Proceedings of

National Workshop on Heat Wave 2024

Management Interventions and Mitigation Strategies for Heat Wave

February 13-14, 2024 | Vigyan Bhawan, New Delhi

National Disaster Management Authority (NDMA)
Government of India
NDMA Bhawan, A-1, Safdarjung Enclave,
New Delhi-110029

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National Workshop on Heat Wave 2024

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Foreword

India is now experiencing a series of extreme climatic conditions, such as rising temperatures, heat waves (HW), and severe heat waves (SHW). These heat waves are linked to other hazards, such as forest fires, electrical faults, water scarcity, and, all of which significantly impact human health, the economy, and the environment.

Every year, various parts of the country endure heat conditions, ranging from moderate to severe that are often unbearable. Reports of fatalities due to severe heat waves are not uncommon. Over the past few decades, heat waves have emerged as a deadly global health hazard, with episodes increasing in frequency, intensity, and duration. In recent years, India has witnessed a marked rise in the frequency, duration, and severity of heat waves.

This significant upward trend in HW and SHW events poses a grave risk to human health, particularly for vulnerable sections of society. According to reports, the heat waves in India have resulted in significant number of deaths over the past few years. In 2024 alone, over 150 people lost their lives due to extreme heat conditions. This stark reality highlights the urgent need for effective heat wave management and mitigation strategies.

To address this, the National Disaster Management Authority (NDMA) has organized annual workshops on heat wave management, coordinating with various stakeholders, including government organizations. As a result, Heat Action Plans (HAPs) were established as India's primary policy response to manage and mitigate heat waves. HAPs outline a range of preliminary activities and disaster responses across state, district, and city government departments.

The issue of heat waves has been duly addressed in the National Disaster Management Plan (NDMP) 2019. The National Guidelines for the 'Preparation of Action Plan,' issued by NDMA, provide a framework for implementing, coordinating, and evaluating heat wave-related activities in India.

HAPs have saved lives through short-term measures focused on early warning systems (EWS), preparedness, immediate relief, and emergency response during heat wave events. Moving forward, NDMA, through this report, reaffirms its commitment to prioritizing the dissemination of risk information to the most vulnerable populations. This ongoing effort, along with support for collaborative

initiatives at national, regional, and global levels, underscores NDMA's pivotal role in protecting communities from the growing threats of heat waves and other natural hazards due to climate change.

Rajendra Singh,
Member & Head of the Department, NDMA

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Background and Concept of the Workshop

Heat wave (HW) and Severe Heat Wave (SHW) events are the manifestations of extreme temperatures causing an array of impacts on health, the ecosystem, and the economy. Almost every year, various parts of the country experience severe hot conditions during April-June. The most affected States/UTs include Odisha, Telangana, Andhra Pradesh, Haryana, Delhi, Punjab, Rajasthan, Madhya Pradesh, Maharashtra, Gujarat, Uttar Pradesh, Bihar, Chhattisgarh on many days and Himachal Pradesh, Jammu & Kashmir (UT), Uttarakhand, Tamil Nadu, Jharkhand, West Bengal, Jharkhand, Arunachal Pradesh, Kerala, and Karnataka on some days during the summer season. In India, severe heat waves are generally experienced during the May-June period and on average, two or three severe heat wave events occur every season. On some occasions, there are reports of loss of lives due to such severe heat wave conditions. Heatwaves have emerged as a deadly health hazard across the globe in recent decades, with episodes strengthening in frequency, intensity, and duration in the past half-century in India as well and these trends are projected to worsen under enhanced global warming.

In recent years, India has experienced a marked increase in the frequency, duration and intensity of heat waves. With rising average global temperatures, mercury is breaking all the records in world weather history. In India, the scientific studies had found a spatial-temporal shift in the occurrence of heat wave events with a significantly increasing trend in three prominent heat wave prone regions i.e., North-Western, Central and South-Central India. This trend is not only a present concern but, as climate

models suggest, is likely to intensify in the coming decades under enhanced global warming, making heat wave management and mitigation a critical issue for India's future. A graphic depiction of variation and trends is given below: -

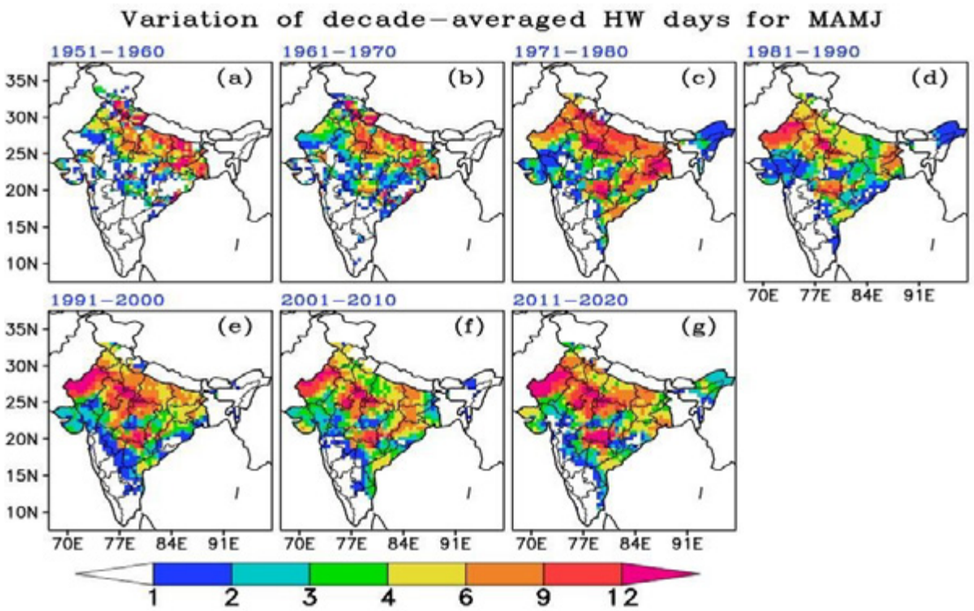

Fig. 1. Variation of decade – average Heat Wave days for MAMJ (Source: IITM Pune)

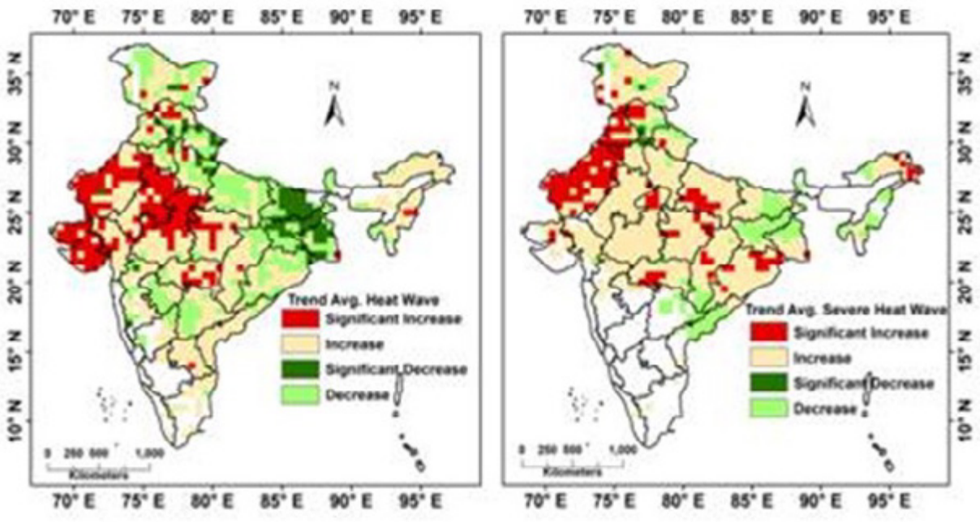

Fig. 2. Long term trend in seasonal heatwave and severe heatwave events (Source: IITM Pune)

Many parts of India have witnessed scorching heat with temperatures mounting as high as up to 50°C in recent years, resulting in morbidities & mortalities, particularly among vulnerable populations such as the elderly, children, and outdoor workers. Heat waves negatively impact agriculture, transport, power, water, housing and other labor-intensive sectors. This significantly increasing trend in HW and SHW events is posing a grave risk to human health, predominantly on the vulnerable sections of society.

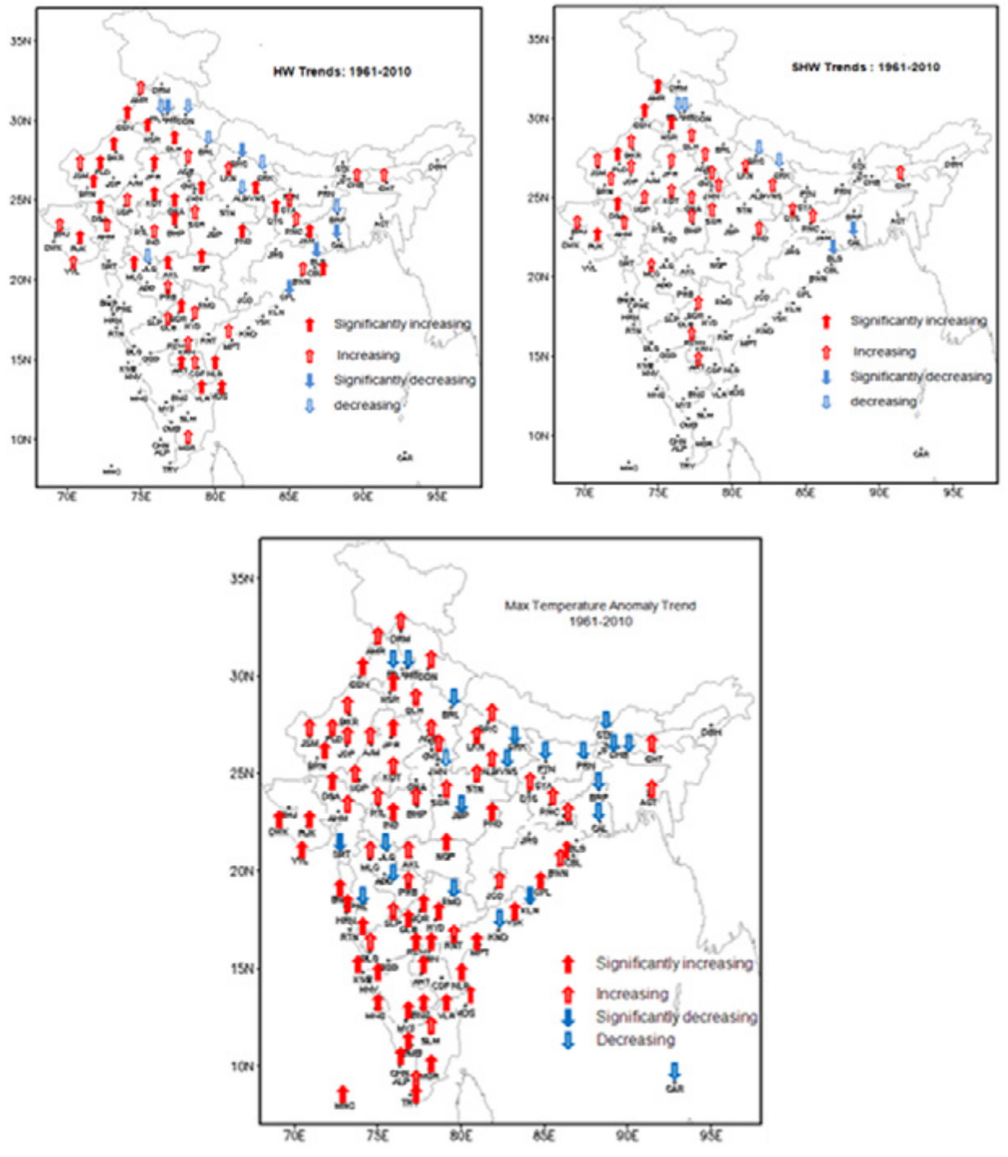

Fig. 3. Long-term linear trends in the station-wise (a) HW days (b) SHW days and station-wise maximum temperature anomaly during hot weather season (March-July) over the 103 stations for the period 1961-2010 (Source: IMD Pune)

Generally, India Meteorological Department (IMD) declares a heat wave or severe heat wave when the daily maximum temperature is above 40°C for two consecutive days in the plains, above 37°C in the coastal areas and above 30°C in the hills and mountains, depending upon the magnitude of its positive variance from normal values.

Urban areas, particularly the densely populated cities, are increasingly experiencing Urban Heat Island (UHI) effect, which is attributed to factors such as concrete surfaces, reduced vegetation, disappearing water bodies and anthropogenic heat emissions. Studies have shown that the UHI effect intensifies heat waves in Indian cities, thus necessitating urban-specific heat wave management and mitigation strategies.

