmedabad's experience with extreme heat resulted in devastating health consequences for city residents in May 2010. During that period, daily maximum temperatures peaked at 46.8 °C, a temperature recording not observed in the city in nearly a century⁴. In 2010 India Meteorological Department (IMD) designated multiple days as heatwaves (April 17–18 and May 13–15, 17, and 20–25). IMD criteria call for a heatwave declaration when the daily maximum temperature registers 5 °C over a long-term (30 year) maximum temperature average of less than 40°C; or an excess daily maximum temperature of 4 °C over the long-term historical maximum temperature of more than 40 °C. On days when the actual daily maximum temperature registers above 45 °C, a heat wave is declared regardless of the normal historical maximum temperature⁵.

Our team of researchers investigated the human health consequences of this event through a study estimating excess mortality (the number of “extra” daily deaths observed in the city during

the heatwave months in 2010, comparing daily mortality counts to the same months in prior year -2009 and subsequent year -2011, when such high temperatures were not recorded). This study was published in 2014⁴. This method allows for partial adjustment of potentially confounding seasonal factors (e.g., air pollution levels) that might also influence all-cause mortality within the city, with the aim of better isolating the effect of excess temperatures on health effects. The Ahmedabad Municipal Corporation (AMC) Office of the Registrar of Births and Death provided data on total daily mortality counts for the heatwave year (2010) and two adjoining years (2009 and 2011), when the city recorded somewhat lower temperatures (1.76 °C lower daily maximum temperature and 1.26°C lower mean temperature) enabling our team to calculate expected mortality counts (an average of 2009 and 2011) and observed mortality counts (2010) over a 7-day moving average during the month of May when the most heatwave days were declared in 2010. The authors accessed daily temperature data from IMD Meteorological Aerodrome Report (METAR) station at Ahmedabad airport. Overall, the study estimated an average of 143.9 ($\pm$ 48.13) daily deaths during May 2010, compared to an average of 100.58 ($\pm$ 10.34) daily deaths observed in 2009 and 2011. On a monthly basis, the analysis estimated 1,344 excess deaths in May 2010 compared to the non-heatwave years, a 43% increase in the observed mortality count. For this analysis, women were observed to have higher daily mortality rates than men, a disparity that was especially wide when the analysis was restricted to the heatwave period (May 19-25). Such information is important when considering the health and economic burdens on women in South Asia linked to worsening extreme heat exposures⁶. While data limitations prevented the authors from analysing patterns in cause-specific mortality, as well as specific heat-mortality relationships for vulnerable subpopulations (e.g., people living in informal slum dwellings

or people suffering from chronic disease), this study was important in that it marked the first documentation of heat-mortality relationships in an Indian and south Asian city. The analysis conducted by Azhar et al. (2014)⁴ is important in demonstrating that, even while populations in Ahmedabad and other South Asian cities typically experience elevated temperatures during the heat season and some adaptive measures to that exposure are in place, extreme heat still poses a significant threat to human health. In light of the evidence demonstrating higher mortality during extreme heat events and the scientific consensus that climate change is increasing temperatures across South Asia⁷, increased attention to extreme heat adaptation strategies is urgently needed across the region.

3. Development of Ahmedabad heat action plan – process and improvements

The devastating daily mortality rise in May 2010 documented by the above mentioned study was an eye opener for the city authorities and worked as a driver for the authorities to set up a system to protect its citizens from any such extreme heat events in future. After the 2010 heat wave, despite the lack of a national policy on extreme heat that time, Ahmedabad city leaders wanted to prepare for the growing threat of rising heat which became the genesis of Ahmedabad Heat Action Plan (HAP). The Ahmedabad Municipal Corporation (AMC) collaborated with the knowledge partners like Indian Institute of Public Health-Gandhinagar (IIPHG), the Public Health Foundation of India (PHFI), and the Natural Resources Defense Council (NRDC) to prepare a plan for the city to deal with the threat of rising extreme heat. This coalition, loosely called Ahmedabad Heat Action Study Group, carried out a series of activities between year 2011 to 2013 such as organizing a stakeholder meeting, analysing temperature and death data, vulnerability surveys, focused group discussions, training workshops of healthcare providers, and

development of forecasting system in for heat waves. All these activities culminated in formation of first HAP for Ahmedabad city. This was launched by the Mayor and the Commissioner of the city in April of year 2013⁸. This event was substantially covered in local media.

The first Ahmedabad HAP included local tailor-made solutions to help citizens and vulnerable communities adapt with rising heat under three key strategies. We reproduce the key strategies as described in that document:

- ***Building Public Awareness and Community Outreach*** to communicate the risks of heat waves and implement practices to prevent heat-related deaths and illnesses. Disseminating public messages on how to protect people against extreme heat through media outlets and orientation materials, such as pamphlets and advertisements on heat stress prevention. Use text messages, email, radio and social media, such as WhatsApp. Special efforts to be made to reach vulnerable populations through inter-personal communication from March to June annually.
- ***Initiating an Early Warning System and Inter-Agency Coordination*** to alert residents of predicted extreme temperatures. The AMC has created formal communication channels to alert government agencies, health officials and hospitals, emergency responders, local community groups, and media outlets of extreme temperatures forecasted by the Indian Meteorological Department's (IMD) Meteorological Centre located in Ahmedabad.
- ***Capacity Building Among Health Care Professionals*** to recognize and respond to heat-related illnesses, particularly during extreme heat events. Such trainings focus

on medical officers of urban health centres, paramedical staff, and community health staff so that these experts can effectively prevent and manage heat-related cases and reduce mortality and morbidity.

The plan was periodically evaluated⁹ in order to update it regularly and eventually a newer fourth strategy was also added in the Ahmedabad HAP in year 2015¹⁰ which is ***Reducing Heat Exposure and Promoting Adaptive Measures*** by launching new efforts including mapping of high-risk areas of the city, increasing outreach and communication on prevention methods, access to potable drinking water and cooling spaces during extreme heat days. Collaboration with non-governmental organizations is also identified as a means to expand outreach and communication with the city's most at-risk communities, and a draft city-wide Cool Roofs Program. The citywide Cool Roof Program includes mandatory, voluntary, and low-income housing focused measures.

4. Impact of heat action plan and lives saved in Ahmedabad

Any plan to deal with impact of heat waves on health should be evaluated for its effectiveness. Such as study was carried out on the effectiveness of Ahmedabad HAP in 2017. Results from this preliminary study published by Hess et al. (2018)¹¹ indicates that the plan has already helped the city to achieve meaningful reductions in health impacts. In that study, researchers sought to quantify how mortality changed in the city when the HAP was launched in 2013 by comparing a pre-HAP implementation period (2007-2010) to post-HAP years (2014-2015). To estimate those changes, the team obtained daily all-cause mortality counts from AMC and developed estimates of how the city's total population changed over time to calculate daily mortality rates in post HAP period. By accounting

for population growth between the pre- and post-HAP implementation periods, a change from 4.64 million in 2007 to 6.71 million in 2015, the researchers were able to adjust for an increasing denominator population and account for any changes in mortality patterns that might be linked to a change in city population. To explore health effects by level of extreme heat observed in the city, the researchers categorized METAR maximum temperature data by days with any IMD-triggered heat alert (forecasted maximum daily temperature above 40 °C), as well as specific IMD heat alert threshold levels: yellow (daily maximum temperature forecast of 41-43.4 °C), orange (daily maximum temperature forecast of 43.5-45 °C), and red (daily maximum temperature forecast >45 °C) .

The analysis found that overall, the city's all-cause mortality rate was lower during the post-HAP implementation period compared to the pre-HAP period. Specifically, the study estimated 1,190 (95% CI: 162-2,218) avoided deaths annually in the city after the HAP was implemented, compared to the years before HAP implementation. Importantly, the highest proportion of those aggregate health benefits (650 avoided deaths, 95% CI: -208, 1508) were observed on the hottest (red warning) days, with successively lower proportions on days with slightly cooler temperatures (336 avoided deaths on orange warning days, 95% CI: 240-443 and 203 avoided deaths, 95% CI: 130-277 on yellow warning days). The authors also noted that this finding depended on the inclusion of data from 2010, an especially hot pre-HAP implementation year, because there were relatively few very hot days in the pre-HAP period from which exposure-mortality associations could be derived. The authors acknowledged that non-HAP related heat adaptation (e.g., including improving natural population resilience to extreme heat, increasing utilization of air conditioning, or changes in exposures to outdoor temperatures etc.) may have also contributed to the estimated health

benefits. Hence further studies are needed to see the benefits of HAP.

While the health benefits of heat adaptation plans have been evaluated in a handful of other settings, including the United States^{12,13} and Canada¹⁴, this analysis represents the first estimation of those benefits in India. Now that the city's HAP has been in place for a decade, city leaders are interested in understanding which components of the plan (e.g., delivery of heat forecasts, public communication of the warnings, provision of water stations, and preparedness in healthcare settings) are especially effective in achieving health benefits¹⁵ and how such interventions might be further strengthened to reach vulnerable groups. Further analysis of health, demographic, and environmental data in the city can help to provide more precise information on the efficacy of HAP interventions and a path forward for continued refinement and improvement of the city's heat preparedness and response efforts.

5. Scaling up of the Ahmedabad HAP via NDMA and other agencies.

Authorities at the local, state, and national levels in India continue to draw learnings from the Ahmedabad HAP as they step up the deployment of local extreme heat warning systems and preparedness plans. Organizations like NRDC and PHFI-IIPHG are collaborating to support the development and execution of HAPs. In India, preparation for and response to heat waves are coordinated by the National Disaster Management Authority (NDMA)¹⁶. They are supported by the heat predications of IMD. In order to create heat response plans, NDMA and IMD have been collaborating with 23 of India's 28 states recognized as heatwave prone states. After substantial evidence generated by Ahmedabad HAP related studies and discussion with Ahmedabad team the NDMA recognised

heat waves as natural disaster and took lead to develop heat action plans in the whole country. The first heat action plan guidelines were released in 2016 by NDMA based on Ahmedabad HAP. Since 2017 NDMA has been organizing yearly pre-summer workshops at the national and regional level with important stakeholders, including state and city administrators, state disaster management authorities, academic institutions, and civil society organizations that are actively involved in extreme heat planning and response in India. In 2019, NDMA amended its “National Guidelines for preparation of action plan – Prevention and Management of Heat Wave”, which serve as a guide for state and local governments in developing HAPs. The amended guidelines put a new emphasis on the role of the built environment such as cool roofs for example which provide a simple and cost-effective solution by improving indoor thermal comfort and reducing energy demand for indoor cooling. Now many states and cities in India have HAPs, even though its implementation remains variable.

6. Lessons from Ahmedabad HAP

Ahmedabad Heat Action Plan (AHAP) is pioneering plan in south Asia with focus on one city and was based on analysis of temperature and mortality. It has been implemented since 2013 continuously every year with assessment each year following the heat seasons. The plan is implemented by Ahmedabad Municipal Corporation with technical support from IIPHG and NRDC. In the process of implementation support and review of the plan over ten years we have observed various lessons for the success of the plan. Here we present some of the key lessons.

1. Need for appointing a Nodal officer for Heat action Plan work by the city government. Ahmedabad city appointed a deputy health officer as nodal officer for

heat action planning. Dr Tejas Shah has been working on the heat action plans of Ahmedabad as nodal officer since 2013 consistently. His main job is to receive the temperature predictions and alert the various departments and agencies as well as media of impending heat waves. This is one of his additional responsibilities as Deputy Health officer. AMC has entrusted this work to Dr Tejas continuously without any change over last 10 years. This helped built up expertise in the officer and develop contact with other stakeholders which helps in better implementation of the program. This is a very crucial lesson which other cities and state wanting to implement HAP should follow. The person chosen as nodal officer should be active and dedicated to it.

2. Using Local available health and temperature data: This data was used from Ahmedabad for calculating correlation between temperature and mortality to show the impact of extreme heat on health. Ahmedabad Municipal corporation officers and elected representatives got convince of heat action plan's need because using local data of daily mortality and temperature we could show that there were 800 additional deaths in one week in the city during the heat wave. This was very simple data with no fancy modelling or complex statistics nor any assumptions which helped the local politicians and bureaucrats to easily understand the impact of heat and the need for HAP to protect the lives of the citizens. Thus each city and districts should workout the impact on mortality and if possible on morbidity using local available data. Using fancy mathematical models borrowed from west some times are not so effective in convincing local policy makers on the impact of heat as can be done with local simple data on death and temperature. These data are available for most big and

medium size cities. The need is to collect this data and analyse them for form the basis for local HAP.

3. Involving all levels of local government:

This HAP formulation and implantation involved all levels of local government including Mayor, standing committee chair, Commissioner, deputy commissioner and Medical Officer of Health. Form the very first meeting of the scientists held in 2011 March – one year after the heat wave of 2010, with help of NRDCs international experience, the team always briefed the mayor, deputy mayor, health committee chair and commissioner about the heat related work and involved them actively in development and release of the HAP. This ensured political and administrative commitment which is crucial to any such plan to succeed. Plans developed by some consultant without involvement of the local government will not succeed.

4. Learning from all over the world and adapting it to local conditions of the city.

Given NRDC's global experience the HAP development benefited from their knowledge. NRDC could also rope in global expertise and brought in various global best practices which then the team adapted to local city situation to make a simple and practical plan which was informed by international practices. Sometimes international examples and experiences are more useful to convince the bureaucrats.

5. Writing of the HAP in detail: The written document of HAP included locally calculated thresholds and actions to be taken by each department and the public in detail. The heart of the plan is the written document which gives the details of the various actions in the plan and what each stakeholder will be doing

under various alert levels. Initial plan was very long which was then realised that not many government and municipal officers who are very busy would read. So, an "Easy Read" version was made. The well written plan help maintain consistency of communication and messaging as well as action. We also revised the plan each year so that new elements can be added and not so useful or impractical actions can be removed.

6. Planning well in advance: Heat action planning cycle each year started in January or February. The plan was launched in March end or April beginning. And it was implemented April to June. Early planning gave AMC enough lead time to do the needed preparations. Doing meeting, table top simulation exercises, workshops and training of various stakeholder was done from January to March so that all the stakeholders are familiar with the HAP and ready to act during the heat season. Many activities in local government take long time to implement due to various administrative and finance related procedure, hence early start was very crucial so that the plan implementation started in time for the heat season.

7. Active communication strategy: Involving Mass media, social media and local community-based NGOs to reach the key messages to the vulnerable communities for action was very important. More than half of the actions to prevent heat exposure and early treatment have to be taken at the community level by people. Hence communication of the key actions – Dos and Don'ts during heat emergency needs to be well communicated to the most vulnerable poor slum dwellers as well as lower middle-class populations. To reach these populations we used the print

media, TV, Radio and in later years social media with standard messages, interview and advertisements. This over the years created much awareness and action at the community level. This is very important part of each HAP.

8. Review of implementation of the HAP each year: After the heat season the team reviewed the implementation of the plan and its effectiveness. The focus was on finding success and learning lessons for improvement from the shortcomings. Adding new activities to improve the plan was done based on local innovations and international new knowledge. This helped the plan to improve over the years and make it more effective.
9. Building formal partnerships via MOUs between various stakeholders: It is important to build formal partnerships between various stakeholder such as AMC, IIPHG, NRDC, State government etc. Also forming informal linkages and friendships with these and other stakeholders is equally important. The formal MOUs provide the continuity over the years as key officers like Mayors, Commissioner and deputy commissioner and health officers change over the year, but a written MOU forms the basis for continued activities even when the officers change. Forming informal linkages helps to motivate the staff which is doing the HAP work as extra duties on top of their regular work. It also helps understand their constraints and innovative ideas which may not come out in formal settings.
10. Need for External facilitation and flexible budget: The external facilitators for Ahmedabad HAP were NRDC and IIPHG. They helped to steer the program. External

facilitation and budget by NRDC, CDKN and other donors help to sustain the activities via appointment of full-time research staff and providing faculty time to drive the project activities. NRDC's program staff was very proactive and visited regularly to guide and move the project activities in the right direction with pace. They also provided global best practice evidence and expertise which helped the project a lot. NRDC also brought in international experts and services which were not easily available in India. IIPHG provide local contextual knowledge, statistical and analytical capacity and close connection with the government. All of this is essential for success of the project.

11. Documentation and dissemination of the efforts for larger impact and recognition. Ahmedabad HAP team over the ten years have produced 5-6 key international publications as well as several policy briefs, several media articles, many presentations, workshops and tools for other cities to develop such a plan. Thus, the success of the plan was well documented with international publications and national dissemination. This provided much higher visibility and appreciation for the project. This is very useful for maintaining the motivation of the teams and making the efforts in one city a platform for others to learn from. It also provided international recognition and received awards that motivated the team.

7. Conclusion and Way Forward

The development, implementation and review of Ahmedabad Heat Action Plan over the last 10 years provided very useful practical example to learn from how a local threshold-based heat action plan can be implemented in a developing country city with low resources. The lessons from this action plan should be taken up by other

cities, states and national authorities to adapt and replicate it in each of the cities, district and at national level. Given the rapid rise of temperatures due to climate change, and the predicted most conservative paths of temperature rise which indicate substantial rise of the temperatures in future, each city and district has to prepare a plan to protect the citizens from the high temperature and heat waves. Ahmedabad HPA lessons given above will go a long way to help city and state authorities to make the local heat action plans to protect its populations. The National and state agencies like NDMA, SDMA and health dept as well the IMD have to take joint lead to protect the people in future from heat waves.