The National Disaster Management Authority (NDMA) issues advisories for managing heat waves to the Central Ministries / Department, States, Districts and Municipal Corporations for taking appropriate proactive actions. A review of heat wave preparedness is regularly done through video conferencing with all heat wave prone states. NDMA also focuses on community sensitisation and awareness generation through social media, print/electronic media, advertisements and short TV commercial films on heat wave protection.

NDMA organised Annual National Workshops on heat wave management to co-ordinate with all the stakeholders including Government organizations, knowledge partners and heat wave prone States since 2017.

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Heat Action Plans (HAPs) for Heat Wave Management and Mitigation

HAPs are supposed to be India's primary policy response to contain and adapt to these heat waves. They propose a variety of preliminary activities and disaster responses across state, district and city Government departments to decrease the impact of heat waves. NDMA issued the National Guidelines for 'Preparation of Action Plan – Prevention and Management of Heat Wave' 2016 to provide a framework for implementation, coordination and evaluation of extreme heat wave related activities in India. NDMA revised the National Guidelines on heat waves in 2019.

The concerned State Governments have taken necessary preparedness and mitigation measures for heat waves. During the last few years, many state governments and districts/cities have prepared Heat Action Plans and are also implementing them. However, some studies suggest that only a few States' HAP carried out vulnerability assessments in the context of heat waves. HAPs need to be prepared for targeting the vulnerable population and sectors at the local level to reduce their adverse impacts. In addressing heat waves, immediate (short-term) to sustained (long-term) strategies are essential with a focus on vulnerable areas & Communities and engage with Knowledge Partners & all Stakeholders.

HAPs have done well in saving the lives of people through short-term measures that focus on early warning systems, preparedness, immediate relief, and emergency response during heat wave events. Apart from the health sector, the impact of heat waves has also been observed in other key sectors such as agriculture, energy, urban, housing, water, transport, forest, communication, etc. in the recent past, which calls for mid-term and long-term strategies that involve both structural and non-structural changes to mitigate the impact of heat waves on the overall economy at large. Mitigation measures can be varied for different sectors and therefore, coordinated measures cutting across the sectors are very important.

The issue of Heat Wave has been given due consideration in the National Disaster Management Plan (NDMP) 2019. While revising the NDMP of 2016, six new disasters were included in the NDMP 2019, and Heat Wave was also one of the six new disasters. With this inclusion, the roles and responsibilities of Central and State level stakeholders were indicated in a time-bound manner in sync with the time frame of the Sendai Framework for Disaster Risk Reduction (SFDRR). In addition, a separate section on Heat Wave has also been included in NDMP 2019 under Hazard, Risk, and Challenges, where different criteria and characteristics of Heat Wave have been explained.

A careful review of the data from different sources suggests that the deaths related to Heat Wave registered the maximum number in 2015. However, after the issuance and implementation of Heat Wave guidelines and HAPs at the National, State and District levels, there has been a considerable reduction in the number of deaths, largely due to better monitoring and management of heat wave conditions.

Objectives and Expected Outcome of the Workshop

One of the prime objectives of the National workshop was to collaboratively collect wisdom to develop India's Framework for heat wave mitigation. By bringing together stakeholders from Government and private Institutes, health sector, meteorological departments, urban planners, NGOs, and community organisations. The framework in context aims to integrate various strategies ranging from immediate emergency response to long-term adaptation for building heat wave resilience. The workshop aims at a better understanding of the scientific basis for addressing the challenges of heat wave mitigation in a wholesome manner.

The workshop was designed to facilitate discussions on guidelines, policy frameworks, and best practices by bringing together experts from various fields and sectors to review the preparedness of the States for Heat Wave Season 2024. It also aimed to provide a roadmap for holistic heat wave management and mitigation and outline actionable and practical strategies that can be implemented at National, Regional, and Local levels, ensuring that the response to heat waves is proactive, efficient, and sustainable in the short, medium and long term.

In order to develop advanced HAPs that are efficient in both, managing the immediate impacts of heat waves but also able to address long-term impacts and help in reducing future warming, sectoral deliberations could take place during this National Workshop on key components such as early warning system, public awareness and community outreach, health systems preparedness, urban planning for reducing urban heat island effect, capacity building of key sectors, financing and implementing heat wave mitigation actions, and monitoring & evaluating them at local level.

The workshop would also bring together Government representatives from various States, districts and cities that have had experience of extreme heat wave spells in the recent past. The resource persons and the participants would share insights into how the extreme heat conditions uncovered the underlying vulnerabilities and how they managed to respond to such unprecedented conditions. As an exemplary approach, this workshop looked forward to hosting the most vulnerable communities such as street vendors, slum dwellers, rag pickers, construction workers, etc., who are at the bottom of the pyramid and look forward to hearing from their lived experiences with extreme heat to better design heat mitigation solutions that addresses their concerns.

The expected outcomes of this event included:

i. Updating of HAPs for 2024 by vulnerable States /districts for improved plan formulations.

ii. Increased awareness, enhanced knowledge sharing for capacity building, strengthened policy formulation with real life examples, strengthened networking & collaboration among key sectors for a heat resilient future.

Schedule of the Workshop

Day-1 (13th February 2024)

REGISTRATION (09.00-10.00)	
INAUGURAL SESSION (10.00 - 11.00)	
10.00 - 10.15	Welcome Address and Context Setting: Shri Kamal Kishore, Former Member and HoD
10.15- 10.30	Special Address: Dr M. Ravichandran, Secretary, Ministry of Earth Sciences
10.30- 10:50	Inaugural Address: Shri Kiren Rijiju, Hon'ble Union Minister of Earth Sciences
10.50- 11:00	Vote of Thanks: Shri Kunal Satyarthi, JS, NDMA
HIGH TEA BREAK (11.00 – 11.30)	
TECHNICAL SESSION I (11.30 – 13.00) **Early Warning and Climate Services** **CHAIR: Dr Krishna S. Vatsa, Member, NDMA** **Moderator: Col. Kirti Pratap Singh, Advisor (Ops & Comn)** **Rapporteur: Dr Swati Sulagna, Sr. Cons.**	
11.30 – 11.45	Weather Services and Effectiveness of Heat Wave Warnings: Dr M Mohapatra, DG, IMD
11.45 – 12.00	Future Climate Projections for Heat Waves: Dr Roxy Mathew Koll, IITM, Pune
12.00 – 12.15	Health-Based Thresholds for Early Warning Systems: Shri Abhiyant Tiwari, NRDC India,
12.15– 13.00	Suggestions from Stakeholders
LUNCH BREAK (13.00 – 14:00)	
TECHNICAL SESSION II (14.00 – 15.30) **Health Impacts of Heatwave** **CHAIR: Dr Dileep Mavalankar, IIPH Gandhinagar** **Moderator: Ms Rakhee Sadhu, DS, NDMA** **Rapporteur: Shri Anuj Tiwari, Sr. Cons.**	
14.00 – 14.15	Health Impacts of Heatwave and Preparedness Measures: Dr Harshal Salve, AIIMS, New Delhi
14.15 – 14.30	Mechanism of Data Collection and Sharing for Heatwave Related Morbidity & Mortality and Preparedness & Mitigation Measures: Dr Aakash Srivastava and Dr Purvi Patel, NCDC MoHFW
14.30– 14.45	Health Sector Data Collection for Cities: Dr Dileep Mavalankar, IIPH Gandhinagar
14.45 – 15.00	Impact of Heat Waves on All-Cause Mortality in India: Dr Siddartha Mandal, Scientist, CCDC
15.00 – 15.30	Discussion on Reducing Heat Wave Morbidity/Mortality and Robust Database
TEA BREAK (15.30 – 16.00)	
TECHNICAL SESSION III (16.00 – 17.30) **Impact of Heatwaves on Infrastructure & Production Sectors and Mitigation Strategies** **CHAIR: Shri Amit Prothi, DG, CDRI Delhi** **Moderator: Dr S K Jena, JA(RR)** **Rapporteur: Shri Priyank Jindal, Sr. Cons.**	
16.00- 16.10	Risks to Critical Infrastructure due to Extreme Heat: Shri Amit Prothi, DG, CDRI Delhi
16.10- 16.20	Impact and Risk Mitigation of Extreme Heat on Agriculture: Dr V K Sehgal, IARI, New Delhi and Dr Sanjoy K Bandyopadhyay, IARI
16.20- 16.30	Heatwave Challenges to Livestock and Mitigation Measures: Dr Vijay Teotia and Dr Sujit Dutta, DAHD, Govt of India
16.30- 16.40	Model Heat Action Plan for Indian Cities: Dr Rajashree Kotharkar, VNIT Nagpur
16.40- 16.50	Heat Wave Risk Assessment Using an Indicator-Based Approach: Subdistrict Levels Analysis of Maharashtra State: Prof Parmeshwar Udmale, IIT Bombay
16.50-17.00	Affordable Strategies to Reduce Heat Stress in Urban Housing: Prof. Minu Aggarwal, CEPT
17.00 - 17.20	**Sectoral Burden of Rising Heat:** • Ministry of Road Transport and Highway: Shri Alok Kumar and Shri Vikram Mittu • Ministry of Railways: Shri Utkarsh, Executive Director (Safety) • Water Sector: Dr Alok Sikka, IWMI • Power Sector: Shri Alok Kumar, Senior General Manager Grid India
17.20 – 17.30	Discussion Q&A

DAY-2 (14th February 2024)

TECHNICAL SESSION IV (10.00 – 11.30)	
Experience Sharing of Heatwave Management: Voices from the Field	
CHAIR: Shri Sanjeev Kumar Jindal, Additional Secretary, MHA	
Moderator: Shri Kunal Satyarthi, JS, NDMA	**Rapporteur: Ms Shalini Singh, Sr. Cons.**
10.00- 11.30	**Sharing of Experience of Extreme Heat Management at local level:** • Dr Sujeet Kumar Yadav, Chief Medical Superintendent, Ballia, UP • Shri Ramveer Tanwar, Pondman (Say Earth), Delhi • Shri Ravindra Kumar, DM, Bareilly, UP • Shri G. S. Naveen Kumar, Relief Commissioner, UP • Shri Kunal Aggarwal, IG, SDRF, West Bengal • Challenges of Urban Heat Management and Heat Resilient Cost-Effective Urban Design Strategies: Ms Minni Sastry UNEP, Delhi
TEA BREAK (11.30– 12.00)	
TECHNICAL SESSION V (12.00 – 13.30)	
Urban Heat Island (UHI) and Impact on Vulnerable Communities: Preparedness and Mitigation	
CHAIR: Lt. Gen. (Retd.) Syed Ata Hasnain, Member, NDMA	
Moderator: Shri Nawal Prakash, JA, (IT &Comn)	**Rapporteur: Shri Abhinav Walia, Sr. Cons.**
12.00 – 12.30	Experience Sharing of Heatwave Management • Brig. Kuldeep Kumar Ashta. Medical Hospital Jalandhar • Maj (Dr) Vishnu Prasad R, OC, SHO Jodhpur • Lt. Col Devendra Dodeja, Army Syndicate
12.30 – 12.40	Impact of Heat on Vulnerable Slum Communities & Possible Solutions: Shri Siraj Hirani, MHT
12.40 – 12.50	Community Based Heat Assessment and Actions for Vulnerable Community: Shri Manu Gupta, SEEDS
12.50 – 13.10	Listening to the Affected People Engaged in Supporting Services, Construction and Informal Sector Enterprises • Ms Laxmi • Ms Uma • Shayra Bano • Ms Raziya • Jarino Begum • Kiran Naval Kishor
13.10 – 13.30	Discussion Q&A
LUNCH BREAK (13.30 – 14:30)	
TECHNICAL SESSION VI (14.30 – 16.00)	
Heat Action Plans (HAPs) - Preparedness and Mitigation Strategies	
CHAIR: Safi Ahsan Rizvi, Advisor, NDMA	
Moderator: Ms Sumita Singh, JS (IC)	**Rapporteur: Shri Amit Tuteja Sr. Cons.**
14.30– 14.40	Extreme Heat Management: Shri Anand Malligavad, Lakeman, Bangaluru
14.40– 14.50	Heat Action Platform and Heat Resilience: Kurt Shickman, Washington, DC (online)
14.50– 15.00	Past Learnings and Next Generation City Heat Action Plan: Dr Mahaveer Golechha, IIPH Gandhinagar
15.00– 15.10	Nagar Van Yojna- Role in Heat Wave Management: Shri Sanjay Kumar Shukla, I/C NAEB, Green India Mission, MoEFCC and Member Secretary, Central Zoo Authority
15.10-15.20	SOP for Developing City Heat Action Plan: Shri Rohit Magotra, IRADe, New Delhi
15.20-15.30	Evaluation of HAPs: Shri Aditya Valiathan Pillai, Sustainable Futures Collaborative, Delhi
15.30-15.40	Role of Passive Buildings for Long-term Urban Heat Mitigation: Ar. Ashok B Lall
15.40-15.50	India Cooling Action Plan: Shri Aditya Narayan Singh, Scientist F, Ozone Cell, MoEFCC
15.50 -16.00	Discussion Q&A

WRAP-UP SESSION (16.00 – 17.00)	
Mainstreaming Mitigation Strategies	
CHAIR: Shri Rajendra Singh, Member, NDMA	
Moderator: Ms Rakhee Sadhu, DS, NDMA	**Rapporteur: Shri Vazeem Iqbal, Cons.**
16.00-16.30	Key Takeaways from all the Sessions: Shri Kunal Satyarthi JS, NDMA and Shri Abhiyant Tiwari, NRDC India, Delhi
16.30 – 16.45	National Heatwave Mitigation Strategy: Dr Krishna S. Vatsa, Member, NDMA
16.45 – 17.00	Concluding Remarks: Shri Kamal Kishore, Former Member and HoD
HIGH TEA (17.00-17.30)	

INAUGURAL SESSION: Welcome and Context Setting

Rapporteur:
Brahm Parkash Yadav,
Sr. Consultant
(Drought and Heat Wave)

The Inaugural Session of the Workshop commenced with the National Anthem and Lighting the lamp by the Chief Guest and the Dignitaries.