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Climate Change and Disaster Resilience in India's Health Sector: A Vision for 2047

Anil Kumar Gupta¹ and Atisha Sood^{2*}

Abstract:

India, like many regions globally, faces the daunting challenge of climate change and its intricate relationship with public health. Climate change threatens to unravel the hard-fought gains in public health and poses unique risks to vulnerable populations. Amidst this backdrop, India has set its sights on the ambitious Vision 2047, aimed at propelling the nation into the league of developed nations. However, this vision's realization faces a formidable hurdle - the need for a resilient health sector, one capable of withstanding the multifaceted impacts of climate change and other disasters.

This article presents a visionary roadmap for the development of a climate-resilient health sector in India by 2047. The confluence of climate change, health, and Vision 2047 underscores the need to address critical challenges within the Indian health system. These include limited infrastructure, human resource constraints, and the financial resources required for effective disaster response. It calls for a fundamental reorientation of health paradigms, recognizing the value of holistic healing practices that incorporate alternative medicine traditions.

A critical component of this vision is enhancing

disaster preparedness and strengthening critical care capacities, which are imperative for mitigating the health impacts of climate-induced disasters. Intersectoral coordination and the seamless integration of health systems with other sectors are crucial to building resilience. Moreover, lessons drawn from the ongoing COVID-19 pandemic underscore the importance of adaptability and innovation.

In conclusion, India's journey to a climate-resilient health sector necessitates substantial investments in infrastructure, a skilled healthcare workforce, early warning systems, and robust public health surveillance. It also calls for an emphasis on community engagement, reinforcing the significance of localized health solutions. Additionally, aligning with the National Health Adaptation Plan for disaster-related health issues and PM's 10-point agenda on Disaster Risk Reduction will further fortify India's healthcare system. Together, these measures will not only help India achieve Vision 2047 but also foster a healthier, climate-resilient future for its citizens.

Keywords: Health sector resilience, climate adaptation, India Vision 2047, holistic healing, disaster preparedness, COVID-19 pandemic. Confluence of Climate Change, Health, and India's Vision 2047

1. Introduction

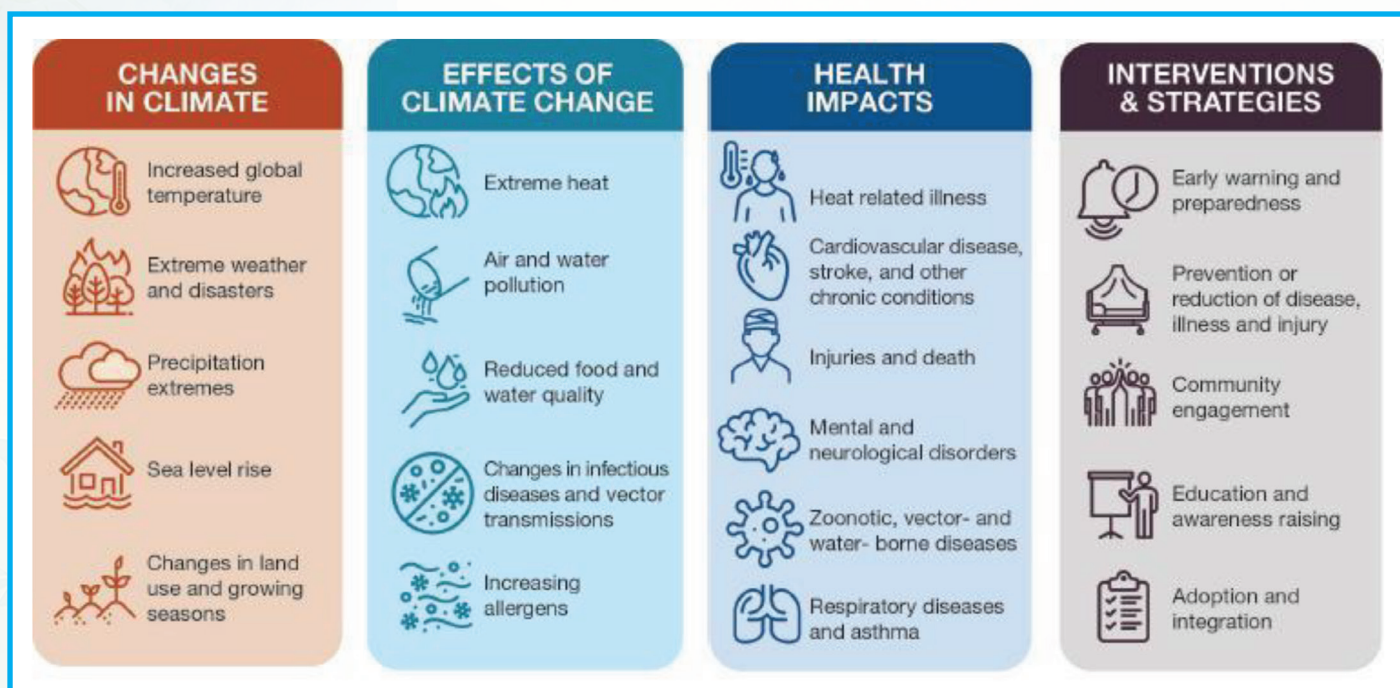
Climate change has escalated from a theoretical projection to a palpable reality, presenting formidable challenges to health systems worldwide (Smith & Smith, 2020). Amidst this dynamic context, India's Vision 2047 emerges as an ambitious blueprint that marries development with disaster resilience. As climatic extremes amplify, the vision's realization hinges on the capacity of the health sector to navigate and mitigate the impacts of these events (Kumar et al., 2018).

A harmonious convergence of global health concerns and national aspirations beckons the recalibration of health systems to not only provide curative care but also preemptive protection. Climate change is a major threat to public health, and India is particularly vulnerable due to its large population, diverse geography, and high poverty levels (WHO, 2022a). Climate change is already having a significant impact on health in India, through factors such as increased heat stress, extreme weather events, and changes in the distribution of infectious diseases (ICMR, 2022).

India's Vision 2047 is to become a developed nation by 2047. In order to achieve this vision, India needs to build a resilient health system that can withstand the shocks of climate change and other disasters (NITI Aayog, 2023). A resilient health system is one that can anticipate, prepare for, and respond to climate-related health risks.

1.1 Synergy of Health and Climate

Climate change imparts multifaceted threats to public health, enveloping sectors far beyond meteorology, see Fig. 1 (Watts et al., 2015). The nexus between climate and health transcends conventional boundaries, encompassing infectious diseases, food security, waterborne illnesses, and mental health impacts (Haines et al., 2019). The intricate interplay between environmental determinants and health outcomes necessitates a paradigm shift in health systems, wherein preparedness, resilience, and adaptability assume pivotal roles (Patz et al., 2014). The



interconnectedness of these elements forms the crucible within which health sector resilience and climate adaptation forge an inseparable bond.

Fig 1: Health Impacts of Climate Change

Health and climate are inextricably linked. Climate change is already having a significant impact on health, and this impact is expected to grow in the future. Climate change can affect health in a number of ways, including:

- Direct health impacts: Climate change can lead to heat stress, extreme weather events, and changes in the distribution of infectious diseases. These can all have a direct impact on human health (WHO, 2022a).
- Indirect health impacts: Climate change can also have indirect impacts on health, such as through food insecurity, water shortages, and displacement. These can all lead to malnutrition, disease, and other health problems (IPCC, 2022).
- Vulnerable populations: Some populations are more vulnerable to the health impacts of climate change than others. These include the poor, the elderly, and children (WHO, 2022a).

1.2 Vision 2047 and Disaster Resilience

India's Vision 2047 is more than an aspirational trajectory; it embodies the nation's commitment to inclusive progress and global leadership. As the country's various sectors mobilize toward this collective dream, the health sector emerges as a cornerstone. The vision's resonance with climate adaptation crystallizes the need for a comprehensive blueprint that bolsters health system resilience against climate-induced disruptions (World Bank, 2016). By aligning Vision 2047 with proactive strategies for disaster preparedness, health systems can serve as vanguards in safeguarding public well-being (Kumar et al., 2018).

Disaster resilience is a key component of India's Vision 2047. The National Disaster Management Plan (NDMP) 2019-2024 emphasizes the need for building a disaster-resilient health system (National Disaster Management Authority, 2019). The NDMP identifies a number of key areas for action, including:

- Strengthening health infrastructure and disaster preparedness
- Building capacity of healthcare personnel
- Enhancing early warning systems and surveillance mechanisms
- Promoting community engagement and risk reduction

1.3 Shaping a Resilient Health Sector

The interplay between climate change and health systems is a dynamic dance, with both partners influencing and being influenced by each other. As India marches towards Vision 2047, it must recognize that resilience is not a passive trait but an active pursuit. The alignment of health sector resilience with climate adaptation molds a sector capable of thriving amidst adversity, catalyzing comprehensive development while insulating against climatic disruptions. Through a harmonious convergence of Vision 2047's aspirations and the strategic directives of the NPDRR 2023, this article paves a visionary path - a path that converges the health sector's prowess with the rhythm of climate's uncertainties, refer Table 1 for Key Components of a Resilient Health Sector.

A resilient health sector is one that can anticipate, prepare for, and respond to climate-related health risks. This requires a number of key elements, including:

- Strong health infrastructure: The health sector needs to have the infrastructure in place to withstand extreme weather events and other disasters. This includes having

strong healthcare facilities, reliable energy and water supplies, and adequate transportation networks.

- **Skilled healthcare workforce:** The health sector needs to have a skilled workforce that is trained to respond to climate-related health risks. This includes having healthcare workers who are trained in disaster management, disease surveillance, and public health.
- **Early warning systems and surveillance:** The health sector needs to have early warning systems and surveillance mechanisms in place to detect and monitor climate-related health risks. This allows the health sector to take early action to prevent and mitigate the impacts of these risks.
- **Community engagement:** Community engagement is essential for building a resilient health sector. Communities need to be involved in identifying and addressing their own health risks, and in planning for and responding to disasters.

Table 1: Key Components of a Resilient Health Sector

Key Components of a Resilient Health Sector	Description
Disaster Preparedness	• Proactive planning and readiness for natural disasters and climate-related emergencies. • Development of response protocols and evacuation plans. • Stockpiling of essential medical supplies.
Intersectoral Coordination	• Collaborative efforts with other sectors such as disaster management, urban planning, and environmental agencies. • Sharing of resources and expertise during crises. • Integrated policies and strategies for climate resilience.
Technological Integration	• Implementation of telemedicine and remote diagnostics for disaster response. • Utilization of artificial intelligence (AI) for predictive modeling and resource allocation. • Integration of health information systems for real-time data sharing.
Inclusivity and Rural Health	• Establishment of health and wellness centers in rural and vulnerable areas. • Accessibility of healthcare services to remote populations. • Focused efforts to address the health needs of marginalized communities.
Holistic Health Approach	• Integration of traditional and alternative medicine systems with allopathy. • Emphasis on preventive care, mental health, and holistic well-being. • Inclusive healthcare that caters to diverse health needs.

2. Evolution of Health Systems in India: From Conventional Paradigms to Vision 2047

The Indian health system has evolved significantly over the past few decades (Government of India, 2005). However, it still faces a number of challenges, including limited infrastructure, human resource constraints, and limited financial resources. The evolution of India's health systems is a captivating journey, interwoven with historical, cultural, and scientific nuances. Anchored in the ethos of providing equitable healthcare, the National Health Policy of 2017 stood as a cornerstone, paving the path for comprehensive health coverage by 2040 (Government of India, 2017). This vision resonates harmoniously with the overarching narrative of India's Vision 2047, encapsulating the nation's aspirations for inclusive growth and global leadership.

2.1 From Allopathy to Holistic Health

The prevailing paradigm of allopathic medicine has been the lodestar of India's healthcare landscape. This model, marked by clinical intervention and pharmaceutical advancements, played a pivotal role in addressing the nation's health needs (Chatterjee et al., 2016). However, Vision 2047 beckons a more profound transformation, one that transcends curative care and embraces a holistic approach to well-being (Government of India, 2017). Allopathic medicine, though dominant, is now poised to harmonize with traditional systems such as Ayurveda, Unani, and Siddha, inviting a strategic convergence of diverse medical philosophies (Ministry of AYUSH, 2020). Traditionally, the Indian health system has focused on allopathy, or Western medicine. However, there is a growing interest in holistic health in India. Holistic health approaches focus on the whole person, including their physical, mental, emotional, and spiritual well-being.

Holistic healing practices have been a part of Indian culture for thousands of years. Ayurveda, yoga, and meditation are just a few examples of holistic healing practices that are becoming increasingly popular in India today.

2.2 Inclusivity and Rural Health

The trajectory of health systems' evolution intertwines with the pursuit of inclusivity and rural health outreach. The establishment of health and wellness centers as envisioned in Vision 2047 aligns with NPDRR 2023's advocacy for decentralized disaster preparedness (Government of India, 2017). These centers, poised to be pillars of preventive care, epitomize a proactive response to both climatic and health challenges, reaching the remotest corners of the nation. As climate change manifests disproportionately in vulnerable regions, these centers form a linchpin in India's disaster resilience strategy.

Another important trend in the evolution of the Indian health system is the focus on inclusivity and rural health (WHO, 2022b). In the past, the Indian health system was largely focused on urban areas and the wealthy. However, there is now a growing recognition of the need to provide quality healthcare to all Indians, regardless of their location or income level.

The Indian government has launched a number of programs to improve rural health and make healthcare more inclusive. For example, the National Rural Health Mission (NRHM) was launched in 2005 with the goal of providing quality healthcare to rural India (Government of India, 2005). The NRHM has helped to improve access to healthcare in rural areas by increasing the number of healthcare facilities and training more healthcare workers.

2.3 Collaboration and Vision Synergy

The tapestry of health systems' evolution weaves threads of collaboration and cross-sectoral synergy. Vision 2047, while projecting India's ascent on the global stage, finds resonance in collaborative partnerships that extend beyond healthcare, encompassing disaster risk reduction, urban planning, and environmental stewardship. This strategic cohesion amplifies the health sector's resilience, imbuing it with the capacity to navigate the complexities of climate-induced disruptions. There is also a growing recognition of the need to align the health system with other sectors, such as education, water, and sanitation. This is important because health is not just determined by the health system, but also by other factors such as access to clean water and education.

Table 2: Evolution of India's Healthcare System: Key Milestones and Policies (1947 - Vision 2047)

Milestone/ Policy	Description	Reference
Pre-Independence Era (Before 1947)	- Limited healthcare infrastructure with an urban-centric focus. - Influence of British colonial medicine and Western medical practices. - Limited access to healthcare for the majority of the population.	Historical Context
Post-Independence (1947)	- Foundation for the post-independence healthcare system laid with a focus on healthcare accessibility and equity. - Emphasis on primary healthcare and public health infrastructure development. - Establishment of the Bhore Committee to outline healthcare reforms.	Bhore Committee Report (1946).
1950s - 1980s	- Expansion of healthcare facilities and medical colleges to improve medical education and healthcare delivery. - Introduction of healthcare policies to address disease control and rural healthcare. - Launch of the National Malaria Eradication Program and Family Planning initiatives.	1. Government of India. (1950). National Malaria Eradication Program. 2. Government of India. (1952). Family Planning Program.

1990s - Economic Liberalization	- Focus on private sector participation in healthcare with the emergence of private hospitals and medical education institutions. - Increased emphasis on medical tourism and healthcare exports. - Launch of the National Health Policy 2002 to address healthcare challenges.	1. Ministry of Health and Family Welfare, Government of India. (2002). National Health Policy - 2002. 2. Ministry of Health and Family Welfare, Government of India. (2019). National Digital Health Blueprint.
2000s - National Health Policy 2002	- Emphasis on equitable healthcare access for all sections of society. - Introduction of healthcare insurance schemes to cover medical expenses. - Focus on disease control and reproductive health programs. - Introduction of the Rashtriya Swasthya Bima Yojana (RSBY) for health insurance.	1. Ministry of Health and Family Welfare, Government of India. (2002). National Health Policy - 2002. 2. Ministry of Health and Family Welfare, Government of India. (2013). Rashtriya Swasthya Bima Yojana (RSBY).
2017 - National Health Policy 2017	- Shift towards holistic healthcare with a focus on preventive and wellness measures. - Inclusion of traditional medicine systems (Ayurveda, Unani, Siddha) alongside allopathy. - Introduction of Health and Wellness Centers in rural and remote areas. - Emphasis on Universal Health Coverage (UHC) and the Ayushman Bharat program.	1. Ministry of Health and Family Welfare, Government of India. (2017). National Health Policy 2017. 2. Ministry of Health and Family Welfare, Government of India. (2019). Ayushman Bharat.
Vision 2047 - Holistic Healthcare	- Integration of traditional medicine systems (Ayurveda, Unani, Siddha) with allopathy for a more holistic approach to healthcare. - Establishment of Health and Wellness Centers in rural and remote areas for comprehensive health coverage. - Focus on research and development in healthcare to align with global standards and aspirations of becoming a global healthcare leader.	