Welcome Address

Shri Kamal Kishore, Former Member and Hod, delivered the welcome address. He conveyed his gratitude to Shri Kiren Rijiju, Hon'ble Minister of Earth Sciences, for sparing time from his busy schedule to inaugurate the National Workshop on Heat Wave 2024, "Management Interventions and Mitigation Strategies for Heat Wave". He conveyed his special welcome to the Hon'ble Minister as NDMA is taking forward the foundation laid down by the Hon'ble Minister on disaster management, including Heat Wave, when he was Minister of State (Home) and In charge of Disaster Risk Management. He informed the delegates that the Hon'ble Minister was designated by the UN as Disaster Risk Champion for his commendable work in Disaster Management in the Asia Pacific region.

Shri Kamal Kishore appreciated the collaboration and close coordination of NDMA with the Ministry of Earth Sciences and India Meteorological Department on Heat Waves for the last five to six years and also extended a welcome to Dr Ravichandran, Secretary, Ministry of Earth Sciences, for participating in the Inaugural Session as a special guest.

While setting the context for the workshop, Shri Kamal Kishore highlighted three main issues:

i. NDMA organizes these annual workshops on heat waves to take stock of its preparedness for the upcoming Heat Wave Season 2024. NDMA has prepared Heat Wave Guidelines in 2016, which were updated in 2019, and deliberations in these two days should be used to take stock of effectiveness of Heat Action Plans (HAPs) prepared by States. He mentioned that despite excellent work done in the field of heat wave management, there had been reports of mortality in a few clusters in 2023. He further emphasised that there is a need to understand why mortality (no. of deaths) due to heat waves in 2023 was higher as compared to recent previous years. We need to understand what needs to be improved, such as:

   a. Early warning system and analysis and communication of warnings

   b. Practicality and Implementation of Heat Action Plans (HAP)

   c. Community Awareness & Outreach and Capacity Building at local level

ii. The annual heat wave workshop 2024 has been designed to be more people-oriented. The delegates have been invited by the Army, various Infrastructure and Production Sectors and from the vulnerable communities to understand the ground reality and actions taken by the people for tackling heat wave problem.

iii. The focus of the heat wave workshop has so far been on saving lives. However, the time has come to understanding the impact of heat waves on different sectors due to climate change and identify mitigation strategies to minimise the loss due to the heat waves on infrastructure and livelihood. Therefore, the scope of the workshop has been broadened by inviting the Ministries from different sectors like Roadways, Railways, Power, Housing, Water, Agriculture and livestock etc.

While concluding his address, Shri Kamal Kishore asserted that we should be better prepared this year for heat wave management and achieve the target of zero mortality as per the vision of Hon'ble Prime Minister and Hon'ble Home Minister of India.

Special Address

Dr M. Ravichandran, Secretary, Ministry of Earth Sciences (MoES), while delivering his special address, said that early warning and forecasting of heat waves were very important for its proper management and mitigation. He said that in addition to maximum temperature, other weather parameters like wind, humidity and night temperature are equally important and he opinioned that heat wave stress index should be prepared at local level. MoES has analysed how temperatures have evolved over the past 100 years,

and stakeholders at the local level should be aware of changes happening in their region and equip themselves to save the lives of the people. He further stated that public awareness, capacity building and education of the common man about the heat stress index are equally important so that vulnerable populations and sectors can prepare for handling the heat waves. He believed cooling centres and first-aid medical facilities must be available at the local level. Urban heat Islands are increasing, and long-term mitigation measures for heat health preparedness are necessary to overcome this urban phenomenon. Inter-agency and inter-departmental coordination, Community engagement and awareness are key to success.

While concluding his address, he said that the heat wave workshop should not be a one-time event. All the stakeholders should meet more frequently, and experience shared & lessons learned should be implemented at ground level.

Inaugural Address

Shri Kiren Rijiju, Hon'ble Minister of Earth Sciences, delivered the inaugural address. Hon'ble Minister expressed his happiness and appreciated NDMA for conducting this heat wave workshop well in time. The planning in the month of February will help States to be better prepared in heat wave management for the ensuing heat wave season 2024. He appreciated the exhaustive technical schedule of this workshop covering all the aspects of impacts of heat waves on various sectors. He said that all the stakeholders would benefit, and the outcome & suggestion from this workshop should be executed at the local level as a team covering individual, community and policymakers. India has come a long way in disaster management from the time when NDMA was established till today. The scope of work of NDMA has been widened and we have far outpaced and exceeded the commitments made at the time of inception of NDMA. He further said that NDRF and various SDRFs are amongst the finest forces in Disaster Management and under the able leadership of Hon'ble Prime Minister, India has become a leading nation in the field of Disaster Management in the World.

Hon'ble Minister said that heat wave is a serious concern for everyone, and climate change has a tremendous impact on the life of every living being. This threatening phenomenon starts affecting various states from April onwards every year. He emphasised the role of human intervention in the natural environment and said that a scientific approach to manage and modify the climate in the long run is very important. Hon'ble Minister expressed his satisfaction that meticulous planning has been done as drawn in the technical program of this workshop covering all the aspects of heat wave preparedness and management to save the life of common people. He emphasised that all the affected States must draw their HAPs as per local weather and climatic conditions. Experience & expertise must be exchanged to make HAPs implementation successful. Heat waves should also be integrated with other hazards for making it as a multi-hazard management system.

From his own experience, Hon'ble Minister said that NDMA is performing extremely well having professional

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people from various backgrounds. He highlighted the importance of collaboration & teamwork and assured all the possible support from the from the Government of India for undertaking Disaster Management activities. He conveyed his best wishes for the successful workshop and hoped that we all will be better prepared than before for tackling heat waves in the ensuing summer season 2024.

Vote of Thanks

Shri Kunal Satyarthi, Joint Secretary NDMA, on behalf of all the members and officials of NDMA, 21 participating States, 18 Ministries of Govt. of India, knowledge Partners, stakeholders, professional Institutes and Experts expressed his gratitude to Shri Kiren Rijiju, Hon'ble Minister of Earth Sciences for sparing his valuable time, in spite of his busy schedule, to be the Chief Guest and doing honours of inaugurating the National Heat Wave Workshop 2024 organised by NDMA. He also thanked the Hon'ble Minister for his appreciation of the exhaustive and inclusiveness of the program of Workshop covering all possible sectors. He felt gratitude to the Hon'ble Minister for appreciating the work being done by NDMA, NDRF, SDRFs.

Shri Kunal Satyarthi thanked Dr M. Ravichandran, Secretary MoES, for being present today as Guest of Honour and delivering his special address and for providing full support in the field of Early Warning System with the help of the India Meteorological Department (IMD). He also acknowledged and thanked Shri Kamal Kishore, Member and HoD, NDMA and other members of NDMA for providing leadership and designing the whole program of the workshop. Shri Kunal Satyarthi also thanked Additional Secretary MHA, DG IMD, IG (NDRF), delegates from States & Ministries, Institutions, Departments and speakers & Experts for their participation in this workshop. He also thanked all the officials of NDMA for providing full support in organising this workshop.

TECHNICAL SESSION I: Early Warning and Climate Services

Chair:
Dr Krishna S. Vatsa,
Member, NDMA,

Moderator:
Col. Kirti Pratap Singh,
Advisor (Ops & Comn)

Rapporteur:
Dr Swati Sulagna,
Sr. Consultant (Climate Change)
NDMA

Dr Krishna S. Vatsa, Member, NDMA, welcoming the distinguished panel emphasised that the first session on early warning and climate services is the most important aspect of heat wave management and will set the tone for the entire workshop. Giving the example of the heat waves that happened in the month of February 2023, he pointed out that "rising temperatures is a new reality", with heat waves showing anomaly in duration, seasonality as well as spatial occurrence.

i. The occurrence of heat waves is observed across plains, hills and coast where the temperature thresholds vary immensely. Hence it is critical not only to establish the local temperature threshold but also inculcate the threshold into day-to-day management and monitoring.

ii. Over time it is also becoming clear that the interplay of humidity and temperature creates severe heat wave conditions. Adaption to occurrence of heat wave in high humidity conditions by the community needs to be ascertained. He further emphasised that delivery of accurate early warning services to States/ Districts/ Communities/people is of paramount importance in heat wave management.

Weather Services and Effectiveness of Heat Wave Warnings

Speaker: Dr M Mohapatra, Director General, IMD

Dr M Mohapatra, DG, IMD put forth that IMD monitors temperature and other meteorological conditions like humidity, wind direction and wind speed to determine heat wave conditions. As per the analysis of temperature, it is becoming evident that the spatial extent and occurrence of heat wave conditions are increasing year by year. Comparatively, El Nino years have more intense and spread of heat wave conditions than La Nino years. Vulnerability of States on the East Coast like Odisha, West Bengal, Andhra Pradesh etc. and states in Northwestern India are exhibiting more heat wave conditions.

Determining thresholds for local areas with different topography is very important in forecasting heat wave and its management. Based on daily maximum/minimum temperature station data, climatology of maximum/ minimum temperature and other parameters are prepared based on the data of 1991-2020 -the temperature and other parameters are compared with normal values of the stations to find out departure/ deviation from normal maximum/minimum temperature etc. of the day for a particular station. Based on numerical models and observed data utilising a decision support system, IMD issues daily forecasts of temperature and other parameters, heat wave forecast up to 5 days, extended range forecast up to 4 weeks on every Thursday and monthly seasonal forecast for every month and season in the beginning of month/season. Based on the forecast, IMD sends out warnings to MHA, NDMA, SDMA, Chief Secretaries, State Emergency Operation Centres, District Authorities, Health Department, Agriculture Department, Railways, Road Transport, Press and Electronic media, and Heat Action Plan Authorities at City, District, and State levels through e-mail, Common Alert Protocol, and social media.

Heat wave forecasting has undergone significant improvement in the last five years. Impact based forecast in colour coded form and information about impact expected with action suggested is disseminated to all stake holders. Heat Wave and Warm Nights are characterised by abnormally high surface air temperatures. The daily forecasts also have an impact-based warning for all the stakeholders. Impact-based forecasts, with the help of tools which include Hot Weather Hazard Analysis (considering different meteorological parameters), Operational Experimental Heat Index, GIS-based Heat Wave forecast and Warning Services products, GIS-based Socio-Economic Exposure products, Percentile-based Extreme Temperature information, and Vulnerability Atlas with respect to Heat Waves, inform the following:

i. Absolute Maximum Temperatures, their departures and percentile status

ii. Absolute Minimum Temperatures, their departures and percentile status

iii. Relative Humidity Forecast

iv. Wind Speed Forecast

v. Persistence of the above conditions

Impact based Forecasting (IBF) requires further fine-tuning of Heat Waves warning: -

i. Multistakeholder team having experts from academia/research and domain experts from specific sectors (agriculture, health, energy, etc.) as well as operational setup from such sectors.

ii. Easy accessibility of data from the sectors.

iii. The aim of the team would be to devise methods and threshold for targeted region wise sector specific impact-based forecasting services.

Heat Waves Over India - Observed Changes, Future Projections, and Compound Risks

Dr Roxy Mathew Koll, IITM

i. North and Central India is a high heat wave risk prone region.

ii. El Nino years are not necessarily when the risk of heat waves is largest for India.