3. Challenges within the Indian Health System

As India strives to align its healthcare system with the ambitious Vision 2047, it confronts a multitude of challenges that extend beyond the integration of traditional medicine. These challenges are critical in the pursuit of a resilient health sector capable of navigating the complexities of climate change and disaster preparedness.

3.1. Public Health Infrastructure

India's health infrastructure faces the daunting task of bridging the urban-rural divide and ensuring equitable access to healthcare services (Mahal, 2016). The expansion of health and wellness centers as envisaged in Vision 2047 is a positive step, but it necessitates substantial investment, healthcare workforce training, and the deployment of resources to remote and vulnerable areas (MoHFW, 2017).

3.2. Human Resource Constraints

The shortage of healthcare professionals, especially in rural and remote regions, remains a persistent challenge (Sood et al., 2015). Vision 2047's emphasis on comprehensive healthcare coverage necessitates not only increasing the number of healthcare workers but also improving their skill sets and retention in underserved areas.

3.3. Health Financing

Ensuring affordable and accessible healthcare for all is a central tenet of Vision 2047 (MoHFW, 2017). However, India's healthcare financing landscape demands innovative approaches to mobilize resources efficiently (Reddy et al., 2018). Striking a balance between public and private financing while safeguarding against catastrophic health expenditures remains a formidable challenge.

3.4. Climate-Resilient Infrastructure

India's health infrastructure must evolve to withstand climate-induced disruptions (Kulkarni

et al., 2019). The construction of climate-resilient healthcare facilities, disaster-ready hospitals, and the retrofitting of existing infrastructure pose logistical and financial challenges (WHO, 2019).

3.5. Technological Integration

The integration of technology, telemedicine, and artificial intelligence into healthcare, as envisioned in Vision 2047, necessitates a robust digital infrastructure, data security measures, and training for healthcare professionals (Rao & Singh, 2019). The digital divide and cybersecurity concerns pose significant hurdles.

Navigating these challenges is essential to realize the overarching goals of Vision 2047 and ensure that India's health system is prepared for the impacts of climate change and disaster events.

4. Holistic Healing Paradigm

India's healthcare landscape blends allopathic medicine with traditional healing practices (Dwivedi, 2018). Allopathic medicine, marked by clinical intervention and pharmaceutical advancements, has long been the cornerstone of India's healthcare (Sharma & Arora, 2017). However, Vision 2047 invites a transformation that transcends curative care and embraces holistic well-being. Allopathy is poised to harmonize with traditional systems like Ayurveda, Unani, and Siddha, offering a comprehensive approach to well-being (Sharma et al., 2019).

4.1 Traditional Medicine and Disaster Resilience

Traditional medicine's integration within the health sector is strategic for disaster resilience (Tewari & Luthra, 2017). Ayurveda, with its preventive care and holistic wellness focus, aligns with disaster preparedness (Sharma et al., 2019). Traditional medicinal knowledge complements allopathic interventions, enabling a comprehensive response to climate-induced health challenges (Dwivedi, 2018). Alternative

medicine practitioners, such as homeopathy, naturopathy, and acupuncture, play crucial roles in disaster response (Chakraborty et al., 2020). These practices provide supportive care, alleviate stress, and bolster mental well-being during disasters (Tewari & Luthra, 2017).

4.2 A Holistic Health Spectrum

Integrating traditional and alternative medicine showcases the health sector's adaptability (Sharma & Arora, 2017). This approach embraces a comprehensive health spectrum catering to diverse health needs, augmenting resilience against climate change impacts (Chakraborty et al., 2020).

Table 3: Integration of Allopathy and Traditional Medicine for Disaster Response and Holistic Wellness

Aspect	Allopathy	Traditional Medicine
Approach to Wellness	Clinical intervention and pharmaceutical advancements	Holistic wellness approach
Preventive Care	Primarily curative care	Emphasis on preventive care and wellness maintenance
Disaster Response	Critical care and emergency interventions	Supportive care, stress reduction, and mental well-being
Health Spectrum	Focused on physical health	Comprehensive approach encompassing physical, mental, and spiritual well-being

5. Disaster Preparedness and Critical Care: District Health Centers and Responsive Strategy

In times of escalating climate-related disasters, the establishment of district health centers emerges as a pivotal strategy for bolstering disaster preparedness and ensuring critical care. As India charts its trajectory towards Vision 2047, disaster preparedness and critical care assume pivotal roles in the health sector's resilience against the impacts of extreme weather events (Government of India, 2019).

5.1 Localized Disaster and Health Centers

In response to the escalating climate-induced impacts, India's health system is strategically establishing district-level disaster and health centers. These centers, integral to Vision 2047's goals, are positioned within district hospitals to enhance anticipatory disaster preparedness. Equipped with critical care facilities, they form a nimble, localized response mechanism, mitigating the ripple effects of climate-induced disruptions (Sharma et al., 2021).

Localized disaster and health centers serve as frontline hubs for disaster response and healthcare provision (Smith et al., 2018). These centers, strategically positioned at the district level, act as the first point of contact for affected communities during disasters. Their proximity to the population ensures swift access to medical care and support, particularly in remote or vulnerable regions (Smith et al., 2018).

Table 4: Roles and Functions of Localized Disaster and Health Centers

Function	Description
Rapid Response	Immediate medical assistance to disaster-affected areas
Medical Triage	Assessment and prioritization of patient care
Emergency Coordination	Coordination with local authorities and other services
Medical Supplies	Stockpiling and distribution of essential medical items
Communication Networks	Establishing and maintaining communication links

5.2 Strategic Preparedness Mapping

Climate-induced health crises exhibit varying patterns and intensities, necessitating tailored responses. Health systems are increasingly adopting strategic preparedness mapping. This approach involves scrutinizing the unique vulnerabilities of each region and calibrating responses accordingly. For example, high-risk areas may have specialized facilities such as burn units in industrial zones to cater to specific disaster scenarios (Srivastava et al., 2018).

Strategic preparedness mapping plays a crucial role in optimizing the effectiveness of district health centers. By identifying high-risk areas and vulnerable populations, health authorities can allocate resources, deploy personnel, and establish communication networks in advance. This proactive approach enhances the capacity to respond rapidly and decisively when disasters strike (Mukhopadhyay & Krishna, 2021).

Table 5: Key Components of Strategic Preparedness Mapping

Component	Description
Risk Assessment	Identifying potential disaster risks and vulnerabilities
Resource Allocation	Allocating medical supplies, personnel, and equipment
Communication Strategy	Developing communication plans and networks
Vulnerable Population Identification	Identifying at-risk groups and their locations

5.3 Rural Health Centers and Vulnerability

In the face of climate change impacts, rural health centers play a vital role in disaster resilience. These centers, often the vanguards of healthcare accessibility, are crucial in addressing both acute health crises and lingering impacts. Their fortification with disaster-ready infrastructure and comprehensive care provisions aligns seamlessly with Vision 2047's emphasis on health and wellness centers. This approach amplifies the health sector's resilience amidst climatic uncertainties (Kumar & Singh, 2020). Rural health centers, often serving as the backbone of healthcare in remote areas, face unique challenges during disasters. Their limited resources and infrastructure can exacerbate vulnerabilities, making it imperative to integrate them into the district-level preparedness framework (Rajan et al., 2019).

5.4 Orchestrating Responsive Care

The establishment of district-level disaster and health centers serves as a transformative response to the challenges posed by climate-induced disruptions. As India advances towards Vision 2047, localized preparedness mapping becomes a guiding beacon for health systems. By embracing disaster and health centers within the comprehensive framework of wellness hubs, the health sector

shapes responsive care mechanisms that resonate with the nation's journey towards inclusive progress. Orchestrating responsive care requires seamless coordination among district health centers, emergency services, and other stakeholders. Standard operating procedures (SOPs) should be in place, delineating the roles and responsibilities of each entity in disaster response. Regular drills and training exercises can ensure that healthcare providers are well-prepared to handle a surge in patients and provide critical care (Rajan et al., 2019).

Table 6: Key Elements of Responsive Care Coordination

Standard Operating Procedures (SOPs)	Clearly defined protocols for disaster response
Training and Drills	Practice exercises to ensure readiness and coordination
Multi-Agency Collaboration	Coordination with emergency services and NGOs

6. Intersectoral Coordination and Integration: Circular Economy and Technological Synergy

Effective intersectoral coordination and integration are essential components of building resilience in the health sector. This section explores the integration of circular economy principles into healthcare waste management and the synergy between technology and disaster management.

6.1. Circular Economy and Healthcare Waste Management

The adoption of circular economy principles in healthcare waste management can significantly enhance sustainability and disaster resilience. Circular economy strategies focus on reducing waste, reusing materials, and recycling resources, thereby minimizing environmental impact (Ellen MacArthur Foundation, 2019).