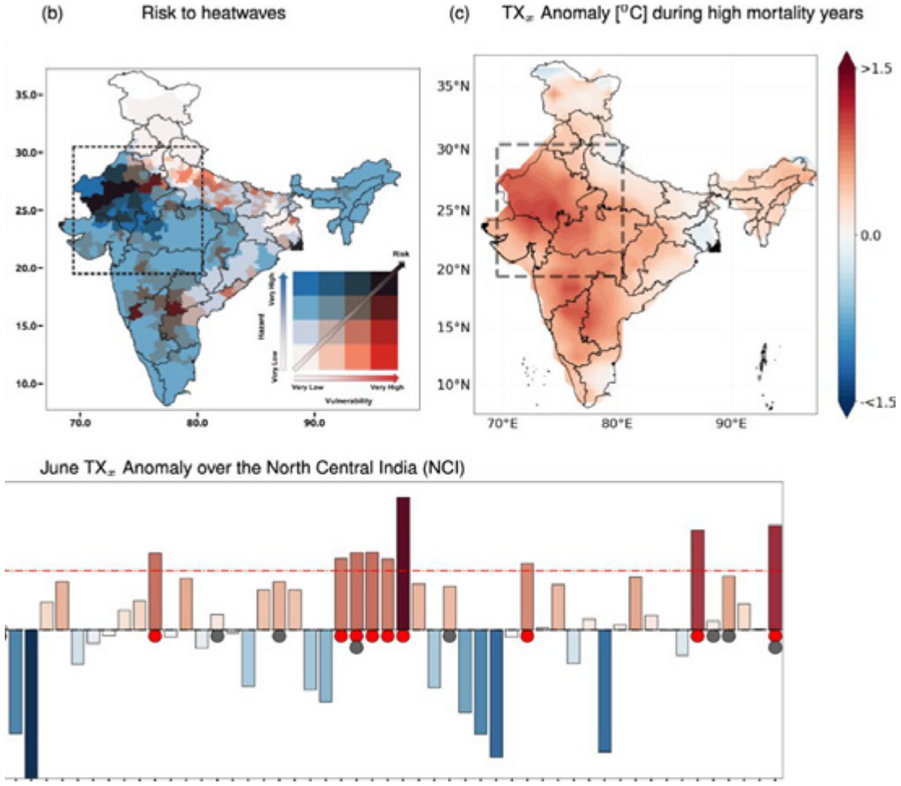

Fig. 4. EL Nino and Heat Waves linkages

iii. Heat waves are projected to increase in intensity, frequency, duration, and area covered. Maximum temperatures have increased diagonally across India, with the largest trends in the northwest. All India's averaged frequency of summer heat waves is projected to increase to about 2.5 events per season by 2040–2069, with a further slight rise to about 3.0 events by 2070–2099 under the IPCC RCP4.5/SSP2 emission scenario. The average total duration of summer heatwaves is projected to increase to about 15 (by 2040–2069) and 18 days (by 2070–2099) "per season" during these future periods under RCP4.5/SSP2 emission scenario.

iv. In Indian urban cities, including Bengaluru and Hyderabad, concurrent hot day and hot night events are projected to increase by 4, 6, and 8 folds of the current level in India under the 1.5, 2, and 3^0 C warming worlds, respectively.

v. Night-time temperatures are important for understanding urban heat islands.

vi. Compound risks need to be considered while considering heat

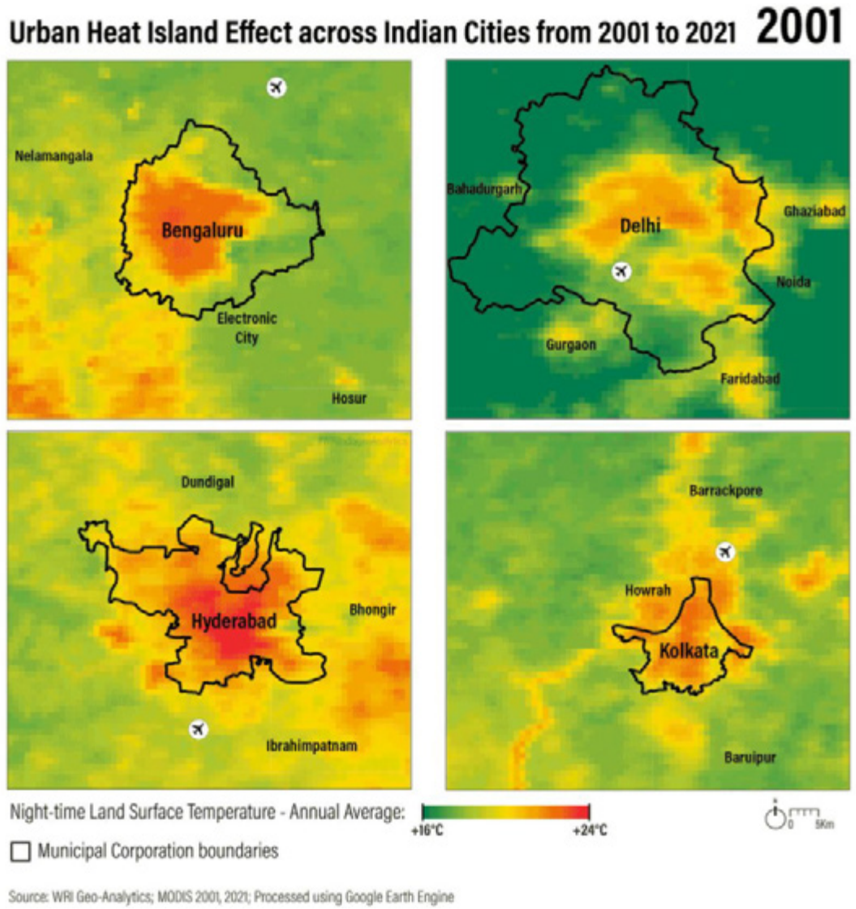

Fig. 5. Urban Heat Island effect across Indian Cities from 2002 to 2021

wave management. Adding other overlapping factors like — humidity, rainfall deficit, wildfire, air pollution etc., is important.

vii. Hazards like heatwaves become lethal when the most vulnerable sections of the population are exposed to it for prolonged periods. Especially the night time temperatures and the urban heat island during the day in urban areas are resulting in significant heat health impacts.

viii. The models and data to identify heatwave/compound hotspots may be identified and subsequently managed by cutting down working hours in the peak season for those working out in the sun (construction, agriculture, traffic police, etc.) and commuting during peak hours (schools).

ix. Policies that prioritise ecosystem-based urban-scaping may be preferred over other mitigation measures. Open green spaces and natural environment with trees can help release heat faster during the night

x. Predict climate-sensitive diseases and heat-related incidences well in advance by training forecast models with the past climate and health data.

Thresholds for Heat Health Warning Systems - Challenges and Opportunities

Shri Abhiyant Tiwari, National Resources Defense Council

i. Heat-related mortality for vulnerable people (adults over 65 years of age) increased by approximately 68% between 2000-2004 and 2017-2021. Annual health-related deaths are projected to increase by 370% by mid century

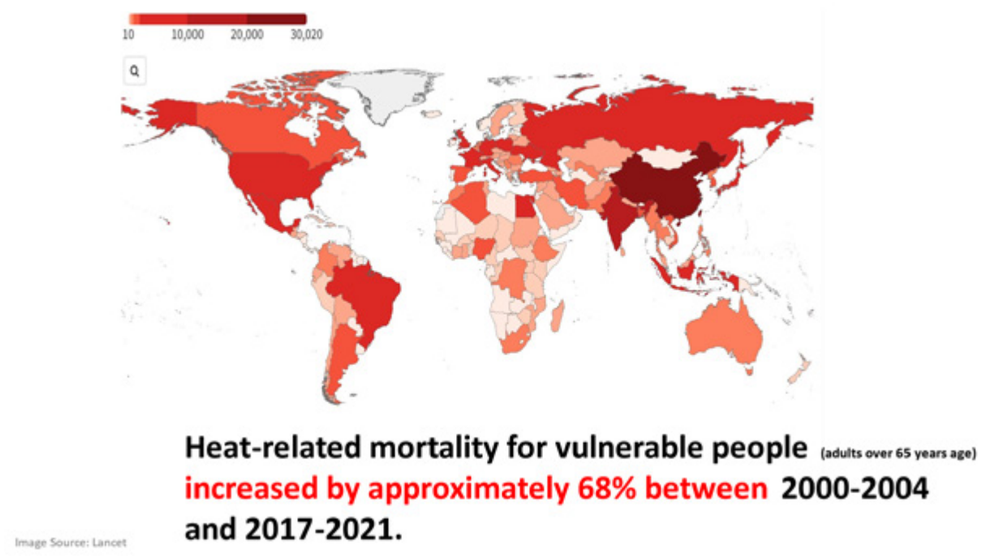

Fig. 6. Heat-related mortality for vulnerable people

ii. Heat Health Warning Systems is an integral part of a wider Heat Health Action Plan which provides meteorological and/or climate-prediction-based information (forecast) on the likelihood of forthcoming hot weather that may have an effect (impact) on health.

iii. Heat-Health Action Plan (HHAP), provides meteorological and/or climate-prediction-based information (forecast). This has interventions designed to reduce the effects of hot-weather extremes on health.

iv. Early warning services have a profound impact on heat-related illness and mortality. It is important that steps may be taken to make it effective at the local level.

v. Health impact variables such as All cause daily mortality count data, cause-specific daily mortality count data, hospital daily admissions count data, and emergency ambulance services daily call count data can be used.

vi. The epidemiological study method informs local heat health effects and responses over time and can help in planning heat adaptation. While performing the time series analysis, we need to consider confounders like air pollution, other disease outbreaks, lag, or acute effects of heat, etc. Such studies can be undertaken by an epidemiologist, or a biostatistician stationed at State/District Medical Colleges, Public Health Institutions, etc.

vii. In situations where there is basic meteorological information but no health data, a percentile-based threshold (90^{th}, 95^{th}) could be contemplated as a warning trigger value.

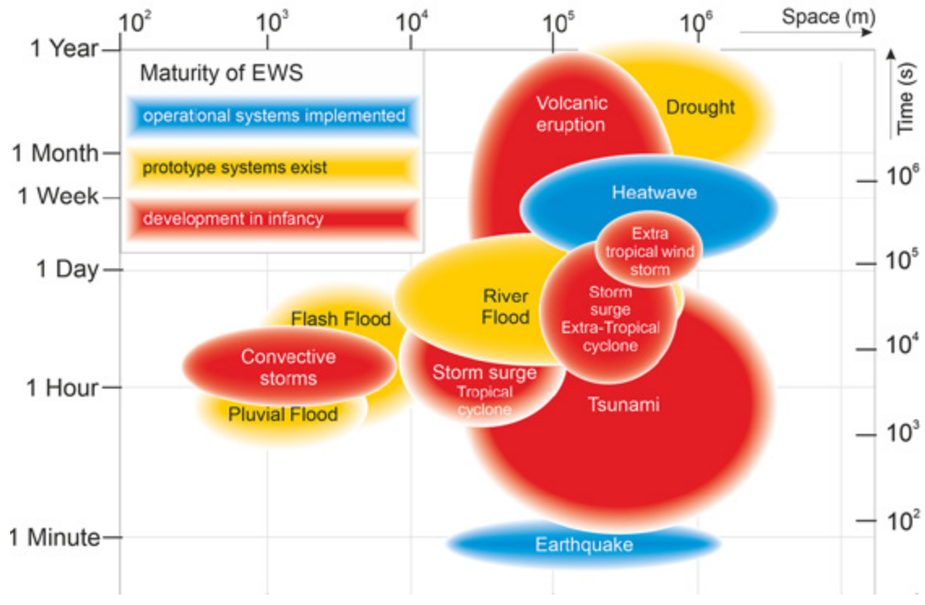

Fig. 7. Maturity of impact forecasting systems

viii. Ambient temperature doesn't vary much geographically within the district unless there are major differences in contour/weather system.

ix. Threshold estimation should be done at Megacity (Population > 1 million) and District levels. They should be the operational units for HAP development and implementation.

x. States should develop state-specific guidelines using national guidelines issued by NDMA, and cities/districts should prepare and implement their local heat action plans with locally determined thresholds for early warning.

xi. Several constraints/dilemmas arise in decision making that need to be sorted, like determining thresholds for heat like choosing the methodology between biostatistical simple and biometeorological complexed. Ensuring that the forecasting has high confidence and is reliable. It is also confounding which heat health impact data can be used to gauge the real impacts of heat on human health.

Actionable Points

i. Impact Based Forecasting (IBF) requires further deliberation in collaboration with a Multistakeholder team having experts from academia/ research as well as operational setup from specific sectors to devise methods and thresholds for targeted region-wise sector-specific impact-based forecasting services.

ii. Compound risks with other overlapping factors like — humidity, rainfall deficit, wildfire, air pollution etc. needs to be considered.

iii. The thresholds of local temperatures need to be accounted for considering heat waves.

iv. Early Warning Systems must be enhanced and effective to lower mortality due to heat wave.

TECHNICAL SESSION – II: Health Impacts of Heat Wave

Chair
Dr Dileep Mavlankar,
IIPH, Gandhi Nagar

Moderator
Ms. Rakhee Sadhu,
Dy. Secretary, NDMA

Rapporteur:
Shri Anuj Tiwari,
Sr. Consultant, NDMA

This session was focused on the Health Impacts of Heat Wave. The session was chaired by Dr Dileep Mavlankar from IIPH, Gandhi Nagar. Other speakers of the session included Dr Harshal Salve from AIIMS New Delhi, Dr Akash Srivastava & Dr Purvi Patel from NCDC and Dr Siddhath Mandal from CCDC.

The Chair of the session started the session by highlighting the significance of the health impact of heat wave which results in casualties and prolonged illnesses. He invited the speakers of the session to speak on related issues.

Health Impacts of Heat Wave and Preparedness Measures

Dr Harshal Salve, AIIMS

He started his presentation by emphasising that for any emergency preparedness comes first, so NDMA

initiative on Heat Wave at this point of time is commendable. He focused on **scientific evidence of heat wave impacts on health** in his presentation. He said that this problem is high as well as hidden. He also drew attention towards the correlation between environment & climate change with the heat wave impact.

i. He described the epidemiology of climate change and health with the help of Agent, Host and Environment and their interrelationships where Extreme Heat/Heat Waves are an environmental factor that influences and affects human behaviour, pathogen maturation and multiplication. He explained Heat Wave & all-cause mortality and Heat Wave & cause specific mortality.

ii. During the presentation, he talked about linkages of climate change where exposure to extreme heat could cause cardiopulmonary health outcomes, which could cause acute coronary events, heart failure, chronic respiratory diseases, and allergic disorders. Exposure to extreme heat can either cause:

   a. Failure of homeostasis of the body, which can lead to exacerbation of cardiovascular diseases and chronic respiratory diseases among the elderly, ultimately leading to death (or)

   b. Increase aeroallergens, pollen, ozone, etc. causing exacerbation of asthma, leading to death.

iii. He further described various types of vulnerabilities of Heat Wave which could be Social, Economic, Geographical, Political and Biological

iv. He stated that the complexity of interaction of various environmental risks and health outcomes makes generating health evidence very challenging.

v. With the help of various studies, he explained what the all-cause mortality data from across the world had informed:

   a. 6.5% increase in New York during heat wave, higher among 15-64 years of about 37% of the cases registered in Australia.

   b. 2.8% increase for each 0.56^{0}C increase in heat wave intensity.

   c. 4.2% increase for each extra day, a heat wave lasted.

   d. Higher in the Mediterranean region.

   e. Higher among specifically those who are confined to bed (of about 5.5 times), who lived alone (of about 2.3 times) and who particularly lived on the top floor of a building (of about 4.7 times)

   f. In Korea, heat waves have caused a three times increase in cerebra-vascular disease related to mortality, and in China, it increased mortality due to cardiovascular disease by 1.01 times and chronic respiratory diseases by 1.14 times.

vi. On the impact of heat wave on health in India, he referred to research which discussed the impact of ambient air temperature on human health – an increase in the all-cause mortality rate of 41% was reported during a heat wave in India and that current evidence on the effect of ambient temperature and human health is sufficient to initiate an integrated response from policy makers, climate scientists, and public health practitioners in India.

vii. In India, about 97 districts fall under the High Heat Vulnerability Index category and 10 fall under the Very High Heat Category.

viii. Studies suggest that mortality increases by 11% when the mean daily temperature crosses 40^{0}C and that the maximum effect is on day 2 of the maximum temperature. Mortality due to non-communicable diseases increase by 1.57 times during a heat wave and men suffer 1.38 times more than women.

ix. He also highlighted there is scarcity of studies which can describe the relationship between the increase in ambient temperature and cause-specific mortality in India. He also shared how burden of CPD risk factors vary in rural and urban areas.

x. He went on to list the cardio-pulmonary diseases (cardiac and pulmonary) and the burden of such diseases in terms of Disability-adjusted life years (DALYs) Loss. He explained how non-optimal temperatures are one of the major underlying drivers for causing ischemic heart diseases, pulmonary diseases including COPD, Asthma, etc.

xi. He elaborated upon the major domains of preparedness which included Situation Analysis, Capacity Building and System Strengthening, Monitoring, Surveillance and Research, Integration of Cardiopulmonary Disease Management during Heat Wave and Advocacy and Communication.

xii. He said that there are some guiding principles for preparedness. Multi-stakeholder engagement, Science based decision making, Communication, working with national programmes, Community participation are some of the important guiding principles for preparedness.

xiii. He emphasised focusing on community based good practices. On Advocacy and Communication, he emphasised including the agenda of climate change impact on CPD in State level meetings with political leadership and other policy makers and to include CPD related actions in State level Disaster Management Plans. He mentioned making use of tools like IEC materials, Alerts generated by IMD and Early Warning Systems for effective communication.

xiv. On Situation assessment, it is pertinent to apply epidemiological principles, coordinate with the health Department and involve medical colleges. He recommended the following specific actions to assess the situation:

- Mapping of human resources, material, and financial resources.
- Assessment of health system including burden assessment of CPD
- Assessment of risk factors for CPD – tobacco consumption, dietary assessment, indoor air pollution, outdoor air pollution, etc.

- Categorisation of zones/districts as per their vulnerability to climate change. State/Districts can further be mapped into three areas (High, Moderate, Low) based on vulnerability to the development of CPD, with risks being tobacco use, obesity prevalence, and heat wave episodes in preceding years, etc.

xv. On Capacity Building and Systems Strengthening, he highlighted how mapping and preparing trained manpower, training manual, standard algorithms for management of CPD, ensuring availability of medicines at levels of health systems are critical.

xvi. He stated that developing a monitoring framework for implementation of preventive and curative actions is important as a part of the monitoring and surveillance of the system. He recommended how integration of CPD management during a natural calamity could be useful through SOPs.

xvii. On CPD Management, he described phase-wise on how SOPs could be designed during an emergency response:

- Preparation Phase – Identify priority conditions, prepare pre-emergency profile of CPD, assess health facility preparedness, establish a health system contingency plan, ensure availability of essential medicines, prepare individualised emergency plans.

- Emergency Response Phase – Integrate, Map CPD service positions and organise service delivery with a focus on primary health care.

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- Post-Emergency Response – Debriefing on lessons learnt from crises, strengthening of health system response and public health response, and monitoring and evaluation of emergency response to CPDs.

xviii. Take home measures informed by him are generating scientific evidence, data sharing, prioritization based on vulnerability assessment, multi-stakeholder engagement, compilation of good practices, etc.

xix. He emphasised the importance of IEC on measures for prevention of CPDs including promotion of physical activity in day-to-day life, reducing sedentary time, balanced nutrition, stopping usage of tobacco and alcohol and regular checking of Blood Pressure and Blood Sugar etc.

Mechanism of Data Collection and Sharing for Heat Wave Related Morbidity and Mortality and Preparedness and Mitigation Measures

Dr Akash Srivastava & Dr Purvi Patel, National Center for Disease Control

Dr Akash Srivastava & Dr Purvi Patel from NCDC started their presentation by informing about the preparation of the National Action Plan on Heat Related Illnesses (NAPHRI), which addresses the health impacts of heat, clinical management & protocols, Health Facility Preparedness Plan (Pre, During, Post-season) and Heat-related illness and death surveillance.

i. They informed that 34 States/ UTs have state level health action plan which includes Health sector activities, Roles and responsibilities of stakeholders and Inter-sectoral coordination platform.

ii. Chronology of events was shared by the speakers

   a. 2015 – initiated during the 2015 Heat Wave under IDSP where all types of HRI were reported, compiled on weekly basis across 17 heat vulnerable States during May to July

   b. 2019 – Adopted by NPCCHH in which a Centre of Excellence was identified, a Technical Expert Group was formed, Surveillance was evaluated in field and Standard reporting formats were prepared

   c. In 2021, the National Action Plan on Heat-Related Illnesses was launched which mandated the daily compilation of heatstroke (suspected, confirmed), emergency attendance, total deaths, death investigation, etc. across 23 heat vulnerable States during March to July.

   d. In 2023, Integrated Health Information Portal was launched where daily aggregated data for heatstroke cases and deaths, emergency attendance, CVD, etc. are recorded digitally from as low as Primary Health Centres and above, and includes information about temperature, relative humidity from IMD. The portal also shared the reporting status of different States.

iii. On Advisory and Capacity Building front, NCDC has prepared training modules on heat and health for State/District Programme Officers, Medical Officers, Community Health Workers, and Community, conducted Special Trainings on Clinical Management and Surveillance. In 2022, NCDC organised a National Workshop where State NPCCHH Officers visited Ahmedabad to study HAP implementation and issued Guidelines on Strengthening Health System Preparedness. NCDC, in 2024, have begun their joint analysis with IMD and is currently exploring:

   a. To build a composite heat index.

   b. Integration with Civil Registration System.

   c. Development of Guidelines/Tools for Emergency Cooling, Autopsy Findings, and Health facility preparedness assessment tool.

Health Sector Data Collection for Cities

Dr Dileep Mavlankar, Indian Institute of Public Health, Gandhi Nagar

i. Dr Mavlankar informed that the Ahmedabad HAP was based on daily all-cause mortality data, heat stroke deaths from 5 major public hospitals, daily max and min temperature for the last 15 years, very simple data and very simple analysis and major revelation on heat mortality correlation.

ii. He explained the impact of high night time minimum temperature.

iii. He also described how reported heat wave deaths are like tip of an iceberg i.e. 10% of those which are reported are visible and 90% of them invisible–Ahmedabad 2010 Heat Wave reported 76 deaths attributed to heat stroke whereas the heatwave caused an excess mortality of 800. He further described how all-cause mortality over time in Ahmedabad peaked during heat waves in 2010 and 2016 and on the peaking of unconsciousness case calls registered during the heat wave (EMRI 108).

iv. He described how the relative risk of death with maximum temperature declined post-implementation of the HAP in Ahmedabad

v. He also informed about the HAP components - Early warning system and inter-agency emergency response plan, public awareness and community outreach, capacity building of medical professionals and reducing heat exposure and promoting adaptive measures.

vi. He said that the morbidity data were taken from hospitals, ambulance pickups, outdoor cases from health centres and hospitals, data from private hospitals, etc. He recommended that the simplest way to obtain heat and mortality data is to get the total bodies burnt or buried in the city at the end of each day and totalling them. He cited the reasons why Indian cities are not able to collect such data, which include: lack of importance, priority or understanding of the dataset, fearing that such data will cause bad publicity against the government and that there is no mechanism to collect and compile this data on daily basis from the crematorium.

vii. At the end of his presentation, he warned that 'This is the beginning of climate change – worse is yet to come – so let's prepare for the next 80 years.

Impact of Heat Wave on All-cause Mortality in India

Dr Siddhath Mandal, Center for Chronic Disease Control

He started his presentation by explaining about the health impacts of heat in which he informed about its effects, mechanistic factors and interaction with other environmental factors.

i. Dr Mandal also informed that Consortium for Climate, Health & Air Pollution Research in India has come out with a study establishing the association between high temperatures, heat waves, and daily mortality in India.

ii. He explained that in the Study, a two-stage analytical protocol was followed, which included city-specific associations and meta-analyses where the study used:

   a. A 5-day average temperature of current and previous 4-day exposure to estimate the effect on early mortality (comparing minimum temperature mortality vs 99th percentile.

   b. Interaction with air pollution: evaluated the association between temperature and mortality corresponding to low, medium, and high air pollution values.

iii. He also explained the association between temperature and mortality. The study observed that –

   a. Longer and more intense heatwaves are linked to increased mortality risk, whereas using shorter and less intense definitions of heatwaves resulted in a higher burden of heatwave-related deaths.

   b. Both definitions of heatwaves and the burden associated with each definition should be incorporated into planning and decision-making processes for policymakers to effectively prioritise public health interventions that address the present and future health risks associated with heatwaves in India.

Following the presentations, the forum was kept open for questions & answers and discussions. Following important issues came up during the discussion:

Dr Krishna Vatsa, Member, NDMA raised the point that all the presentations talked about the socio-economic determinants of deaths, i.e., how it correlates to the socio-economic conditions of the affected population, he requested the presenters to through some light on that. Dr Akash Srivastava of NCDC said that like all other disasters, heat wave also has a socio-economic dimension. He said that certain occupational and demographic groups are more vulnerable to heat waves. Dr Purvi Patel of NCDC said that there are some epidemiological studies done

in India. She referred to such a study done in the slums of Kolkata and said that those living in poor houses, over-crowded rooms or less ventilated rooms etc. were more vulnerable to heat related mortality and morbidity.

Shri Kunal Satyarthi, Joint Secretary, NDMA asked if it is possible to have a definite analysis about whether a person died due to heat wave? Dr Harshal responded to it and said that for this, we need to understand mortality surveillance going on in the country. IN CRS data, they only record the deaths. The cause of death is generally not properly mentioned. This is in 95% of cases. The second component is MCCD, i.e., Medical Certification of the Cause of Death, which is for the deaths happening at an institute or hospital. Such deaths are only 8%. There is also a Sample Registration System (SRS) under Registrar General of India. Under SRS, statistical sampling is done in the country where 45,000 – 50,000 deaths are analysed through verbal autopsy. He said it is difficult to establish whether a death is caused by a heat wave. He suggested that in death certificates additional factors may be included. Mavlankar said that death factors may be classified into underlying and contributory factors. He said this area needs to be further worked upon.