Table 7: Key Components of Circular Economy in Healthcare Waste Management

Component	Description
Waste Minimization	Strategies to reduce the generation of healthcare waste
Recycling and Reuse	Processes for recycling materials and reusing equipment
Sustainable Procurement	Sourcing environmentally friendly healthcare products
Eco-friendly Disposal	Safe disposal methods in line with circular economy principles

6.2 Technological Synergy in Disaster Management

Technological advancements play a pivotal role in improving disaster management and response. The integration of technology, such as Geographic Information Systems (GIS), remote sensing, and real-time data analytics, can provide critical information for disaster preparedness and response (UNDRR, 2020).

Table 8: Key Technologies for Disaster Management

Technology	Description
Geographic Information Systems (GIS)	Spatial data analysis for disaster mapping and planning
Remote Sensing	Satellite and aerial imagery for disaster monitoring
Early Warning Systems	Real-time alerts and notifications for disaster events
Data Analytics	Big data analysis for decision-making in disaster response

7. Lessons from the COVID-19 Pandemic: Strengthening Health Systems in Times of Crisis

The COVID-19 pandemic has unveiled vulnerabilities within global healthcare systems, emphasizing the urgency of enhancing preparedness and resilience (WHO, 2022c). Amidst the challenges, it has provided invaluable insights that can serve as cornerstones for fortifying health systems during crises (Kieny et al., 2017).

Lesson 1: Invest in Robust Public Health Infrastructure

The pandemic underscored the critical need for substantial investments in public health infrastructure, including hospitals, clinics, and laboratories (WHO, 2022c). These foundational elements are indispensable for the early detection, effective prevention, and rapid response to public health threats.

Lesson 2: Cultivate a Resilient Workforce

The pandemic has illuminated the pivotal role of a skilled and resilient healthcare workforce (WHO, 2022c). Healthcare professionals are the linchpin of healthcare delivery and emergency response. Nations must invest in their training, retention, and ensure they have the necessary resources and support to execute their duties safely and efficiently.

Lesson 3: Champion Universal Health Coverage (UHC)

COVID-19 has emphasized that access to quality healthcare is a fundamental right, irrespective of income or social status (Chattu et al., 2023). Universal Health Coverage (UHC) ensures that healthcare services are accessible to all when needed. UHC investments are essential to bolster health systems' resilience against the shocks of public health emergencies.

Lesson 4: Foster Robust International Collaboration

The pandemic has unequivocally demonstrated that public health threats transcend borders and necessitate collaborative global responses (UN, 2022). Nations must reinforce international cooperation by sharing information, exchanging best practices, coordinating research and development, and extending financial and technical support to countries in need.

Some Additional Key Considerations:

- **Data and Surveillance:** The pandemic highlighted the indispensable role of data and surveillance in detecting, preventing, and responding to public health threats (Filip et al., 2022). Nations should prioritize the development of comprehensive data collection and analysis systems and foster data sharing to gain a deeper understanding of public health challenges.

- **Risk Communication:** Effective risk communication emerged as a linchpin for educating the public about public health threats and encouraging preventive behaviors (Donadelli et al., 2023). Countries must develop and implement robust risk communication strategies that reach all segments of the population.
- **Community Engagement:** Engaging communities in the planning and execution of public health interventions is pivotal for building trust and ensuring the effectiveness of such measures (Rehfuess et al., 2022). Nations should actively involve communities in the decision-making process to facilitate more inclusive and successful public health interventions.

8. Integration of Climate Adaptation with Vision 2047: Forging a Climate-Resilient Future

Climate change stands as a formidable threat to India's development aspirations, most notably encapsulated in Vision 2047. The country is already grappling with the tangible impacts of climate change, manifesting as an increase in extreme weather events, including floods, droughts, and heatwaves (Clarke et al., 2022). These events, in their wake, leave a trail of devastation, damaging critical infrastructure, decimating crops and livestock, and displacing millions of people (IPCC, 2022).

To realize the ambitious Vision 2047, India must embed climate adaptation into every facet of its development planning. This necessitates the creation and implementation of climate-resilient infrastructure, sustainable agricultural practices, and robust health systems. Equally crucial is the fortification of communities to withstand the mounting impacts of climate change (WHO, 2022a).

Specific Integration Approaches:

1. **Investing in Climate-Resilient Infrastructure:** India's development trajectory should encompass investments in infrastructure capable of withstanding the adverse effects of climate change. This includes the construction of flood-resistant embankments, drought-resilient irrigation systems, and heat-tolerant buildings.
2. **Strengthening Health Systems:** India's health systems require reinforcement to confront the escalating health risks linked to climate change. These risks encompass heat-related illnesses, the resurgence of vector-borne diseases, and food insecurity. Strengthening health systems involves investments in early warning systems, robust public health surveillance, and comprehensive health education (Lal et al., 2022).
3. **Building Community Resilience:** The cornerstone of climate adaptation lies in enhancing community resilience to climate-induced shocks. This involves facilitating access to essential information and resources, and empowering communities to formulate and implement their adaptation strategies (Carmen et al., 2022).

By seamlessly integrating climate adaptation within the framework of Vision 2047, India can chart a course toward a more resilient future, securing the well-being of all its citizens.

Conclusion

In the grand tapestry of global challenges, climate change stands as an unparalleled threat to our planet's health and well-being. Within this complex and evolving narrative, India emerges as a nation at the crossroads of both formidable risk and profound opportunity. With Vision 2047 as our guiding star, we find ourselves at a pivotal juncture, poised to rewrite the story of India's health sector—transforming it from a reactive

entity to a proactive, resilient force capable of safeguarding the health of its people against the relentless march of climate change.

Throughout this comprehensive exploration, we have traced the intricate threads binding health sector resilience and climate adaptation. From the multifaceted threats posed by climate change to the imperative for investment in climate-resilient infrastructure, from the critical role of health systems in mitigating climate-induced health risks to the indispensable need for community empowerment, we have uncovered a vision. This vision envisions a holistic, integrated approach that transcends sectoral boundaries, placing human health and well-being at its core.

India has embarked on this journey, laying the foundation through initiatives like the National Action Plan on Climate Change and the National Health Mission. Yet, as the climate landscape evolves, so must our commitment to fortify our health sector. We must invest in infrastructure capable of withstanding the capricious impacts of climate change, strengthen health systems to confront emerging health risks, empower communities to face the challenges ahead, and take a holistic approach that recognizes the interconnectedness of all aspects of our society.

By embracing these principles and taking decisive steps to integrate climate adaptation into our health sector, we can pave the way for a healthier, more resilient future. It is a future where climate change is not merely a threat but a challenge to be met with innovation, determination, and collaboration. A future where the health and well-being of all our citizens are safeguarded, regardless of the changing climate.

In closing, let us unite in our commitment to this transformative vision. Together, we can forge a climate-resilient health sector—a beacon of hope and resilience for India and a model for the world. As we journey toward Vision 2047, let us remember that our actions today will shape the health and well-being of generations to come. It is a responsibility we bear with unwavering dedication and a promise of a healthier, more resilient tomorrow.

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The Looming Shadow: How Climate Change Casts a Long Shadow on Our Mental Health

Authors: Marjyada Medhi¹, Prakyath Ravindranath Hegde², Channaveerachari Naveen Kumar³

□ Affiliation:

1 Clinical Psychologist, GS-NIMHANS Mental Health Programme, National Institute of Mental health and Neurosciences, Bangalore

2 Assistant Professor of Psychiatry, GS-NIMHANS Mental Health Programme, National Institute of Mental health and Neurosciences, Bangalore

3 Professor of Psychiatry, Head Community Psychiatry at National Institute of Mental health and Neurosciences, Bangalore and the Officer In Charge of COE in Mental Health under the National Program of Climate Change and Human Health, Govt. of India.

Introduction:

Climate change is no longer a looming threat; it is a harsh reality with consequences that ripple far beyond the environment. One of the most concerning aspects of this crisis is its insidious impact on our mental health. This impact is not limited to witnessing dramatic events like wildfires. It is a complex web woven from direct and indirect pathways, slowly eroding our well-being.[1]

□ Direct Pathways: When Disaster Strikes

The fury of nature unleashed by climate change takes the form of increasingly frequent and intense floods, cyclones, and wildfires. These events leave a devastating mark on physical landscapes and the minds of those who

experience them.

Direct exposure to such disasters can trigger mental health issues like post-traumatic stress disorder (PTSD), anxiety, and depression; losing homes, loved ones, and livelihoods can lead to overwhelming feelings of grief, despair, and helplessness[2][3][4]. The displacement caused by these events further disrupts social support networks, making rebuilding an even more daunting task with a heavy toll on mental well-being.

□ Indirect Pathways: A Chain Reaction

Climate change's influence on mental health goes beyond the immediate aftermath of disasters. It operates through various indirect pathways, subtly eroding our well-being over time. Here, we explore four vital indirect pathways:

1. **Biological Pathway:** Climate change disrupts the delicate balance of our environment, leading to increased exposure to heat stress, air pollution (including ozone and toxins), and vector-borne diseases. This, in turn, can have a detrimental effect on our physical health, which can then impact our mental well-being. Studies have shown a correlation between exposure to extreme heat and increased rates of suicide.[5] [6]
2. **Cognitive Pathway:** The cognitive burden of climate change is substantial. Witnessing environmental degradation, the loss of biodiversity, and the threat to future generations can trigger feelings of

despair, hopelessness, and a unique form of grief - ecological grief[7]. The constant worry about the future impacts of climate change can further contribute to anxiety and stress.

3. **Social Pathway:** Climate change weakens the fabric of communities. This can happen due to factors like displacement caused by extreme weather events, competition for dwindling resources leading to conflict, and the breakdown of traditional social support systems. These disruptions can lead to feelings of isolation, loneliness, and a loss of sense of belonging, all of which are major risk factors for mental health problems. [8]
4. **Emotional Pathway:** Climate change evokes a range of intense negative emotions, including fear, anger, guilt, and shame. These emotions can be overwhelming and lead to emotional dysregulation, anxiety, and depression. The feeling of powerlessness in the face of such a large-scale challenge can further exacerbate these negative emotions. [9]

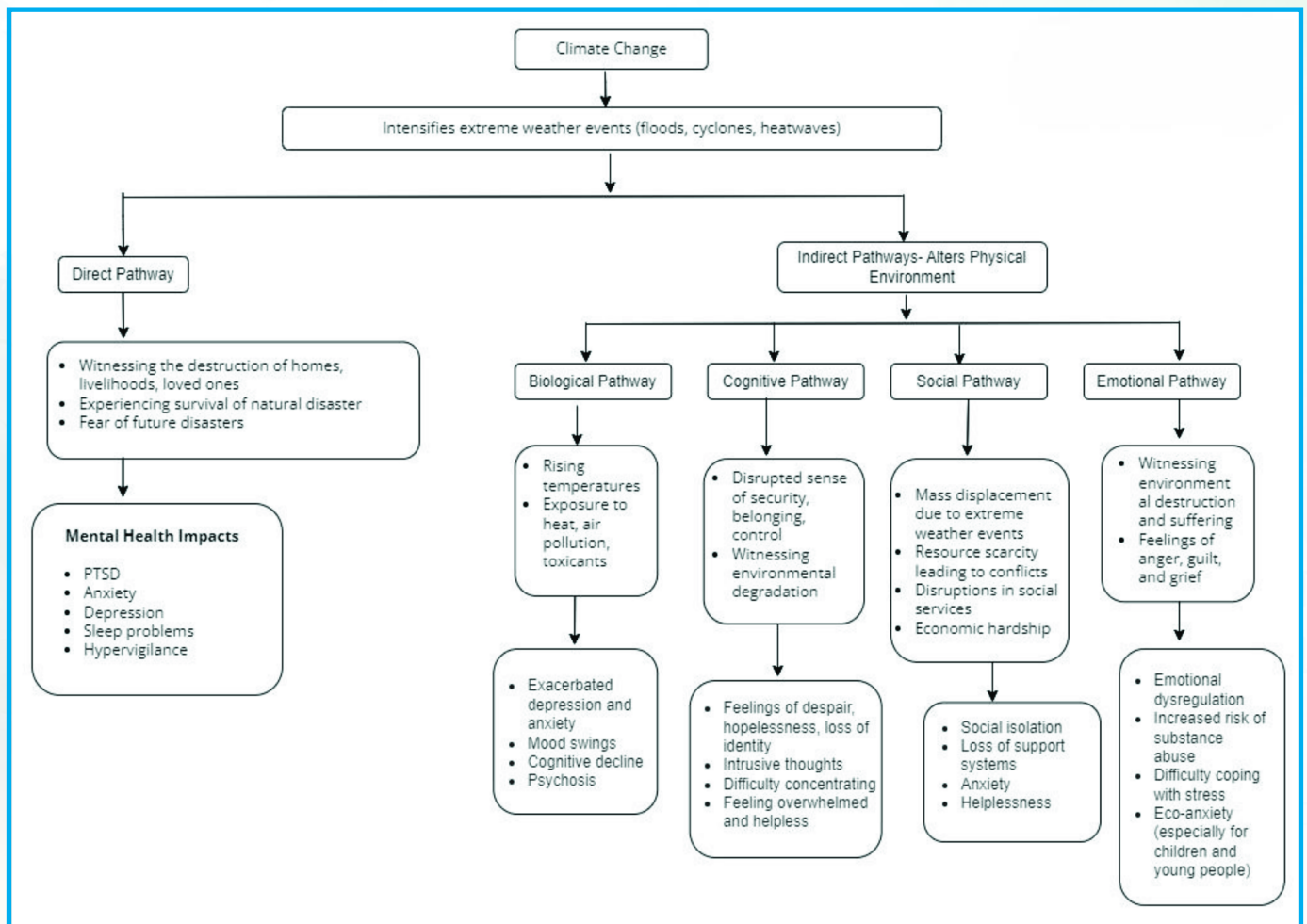


Figure 1: Illustration of direct and indirect pathways to climate change and mental health effects

❑ A Tangible Example: The Interconnectedness

Imagine a farmer whose crops have been destroyed by a drought. This experience exposes him not only to the biological stress of heat and potential malnutrition (Biological Pathway) but also to financial hardship and loss of livelihood. These stressors can trigger feelings of despair and hopelessness (Cognitive Pathway), leading to depression and anxiety (Emotional Pathway). Additionally, the farmer might be forced to migrate, disrupting his social support network (Social Pathway). This complex interplay of factors highlights how climate change affects mental health through interconnected pathways.

□ Building Resilience: A Ray of Hope

While the impact of climate change on mental health is significant, there are steps we can take to build individual and community resilience. These include:

- Promoting access to mental health services: Making culturally competent mental health services readily available is crucial for those impacted by climate change.
- Strengthening social support networks: Building strong community connections can provide a buffer against the negative impacts of climate change.
- Investing in climate adaptation: Investing in infrastructure and practices that help communities adapt to the changing climate can reduce the risk of disasters and associated mental health problems.
- Promoting climate education and awareness: Raising awareness about the mental health impacts of climate change can empower individuals and communities to prepare and cope.
- Individual coping strategies: Practicing mindfulness, relaxation techniques, and seeking social support can help individuals manage the stress and anxiety associated with climate change.

□ Conclusion: A Collective Responsibility for a Brighter Future

Climate change is a multifaceted crisis that casts a long shadow on our mental well-being through direct and indirect pathways. Recognizing these pathways and their interconnectedness is crucial to developing effective strategies for mitigating the mental health impacts of a changing climate. Building resilience at individual and community levels is essential. This requires promoting access to culturally competent mental health services, strengthening social support networks, investing in climate adaptation, and fostering climate education and awareness. Additionally, individual coping strategies like mindfulness and relaxation techniques can empower individuals to manage the stress and anxiety associated with climate change.

We can navigate this challenge with greater collective strength by acknowledging the mental health dimension of climate change and taking proactive steps to build resilience. We have a responsibility to mitigate the environmental impacts of climate change and safeguard the mental well-being of present and future generations.

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Lancet Countdown on Health and Climate Change, 2023: Summary of Key Findings and Policy Implications for India

Dr. Varun Kakde, Consultant – Climate Change and Health, WHO India Country Office

Introduction

The Lancet Countdown's 2023 report provides a comprehensive assessment of the intersection between climate change and global health. In the Indian context, several key findings underscore the urgent need for targeted interventions. Below is a summary of these findings, accompanied by relevant findings and their policy implications for India.

□ Climate change and health in the Indian context

1. Temperature-Related Health Risks

In contrast to 1986–2005, there was a 94% global increase in heatwave days during 2013–22. This led to a 110% rise in heatwave exposure for infants under one (increasing from 4.0 to 8.4 days), and a 96% increase for individuals above 65 years (rising from 5.0 to 9.8 days).

- Key findings for India

- o For adults over 65 years, heat-related mortality at the mid-century (2041-2060) is projected at 128,681 deaths (96,781 – 160,218) under a 2°C scenario and 259,658 deaths (159,013 – 368,616) under a 3.7°C scenario.
- o The expected change in per-person days of heatwave exposure for individuals over 65 years at mid-century compared to 1995-2014 baseline is estimated to be 20.14 days (29.16 - 20.62) under a 2°C scenario and 31.63 days (83.73 - 31.66) under a 3.7°C scenario.