Other issues discussed included -

i. Immediate and antecedent and other factors
ii. Temperature and Humidity combination (Dry vs Wet Heatwave)
iii. Heat Index importance: Thresholds
iv. RGI of cities and Meteorologists
v. Need for robust **data collection** and its analysis to ensure the formulation of evidence-based policies
vi. Need to build the **capacity of doctors, paramedics and volunteers**

Actionable Points

i. The problem is both high and hidden, and worse is yet to come; hence, there is a need to focus on preparedness for the health impact of heat waves.
ii. There is a need to understand different types of vulnerabilities to heat wave impacts like, Social, Economic, Geographical, Political and Biological and address them suitably.
iii. Community-based good practices need to be followed and adopted.
iv. There is a need to prepare and update the health-related action plans for heat waves to reduce mortality and morbidity.
v. Availability and accuracy of data play an important role in preparing for heat wave impacts.
vi. The Impact of heat waves on all-cause mortality needs to be addressed.

TECHNICAL SESSION III: Impact of Heat Waves on Infrastructure & Production Sectors and Mitigation Strategies

Chair:
Shri Amit Prothi,
DG, Coalition for Disaster Resilient Infrastructure, Delhi

Moderator:
Dr S K Jena,
JA (RR), NDMA

Rapporteur:
Shri Priyank Jindal,
Sr. Consultant (DM) NDMA

Risks to Critical Infrastructure due to Extreme Heat

Shri Amit Prothi, DG, CDRI

Shri Amit Prothi, DG, CDRI welcoming the distinguished panel emphasised that the rising temperatures have significant implications, notably impacting critical infrastructures. In 2023, the global temperature reached a record high, approaching the critical threshold of 1.5 degrees Celsius.

i. Research indicates that for every one-degree increase in classroom temperature, there is a corresponding 1% decrease in students' learning ability. This underscores the far-reaching consequences of rising temperatures on educational environments.
ii. Within the European Union, the annual cost of heat and drought damage to the road sector was estimated at 50 million Euros from 1998 to 2010. This financial toll highlights the tangible economic impact of heat-related damage to critical infrastructure.
iii. In the US, sun kinks (buckling of rail) caused over 2,100 train derailments in the last 40 years, equivalent to around 50 derailments per year.
iv. A projected decrease of 20% in renewable water resources is expected for each $1^{0}C$ rise in the global average temperature.
v. The session provided a contextual foundation by emphasising the importance and vulnerability of critical infrastructures to heat. This discussion

was framed within the broader context of the global scale, accompanied by illustrative examples.

vi. The session delved into four main sectors: Buildings, Transportation (Roads, Railways, and Aviation), and Power & Energy. Each sector's sensitivity to heat and its potential consequences were thoroughly examined, contributing to a comprehensive understanding of the challenges posed by rising temperatures on critical infrastructures.

vii. In Railways, for example, according to a study, in Australia, an increase in air temperatures can cause rail-track deformities and can lead to equipment failure, causing operation delays costing from $103 to $138 billion (about $420 per person in the US) by 2100. Sensors fitted above the overhead rail wires can collect real time temperatures to derive the thermal expansion data of tracks. Best practices can be referred to building a resilient rail infrastructure and to learn about impact-based warnings specific to railway assets.

viii. For Roads and Bridges, cool pavements, increasing green cover, highway landscaping, replacing or reconstructing bridge deck expansion joints, use of heat-tolerant steel, etc. can be useful adaptation solutions. The melting of runways in the Aviation sector, damage to navigation equipment in aircraft, etc. are some of the impacts of high temperatures which cause the grounding of flights and cargo losses. Lengthening of runways, improving aircraft technology, cooling measures for aircraft, etc. are some of the adaptation solutions.

Impact and Risk Mitigation of Extreme Heat on Agricultural Crops

Dr Vinay K Sehgal, Indian Agricultural Research Institute and Dr Sanjoy K Bandyopadhyay, Borlaug Institute of South Asia

Dr Vinay K Sehgal, IARI put forth that IMD's definition focuses more on human health impacts. World Meteorological Organisation has not yet adopted a standard and mathematically rigorous definition for heatwaves.

i. Extreme temperatures are a reality in India, significantly affecting crop growth, with higher impacts in areas with higher yields.

ii. Elevated atmospheric CO2 concentrations, coupled with drought and heat stress, can limit soil mobility and root uptake of nutrients, adversely impacting the nutritional content of edible parts.

iii. Need to develop a separate criterion in defining the cardinal temperatures of crops wherein it can be based on percentile deviation from the baseline period and that Heat Wave Magnitude Index can be defined based on the sequence of 3 or more days in which the daily maximum temperature is above the 90th percentile of daily maximum temperature for a 31-day running window.

Crops	Minimum	Optimum	Maximum
Oat	4 - 5	25	30
Maize	8 - 10	32 - 35	40 - 44
sorghum	8 - 10	32 - 35	40
Pearl millet	8 - 10	30 - 32	40
Berseem	3 - 4.0	25 - 27	32
Wheat	3 - 4.5	25	30
Rice	10 - 12	30 - 32	36 - 38

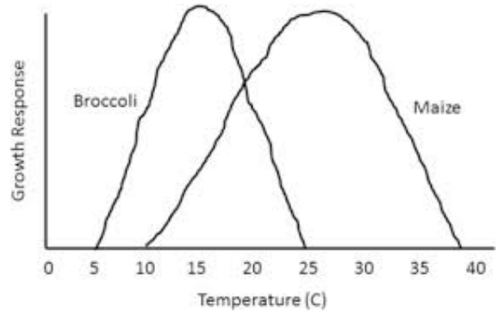

Fig. 8. Cardinal Temperatures of Crops

iv. Described the wheat yield loss due to the March 2010 Heat Wave across States of Punjab, Haryana, and Uttar Pradesh.

v. During 1951 to 2014, in calculating HWMId, there is an abrupt shift in time series, i.e. an increase of over 56% area and a decrease of only 8.5% area across India.

vi. Explained the broader impacts of external Heat/Heatwave on Agriculture:

a) Make the soil dry, decrease the soil carbon causing a reduction in microbial activity, salt buildup and reduced soil productivity.

b) Increases the demand for water, reduces the supply, and increases

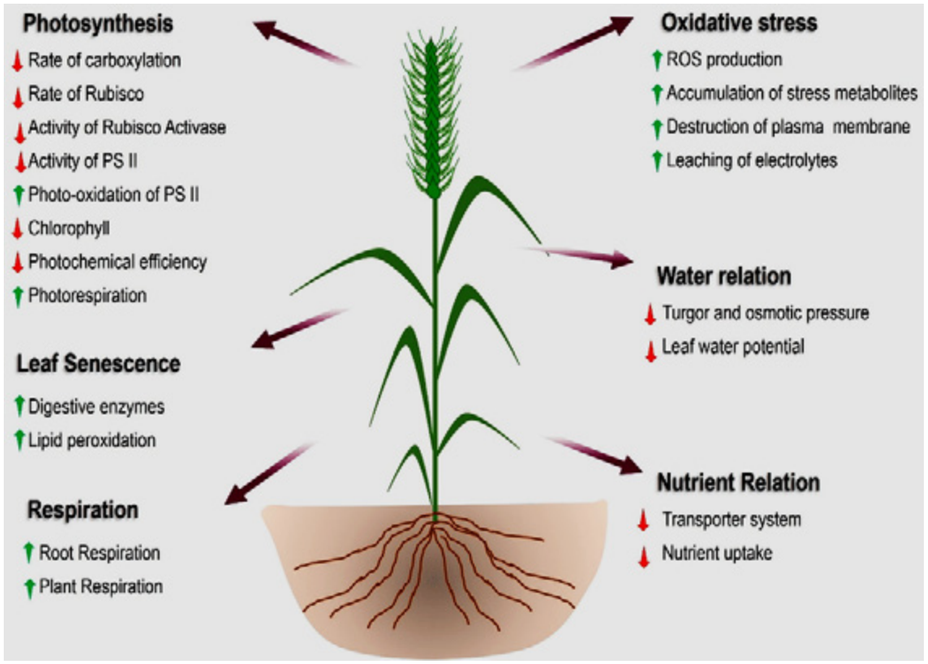

Fig. 9. The upward arrow means increase, and the downward arrow means decrease
Source: Mishra et al., 2023

the use of poor-quality water, reduces crop yield (resulting in the production of shrivelled grains and scaled fruits), limit soil mobility, etc.

c) Regarding livestock management, increased temperatures have caused reduction in milk production, lowered the fertility rate, increased the death rate and costs incurred in providing shelter.

d) Increased temperatures, especially in colder areas, have positively impacted the crop yield by effectively controlling soil borne diseases and pests.

vii. Described in detail the effect of heat stress on wheat – in terms of reducing grain number and weight, decline in crop reproduction, grain filling rate, causing advanced flowering, increase the broken grain, etc., which in turn can affect the nutrient intake of humans, affecting human health with respect to the intake of mineral nutrients, essential amino acids, vitamins, antioxidants, carbohydrates, etc.

viii. Heat Waves can also cause scorching of leaves and twigs, sunburn on leaves, branches and stems, leaf senescence, shoot and root growth inhibition, fruit discolouration, reduction in the internodal health, and often resulting in rapid death of plant parts or whole plant.

ix. Highlighted some examples of Necrosis, where fruit tissue dies on the sun exposed side of the fruit, Browning causing loss of pigmentation in fruit, etc.

x. High Temperatures at night may sometimes lead to complete sterility in rice crops, affecting their booting and flowering.

xi. Few of the adaptation measures in response to high temperatures could be:

a) Monitoring and Early Warning,

b) Preparing crop contingency plans,

c) Replacement of heat-sensitive cultivars with heat-tolerant ones,

d) Choosing crops with a growth duration allowing avoidance of peak stress periods and

e) Crop insurance.

xii. Using the global data (aircraft reports, surface observations, satellite observations, etc) IMD and ICAR have developed a medium-range forecast to inform subject experts for dissemination of information at the national and district level (Weather Based Agro-Advisory Services). Further, crop health monitoring by satellites could improve the Agro advisory services.

xiii. ICAR had prepared 640 district-level contingency plans for weather aberrations in crop, livestock, poultry, and fisheries sectors through a bottom-up approach involving district-level scientists of Agricultural Research Stations and State Agricultural Universities. The plans cover recording occurrences of extreme weather events, including heat waves. Plans include on-farm demonstrations of climate resilient technologies taken up under the National Initiative on Climate Resilient Agriculture across 100 districts.

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xiv. Climate-smart Crop varieties are tolerant to weather externalities, including heat stress and salinity.

xv. Certain agronomic measures include:

a. Adjustment of sowing time

b. Efficient irrigation (drip or sprinkler based)

c. Canopy management.

d. Raised bed planting.

e. Cover crop or intercropping.

f. Fruit bagging, etc.

xvi. There's a need to develop region and crop-specific extreme temperature and heat wave criteria for India.

xvii. 'Agriculture' could be included in national guidelines for the management of heatwaves.

xviii. Successful risk management depends on technological or biological solutions, as well as policy and economic considerations.

xix. An enabling policy framework should be in place, focusing efforts through legal and economic instruments.