- o Labour hours lost annually due to heat exposure in key sectors (agricultural, construction, manufacturing, and service) increased significantly from 122,000 million hours in 1990- 2000 to 191,000 million hours in 2022.

- Implications for India: India, with its diverse climate zones, faces an elevated risk of heat-related health issues. Vulnerable populations, including the elderly and outdoor workers, are disproportionately affected. This necessitates the implementation of heat action plans, public awareness campaigns, and targeted interventions in high-risk regions.

2. Air Pollution

Exposure to air pollution increases the risk of respiratory and cardiovascular disease, cancer, diabetes, neurological disorders, and adverse pregnancy outcomes. Many of the major sources of GHG emissions also contribute substantially to air pollution. In 2020, anthropogenic PM_{2.5} was responsible for 3.3 million deaths globally. Use of coal as reduced over a period however, coal still contributed to 53% (640 000) of all deaths attributable to fossil-fuel-derived PM_{2.5} in 2020

- Key findings for India

- o Attributable deaths due to PM_{2.5} ambient air pollution increased from 53 deaths per 100,000 in 2005 to 60 deaths per 100,000 in 2020
- o Mortality from exposure to household air pollution in 2020 is estimated at 108 deaths per 100,000. There is significant

variance in deaths attributable to indoor air pollution in rural and urban India with 116 deaths per 100,00 and 97 deaths per 100,000 respectively.

- Implications for India With increasing urbanization and industrialization, India grapples with severe air pollution. Robust health surveillance mechanisms, stricter air quality standards, sustainable transportation policies, and a transition to renewable energy sources are imperative to mitigate the health impacts of air pollution. In addition to ambient air pollution, indoor air pollution continues to remain a significant health burden in India. Policies implementing accelerated shift to less polluting fuels, such as biogas, natural gas, liquefied petroleum gas as well as solar and electric energy can help reduce this health burden.

3. Vector-Borne Diseases

Globally, Dengue cases have doubled every decade since 1990 due to climate change, urbanization, and human movement, putting almost half of the global population at risk. A mechanistic model, considering temperature and precipitation changes, reveals a 28.6% and 27.7% increase in the average R01 for dengue transmission by *Aedes aegypti* and *Aedes albopictus*, respectively, from 1951–60 to 2013–22. Similar trends are observed for other arboviruses. Chikungunya transmission by *Aedes albopictus* increased by 27.7%, and Zika transmission by *Aedes aegypti* rose by 31.9% during the same period

- Key findings for India

From 1951–60 to 2013–22, the average R0 for dengue transmission increased by 23%. By mid-century, compared to the 1995-2004 baseline, projections indicate a 4% (-8% - 12%) increase under the 2° scenario and an 11% (-1% - 13%) increase under the 3.7° scenario.

- Implications for India Given India's

susceptibility to vector-borne diseases, rapid pace of urbanization and the changing climate patterns pose a significant threat. The country must reinforce vector control programs, invest in climate-resilient health systems, and enhance community-based surveillance to curb the spread of diseases.

4. Healthcare Sector Greenhouse Gas Emissions

Quality healthcare demands energy, goods, services, and infrastructure, all contributing to global Greenhouse Gas (GHG) emissions. Despite a 3.7% reduction in absolute emissions from 2019, the global healthcare sector still accounted for approximately 4.6% of GHG emissions in 2020. Furthermore, healthcare-related air pollution and supply chain impacts globally led to an estimated loss of 4 million Disability Adjusted Life Years (DALYs) in 2020.

- Key findings for India

In 2020, Indian healthcare sector is estimated to have contributed 26.29 megatonnes of CO2 equivalents of GHG, which is 18.8 kilograms of per capita carbon footprint.

- Implications for India

Significant investments and efforts to minimize healthcare related emissions will also reduce health-care demand and associated impacts of high emissions. Clean, renewable energy also offers the chance to supply electricity to remote or energy-deficient areas, potentially saving lives and enhancing the health of vulnerable populations. Reaching this objective requires collective action and close collaboration with the energy and finance sectors, civil society, and indigenous communities to implement renewable energy technologies in healthcare delivery and supply chains.

Adaptation, planning, and resilience for health

Scientific evidence unequivocally demonstrates the current and future impact of climate change on health. Addressing the escalating health

risks necessitates enhancing the adaptability of health systems and related support structures. Simultaneously, there is a need to curb GHG emissions to maintain climate change within manageable limits. Successful adaptation requires informed climate change-health risk assessments, well-funded implementation, and ongoing evaluation for continuous improvement.

Key strategies for informed adaptation include

A. Assessments of Climate Change Impact and Vulnerability for Health

- Mitigation reduces climate change hazards, while adaptation plans address climate risks equitably.
- Plans should be informed by a comprehensive understanding of health risks across demographics.

B. Enabling Climate Information for Health

- Essential climate services aid health sector research and informed decision-making.
- Close cooperation between meteorological and health services is crucial for accessing, understanding, and acting upon health-relevant meteorological information.

C. City-Level Climate Change Risk Assessments

- Urban centers, housing 36% of India's population, are disproportionately affected by climate change and ironically urbanization also accelerates climate change.
- City-level interventions have potential in preventing climate change-related health impacts and potentially slow down pace at which climate is changing.

D. Detection, Preparedness, and Response to Health Emergencies

- Increasing climatic suitability for infectious disease transmission necessitates and robust health emergency preparedness and response systems complimented with strengthened disease surveillance.

E. Adaptation Plans for Health

- Health Adaptation Plans (HAPs) are crucial for health systems to prepare for the growing climate burden.
- Priorities in HAPs should be guided by vulnerability and adaptation assessments and integrated into comprehensive adaptation plans.

F. Climate Resilient Healthcare Infrastructure

- The report emphasizes the strain on healthcare systems due to climate-related health emergencies, urging the need for capacity building, training of healthcare professionals, and the establishment of regional response centers.

G. Cross-Sectoral Collaboration and Policy Integration

- The findings highlight the importance of inter-ministerial coordination, urging the integration of health considerations into broader climate change policies. An action plan is recommended to foster collaboration between health, environment, and disaster management agencies.

H. Resource Mobilization and Intersectoral Collaboration

- Adequate resource allocation, including the establishment of a dedicated fund for climate- health initiatives, is essential. Active engagement and collaboration with other sectors are encouraged to address

shared challenges and facilitate resource mobilization.

□ Mitigation actions and health co-benefits

The report emphasizes the pivotal role of the health sector in driving mitigation actions that yield substantial health co-benefits. The report underscores that the health sector is uniquely positioned to advocate for and implement policies that not only address climate change but also directly improve public health outcomes. By championing initiatives such as the reduction of fossil fuel dependence, the promotion of active and sustainable transportation, and the enhancement of green spaces, the health sector becomes a catalyst for mitigating climate change and simultaneously fostering a healthier population.

Highlighting the interconnectedness of environmental and human health, the report emphasizes that the health sector can act as a key advocate for policy interventions that yield both climate and health dividends. For instance, shifting to accessible active, public, and electric travel not only reduces carbon emissions but also has potential to avoid 460,000 deaths globally every year from travel related PM2.5 emissions and encourage increased physical activity. Moreover, encouraging sustainable practices in healthcare facilities, such as energy-efficient buildings and waste reduction, contributes to broader climate goals while ensuring that healthcare settings prioritize patient well-being. The Lancet Countdown underscores the imperative for a health-centered response, emphasizing the symbiotic relationship between climate action and improved public health outcomes, thus making the health sector an essential driver of positive change in the face of irreversible environmental challenges.

□ Conclusion

In conclusion, the report underscores the urgent need for a comprehensive and health-focused approach to address the climate crisis, especially in the context of India. The co-benefits associated with mitigation actions aimed at reducing greenhouse gas emissions can substantially improve air quality and, consequently, public health outcomes. Given India's unique vulnerabilities to climate change, including extreme heat events, changing disease patterns, and air pollution, adopting a health-centered response becomes imperative for safeguarding the well-being of its population. In the Indian context, where the health sector faces the compounded challenges of a vast and diverse population, integrating health considerations into climate action is vital.

The report serves as a crucial guide for policymakers in India, urging them to prioritize health-centric strategies that simultaneously address climate change and improve public health outcomes. By aligning policies with the findings and recommendations of the Lancet Countdown, India can navigate the complex landscape of climate-related health risks, ensuring a resilient and sustainable future for its citizens.

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National Centre for Disease Control (NCDC)

Directorate General of Health Services

Ministry of Health & Family Welfare, Government of India

22-Sham Nath Marg, Delhi-110054

E-mail ID: journalncdc@gmail.com

Website: <http://www.ncdc.gov.in>

Contact No: +91-11-23971272, 23971060