Heat Wave Management in Animal Husbandry and Dairy Sector

Dr Vijay Kumar Teotia, Joint Commissioner (Livestock Health)

Dr Vijay Kumar Teotia, Joint Commissioner, DAHD, highlighted that DAHD has been working to provide rapid assistance to states during natural disasters such as heat waves, droughts, and cold waves. The DMP/Guidelines aim to protect livestock assets, rebuild them, and increase awareness in veterinary care.

i. Animal Husbandry is a state subject, and the Department has been supplementing the efforts of various State Governments through schemes which include vaccination and disease control.

ii. States/UTs are advised to set up Disaster Management Plan as per local risk, animal profile, disease epidemiology, resources, animal susceptibility to different types of disaster, etc.

iii. Disaster resilience infrastructure is essential, with technical support at ground level through field visits and support through mobile units (MVUs). One Health initiatives and joint operations are being implemented, including risk assessment, assessment of available manpower, review preparedness, adequate storage of medicine, vaccines, surgical and veterinary applications, diagnostics, personal protective equipment (PPEs), and life-saving equipment.

iv. Logistics, disease diagnosis and control measures, and capacity building and mock exercises are also being addressed. Animals at high risk include young animals, dark coloured animals, sick animals, newly shorn sheep, lactating and pregnant animals, heavy and working animals, underfed animals, and unvaccinated animals.

v. Measures that are undertaken as a part of the Disaster Management Plan include:

   a. Organize animal camps,

   b. Rehabilitate animals and identification of safe locations,

   c. Feed and Fodder stocking and supply,

   d. Improvement of grasing land,

   e. Vaccination and emergency medicine, etc.

vi. Heat conditions can affect overall animal health, leading to physical accidents, abnormal eating habits, panting, irregular pulse rate, dull skin, reduced feed intake, increased water intake, and predisposition to infectious diseases. This can in turn, cause loss of productivity (milk), reduced breeding efficiency, vaccination failures, amplify the effects of parasitic diseases, cause digestive problems and food poisoning, cause co-morbidity, low immunity for diseases and loss of life in extreme cases. To prevent these issues, it is crucial to keep up with local weather forecasts, ensure proper mixing of salt mixtures with feed and water, delaying the milking of lactating cows by an hour or more in the evening, using sprinklers and shade in holding yards, allowing drought animals to rest in the shade during the afternoon hours, providing additional feed for pregnant animals (more than 6 months), providing mud hole areas for pigs, to place the burials of dead animals away from water bodies, and providing cool water at least four times during the day. It is important to identify animals which are at high risk which include: young animals, dark colored animals, sick animals with history of various diseases, newly born sheep, lactating and pregnant animals, heavy and working animas, underfed animals, and unvaccinated animals.

vii. Heat disorders could include sunburn, heat cramps, heat exhaustion, heat a stroke, etc. It is important to have stock of mineral mixtures, lifesaving drugs, fluids, and other medicines and equipment in veterinary hospitals at all times, and the activation of mobile veterinary units.

viii. Future strategies include more cooperation between sectors, involving state AHDs with the SDRF, training officials, and involving local youths, NGOs, and children in regular awareness campaigns.

Framework for the Model Heat Action Plan for Indian Cities

Dr Rajashree Kotharkar, Professor, Visvesvaraya National Institute Technology, Nagpur

Dr Rajashree Kotharkar, Professor, VNIT, stated that the Model Heat Action Plan (mHAP) addresses the lack of a precise definition for heatwaves, emphasising factors such as intensity, duration, frequency, and local thresholds

i. Reflecting on the scale and complexity of cities, the mHAP critiques that current plans often fail to capture the intricacies of urban settings.

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ii. The plan highlights the oversight of water resource management in existing strategies for heat management. It stresses the need to recognise the role of water in mitigating the impacts of heatwaves.

iii. The mHAP points out the inadequate consideration of Urban Heat Island (UHI) effects in current plans. It stresses the importance of factoring in UHI when formulating effective Heat Action Plans.

iv. The mHAP suggests a spatial framework for the assessment of heat stress in urban areas, emphasising the need to consider urban morphological parameters and climate types.

v. Highlighted the principles for HAP, which include the use of existing systems and link to general emergency response arrangements, adopting a long-term approach, be broad and multi-disciplinary, communicating effectively, ensuring that heatwaves do not exacerbate the problem of climate change, etc.

vi. Listed the objectives of HAP: To reduce extreme heat-induced mortality and morbidity, to improve the micro-climate of the city without increasing emissions, to integrate water and heat planning with the city planning for long-term measures, to work towards heat resilient cities, etc.

vii. Measures could range from short term to medium term and long term, and might result in reduction in indoor heat exposure, preparation of health information plan, accurate and timely alert systems, long-term urban planning, real-time surveillance, etc.

viii. Short-term measures in public health prepare the city, for example, to tackle extreme heat through rapid heat vulnerability assessment and identification of vulnerable populations, preparing health infrastructure for possible eventualities, effective heat-health warning systems, etc.

ix. Medium-term measures include hyper-local information for an effective communication plan, detailed heat vulnerability and risk assessment, retrofitting of buildings to reduce indoor overheating, urban greening policy, etc.

x. Prepare on the lines of Meteorology (installing multiple weather stations as per the WMO guidelines), Public Health (Heat Health Warning Systems based on the local threshold with implementation at hyper-local level), Urban Planning (Ward level heat vulnerability and risk assessment, retro fitment of buildings which means modifying roof and wall, providing shading for the windows, reflective roofs, roof gardens, rainwater harvesting, developing climate resilient housing design, implementing ECSBC norms irrespective of the size of the building and its energy consumption, etc., greening policy, walkability and bicycle friendly neighbourhoods, improving usage of public transport, vegetation plan at the city-level etc.)

xi. Long-term measures include integrating various city-level plans (water), monitoring and forecasting the urban climate of the city through climate modelling, identifying possible future threats to human health due to extreme heat and preparing a plan, building capacities in the governance structure, etc.

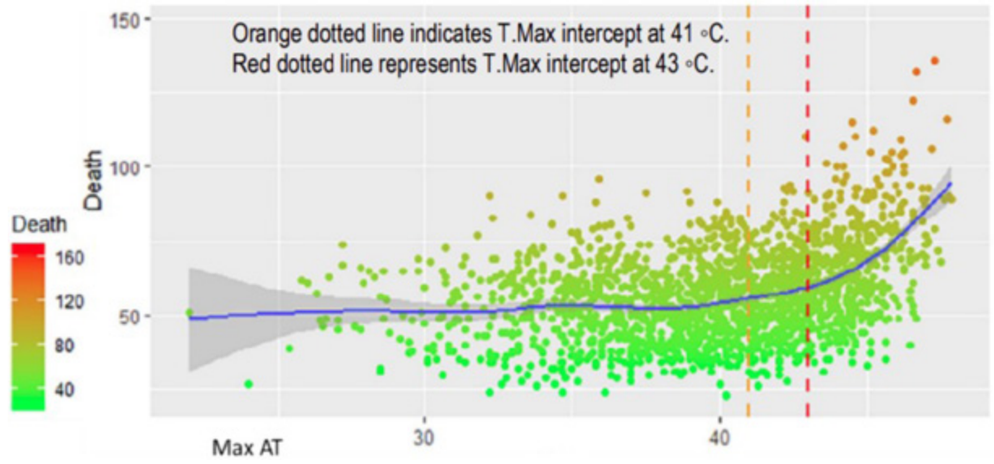

Fig. 10. Threshold determination and temperature trends analysis of Nagpur

Multi-dimensional Disaster Risk Assessment

Parmeshwar D. Udmale, Assistant Professor, Centre for Technology Alternatives for Rural Areas (CTARA)

Prof. Parmeshwar D. Udmale, Assistant Professor, Central for Technology Alternatives for Rural Areas outlines a comprehensive Disaster Risk Management framework that includes hazard monitoring (hydrological, meteorological, climatological), impact assessment (vulnerability and adaptative capacity), response, recovery, reconstruction, preparedness, and mitigation and prevention.

i. The presentation introduces LiSeRA, an assessment tool for livelihood security and resilience. It emphasises the integration of climate resilience into developmental planning. It categorizes heat wave risk on parameters like hazard, exposure, and vulnerability and vulnerability is sub-characterised by factors such as sensitivity and adaptive capacity. It studies risk in space and time, and how its characteristics vary in time.

ii. Regarding risk components and indicators, hazard is determined with the help of indicators like maximum temperature, minimum temperature, and humidity, while exposure is studied using population, population density, agricultural land, workers, labourers, etc., sensitivity is determined by indicators like poverty, child population, infant mortality rate, livestock, older population & female population, while adaptative capacity is determined by indicators like irrigated area, forest area, literacy rate, access to cooling, electricity, per capita income, etc.

iii. The presentation suggests policy recommendations and preparedness strategies based on hazard impact assessment, considering climatological and hydrological factors. It emphasises the importance of adapting to and mitigating the impacts of extreme weather events on agriculture.

iv. The presentation delves into a specific case study of Heat Wave Risk Assessment in Maharashtra, considering indicators such as maximum temperature, minimum temperature, humidity, and various socio-economic factors.

v. Vulnerability Index and Risk Index are important for prioritising mitigation and resource allocation.

vi. The concluding section discusses challenges such as dynamic risk, data limitations, and spatial unit analysis, emphasising the need for trans-disciplinary research and advanced technologies in disaster risk reduction and management. The presentation provides a holistic view of the disaster risk management, illustrating its application to heat wave risk in Maharashtra, and emphasises the importance of stakeholder engagement and advanced methodologies in this critical field.

Affordable Strategies to Reduce Heat Stress in Urban Housing

Prof. Minu Agarwal, CEPT University

Professor Minu Agarwal, Centre for Environmental Planning and Technology University emphasises the importance of thermal comfort in urban housing, considering it as our “third skin” that helps manage the thermal environment. The presentation stresses the interplay between physiological, psychological, and behavioural factors in achieving thermal comfort.

i. The consequences of thermal discomfort extend beyond physical discomfort to physiological and psychological effects, such as increased heart rate, loss of concentration, irritation, sickness, and unconsciousness and death.

ii. Over 50% of India’s population resides in warm and humid climates, facing challenges related to extreme heat. The presentation highlights the Cooling Degree Days for major cities, indicating the need for effective cooling strategies.

iii. Data is presented on the global impact of heat waves, revealing a staggering number of human deaths and economic losses. It establishes the urgency for housing designs that can provide comfort over extended periods without heavy reliance on electro-mechanical systems and affordability to achieve thermal comfort.

iv. The presentation delves into the science of heat transfer within buildings, discussing interactions between parameters and proposing improvements in Solar Heat Gain Coefficient (SHGC) for windows through shading devices and changes in glass material. These strategies aim to reduce Degree of Discomfort Hours and enhance thermal comfort.

v. Opportunities for operating buildings with comfort strategies are discussed, highlighting the importance of balancing thermal mass and insulation. The presentation concludes with a summary of comfort hours under different operational modes, emphasising the significance of day shutting and nighttime comfort strategies.

Sectoral Challenges and Mitigation Strategies in Road Transport and Highways

Shri Alok Kumar and Shri Vikram Mittu

Shri Alok Kumar, Ministry of Road Transport and Highways emphasised that NHAI and MoRTH are actively monitoring weather conditions. Whenever extreme heat warnings are received, accordingly advisories are issued, and work plans are adjusted, considering factors like avoiding daytime work on heat-generating activities.

i. MoRTH has undertaken various initiatives to reduce the carbon footprint in highway construction. These include using green technologies, use of new/alternate materials, and promoting sustainable practices like steel slag, cement-treated sub-base, and the use of industrial waste. NHAI published its first Sustainability Report as per the Global Reporting Initiative norms, which captures the initiatives of NHAI.

ii. Promotion of green technologies include steel slag, cement-treated sub-base, use of reclaimed asphalt, using inert material for landfills, re-using industrial wastes like phosphor-gypsum, using municipal waste, etc.

iii. The presentation highlights the utilisation of various industrial wastes such as fly ash, steel slag, and municipal waste in road construction, demonstrating a commitment to environmental sustainability. About 7 Lakh Tons of solid waste material has been utilised in the construction of Urban Extension Road (UER-II). The presentation discusses the use of plastic waste in road construction, with over 853.75 km of roads constructed using this environmentally friendly approach.

iv. This comprehensive approach reflects the commitment of NHAI and MoRTH to environmentally sustainable practices, mitigating the impact of extreme heatwaves, and ensuring the long-term resilience of national highways.

v. Use of renewable energy by installing solar panels on the roof of toll plaza, and vacant places on Highways, solar blinkers along the highway, etc. are other measures.

vi. Planting trees along the highways under the Green Highways Policy has been launched by MoRTH in 2015 and so far, 393.5 lakh plants have been planted and 64,466 mature trees have been transplanted.

Sectoral Burden of Rising Heat – Indian Railways

Shri Utkarsh, Executive Director, (Safety), Ministry of Railways

Shri Utkarsh, ED Safety, Ministry of Railways emphasised on critical role of the Indian Railways, therefore the need for resilience through strategic planning and mitigation efforts.

i. Participants were presented with data depicting the global temperature anomaly, highlighting a consistent rise, predominantly attributed to anthropogenic activities. The session emphasised the imperative for the Railways to adapt to unpredictable weather patterns resulting from these temperature shifts.

ii. Insights into the direct effects on the railway workforce were discussed, including reduced availability of maintenance windows, increased manual patrolling demands, worker fatigue, and the need for unhealthy working conditions. The staggering rise in drinking water requirements for both passengers and staff was highlighted.

iii. The discussion on the direct effects comprises of railway infrastructure, covering tracks, overhead equipment, signalling systems, locomotives, and passenger coaches. Specific challenges and increased maintenance needs were addressed for each aspect, necessitating proactive strategies for mitigation.

iv. The session explored the indirect effects of heat waves, particularly the rise in violent weather phenomena like cyclones, mudslides, boulder falls, and flash floods. Infrastructure damages were discussed, emphasising the need for constant monitoring, detailed standard operating procedures (SOPs), and resilient systems for restoration.

v. The impact on railway tracks was scrutinised, focusing on stored stresses, buckling, and the need for enhanced maintenance. Strategies such as better-quality track fittings, mechanised maintenance, and efficient hand tools were proposed for mitigating the challenges faced.

vi. Challenges in maintaining overhead equipment due to thermal expansion and increased tension requirements were discussed. Resistance of Copper rises by 0.393% per degree Celsius rise in temperature. The impact of higher resistance in copper on ohmic losses in overhead equipment and transformers was highlighted, emphasising the need for advanced maintenance strategies.

vii. Concerns related to signalling systems and locomotives were presented, including the higher cooling requirements of high-tech electronics and reduced efficiency in diesel locomotives. Strategies such as air-conditioned cabs and enhanced maintenance were proposed to counter these challenges.

viii. The session delved into the increased comfort cooling and water consumption requirements for passengers, increase in shaded passenger and refuge areas, air circulators and fans, functional hand pumps at remote stations, enhanced facilities like elevators and escalators for passengers to avoid fatigue and to help curb dangerous behavior of crossing tracks on stations. Strategies for addressing these challenges, including water-saving taps, bio-vacuum toilets, and reduced energy consumption, air-conditioned cabs for locomotives to prevent driver fatigue, air-conditioned crew lobbies for outstation rest, etc., were discussed.

ix. The session concluded with a summary of challenges and proposed mitigation measures. Challenges include more frequent equipment maintenance, increased hot weather patrolling requirements, reduced human efficiency, imposing speed

restrictions due to maintenance, etc. Further, high heat load and reduced equipment efficiency coupled with high ambient temperatures increase the risk of fire in trains, thereby demanding the provision of automatic FSDS in every coach. It was emphasised that adapting to the rising heat involves not only infrastructural changes but also innovative strategies to ensure the safety, comfort, and efficiency of both passengers and railway staff amidst the changing climate.

Impact of Heat Wave on Water Sector

Dr Alok Sikka, ***International Water Management Institute***

Dr Alok Sikka, IWMI emphasised recognition of water's central role spanning all sectors, acting as the linchpin for climate change and heat wave adaptation. Acknowledging its equivalence in importance to energy for mitigation, the session highlighted the often-underreported co-benefits achievable through effective water management.

i. The recent findings from IPCC AR6 were emphasised, revealing a disturbing trend of increasing heat stress and extreme heatwaves. According to a study, some estimates projecting a potential 30-fold rise with a mere 2-degree Celsius increase in temperature underscored the gravity of the situation.

ii. Notably, these changes significantly impact the already altered hydrological cycle due to climate change. Moving beyond precipitation, discussions delved into the visible effects on both the supply and demand sides of water management.

iii. Special emphasis was placed on the critical need for a detailed analysis of the demand side, especially within sectors like agriculture. The impact of episodic events on water demand during Rabi crop seasons and drought situations in agriculture emerged as a key concern.

iv. The speaker highlighted the significance of integrated water management solutions, with an emphasis on robust storage mechanisms. The importance of community participation in water resource management was underscored, along with the need for specific attention to groundwater management, efficient systems, and aquifer management. On behalf of the delegates, the chair of the session collectively recognised the imperative of adopting a comprehensive approach to water management in light of evolving climate patterns.

Impact of Heat Wave on Power System

Shri Alok Kumar, Senior General Manager, Grid, India

The session delved into the seasonal variations affecting power systems, including the peak summer period (April to June), which can cause an increase in demand, occurrences of dust storms, load crashes and events of high voltage, monsoon period (July to September, which can witness sudden load crash & high voltage events, hydro-generation outages due to high silt content), winter

period (December to February which causes multiple element outage due to fog/smog, etc.), cyclones, and the intermittent nature of renewable energy sources.

i. The impact of heat waves on electricity demand was discussed in detail. The rise in ambient temperature was linked to an increase in peak demand, higher energy consumption, and potential overloading of transmission lines and transformers, causing congestion in the system, and high electricity market prices. On an average, aggregate electricity demand in India increases by 11% or more at temperatures above 30^{0}C from demand at temperatures of 21-24^{0}C.

ii. The session recognised the significant impact of heat waves on states with a substantial agricultural load. The dependency of power demand on rainfall, particularly in states like Punjab and Haryana during summer/ monsoon, was underscored. It is evident that the maximum demand period is shifting from August to September to April to June months with the increase in demand for space cooling requirements and agricultural load.

iii. Insights were provided into the impact of rising temperatures on solar, wind, and battery energy storage system (BESS) generation. Efficiency reduction in solar modules and derating effects on wind turbines and inverters were detailed. With increase in ambient temperatures above 25^{0}C, solar modules efficiency gets reduced (less DC generation with rise in temperature). Increased

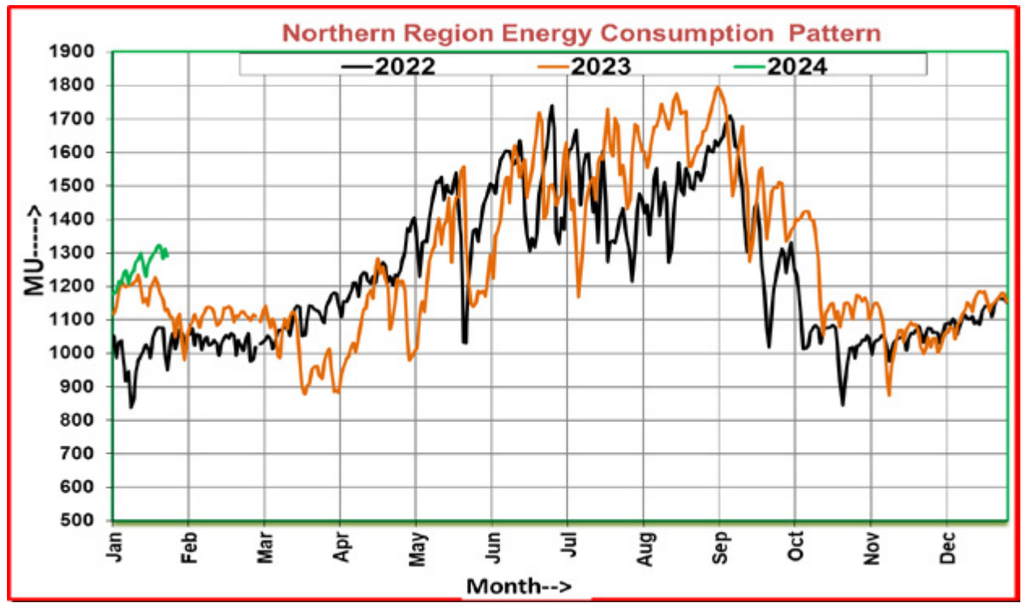

Fig. 11. Northern region energy consumption pattern; Reveals shift in maximum demand period

air temperature also causes derating effects, i.e., reduced capacity and efficiency of gas-turbine and combine-cycle gas turbines and increases boiler tube leakage related outages in thermal plants.

iv. On transmission, higher ambient temperature reduces the thermal capacity of transmission lines, increasing the possibility of tripping due to increased sag, causing forced outage. Thus, it demands frequent maintenance and causes difficulty working on transmission lines due to high temperatures.

v. The session concluded by proposing measures to mitigate the impact of heat waves on power systems. Strategies included defining temperature zones, designing solar/wind/BESS plants based on temperature zones, additional capacity for high-temperature zones, generation planning considering heat wave/high temperature, and ensuring resource adequacy for uninterrupted power supply. The importance of resilient transmission and distribution infrastructure was emphasised.

Actionable Points

i. The 2023 global temperature surge, nearing the critical 1.5-degree Celsius mark, signals profound consequences, particularly for critical infrastructures. Notably, research highlights a 1% decline in students' learning ability for every one-degree rise in classroom temperature, emphasising the broad impact on educational settings. The session strategically outlined these challenges within a global framework, focusing on sectors like Buildings, Roads, Railways, and Power & Energy, offering a nuanced understanding of the escalating threats posed by heat to critical infrastructures.

ii. The intricate connection between heatwaves and human health, exemplified by plant nutrient deficiency affecting nutrition, underscores the urgency for climate-smart agricultural practices. Night-time high temperatures and sensitive crop stages, such as booting and flowering, demand innovative solutions, including climate-resilient crop varieties. Recommendations include tailored heatwave criteria for India, the explicit inclusion of agriculture in national guidelines, and a holistic policy framework encompassing technological, biological, and economic dimensions for effective risk management.

iii. The mHAP draws attention to the often-neglected Urban Heat Island (UHI) effects and proposes a spatial framework for assessing heat stress in urban areas. Recognising the role of water and incorporating UHI considerations are pivotal for formulating effective Heat Action Plans tailored to the intricacies of urban environments.

iv. The session highlights challenges, such as dynamic risk and data limitations, advocating for trans-disciplinary research and advanced technologies in disaster risk reduction and management. It emphasises stakeholder engagement and advanced methodologies as key components in effective disaster risk mitigation.

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v. The session delves into the science of heat transfer within buildings, proposing improvements in window shading devices and changes in glass material to enhance thermal comfort. Opportunities for operating buildings with comfort strategies are explored, stressing the importance of balancing thermal mass and insulation for optimal results.

vi. The session highlighted the profound impact of global warming on rising temperatures and its multifaceted consequences, focusing on the pivotal role of the Indian Railways. Addressing the direct effects on railway infrastructure and workforce, the discussion emphasised challenges such as reduced maintenance windows, worker fatigue, and increased water requirements. Specific attention was given to challenges in maintaining tracks, overhead equipment, signalling systems, and locomotives, proposing proactive strategies for mitigation. The session extended its exploration to the indirect effects of heat waves, including the rise in violent weather phenomena and its impact on railway tracks. Strategies for enhanced maintenance, innovative technologies, and water-saving measures were proposed to adapt to the changing climate, ensuring the safety, comfort, and efficiency of both passengers and railway staff.

vii. A strong call for integrated water management solutions, community participation, and specific attention to groundwater and aquifer management emphasised the need for a holistic approach to water resilience amid evolving climate patterns.

viii. Seasonal variations, especially during peak summer periods, were examined, emphasising the impact on electricity demand and the challenges posed to transmission lines and transformers. Insights into the effect of renewable energy sources such as solar, wind, and battery storage were provided, concluding with proactive measures to mitigate the impact of heat waves on power systems. The session underscored the importance of resilient infrastructure and adaptive strategies for ensuring uninterrupted power supply in the face of changing climatic conditions.

Technical Session IV: Experience Sharing of Heatwave Management: Voices from the Field

Chair:
Shri Sanjeev Kumar Jindal,
Additional Secretary, MHA

Moderator:
Shri Kunal Satyarthi
JS, NDMA

Rapporteur:
Ms. Shalini Singh,
Sr. Consultant

Ponds for Cooler Cities

Shri. Ramveer Tanwar, Pondman (Say Earth), Delhi

In his presentation, **Shri Ramveer Singh** emphasised upon the role of ponds in mitigating heatwaves and Urban Heat Islands. Ponds also help in mitigating the effects of heat waves by lowering heat stress for humans and animals, lowering temperature, providing a place to socialise/ relax in extreme heat, helping to maintain mental health during elevated temperatures, and lowering heat stress in cattle that could affect milk yields. Surface water in the form of ponds has been shown to create a maximum temperature reduction of 1^{0}C. They facilitate this function by:

i. Evapo-transpiration which dissipates a large amount of energy.

ii. Storing heat during the day.

iii. Increasing surface reflectiveness and decreasing the amount of solar energy absorbed.

Image. 1. Before and after images of pond rejuvenation projects

Studies show that waterbodies are an effective factor in the mitigation of UHI effects. Through air convection, the cooler air on the water bodies blow to the surrounding areas and achieves a cooling effect. Therefore, ponds act as natural mitigation solutions for the UHI effect.

He highlighted key issues affecting the water bodies, including eutrophication, siltation, encroachment, discharge of sewage, disposal of solid waste etc. He further recommended the following actions:

i. Include water bodies in urban development and disaster management plans as natural solutions for heatwave mitigation.

ii. Prioritize restoration and conservation of existing water bodies.

iii. Plan more blue-green infrastructure for urban areas.

iv. Prepare dedicated knowledge products like modules and guidebooks.

v. Conduct awareness generation for the masses at various levels.

He highlighted key issues in sustaining water bodies like ponds which include eutrophication, solid waste dumping, siltation, inflow of sewage, reduction in catchment area due to encroachment, etc.

He further presented a few successful pond restoration projects undertaken by his organisation and elaborated about the positive impacts these had had on the local climate, ecology, wellbeing etc.

Strategies to mitigate effects of Heatwave

Dr Sujeet Kumar Yadav, Chief Medical of Superintendent, Balia, Uttar Pradesh

Dr Sujeet Kumar Yadav presented the climatological and geographical profile of district Balia, which includes

two major rivers, i.e., Ganga and Saryu (Ghaghra), minor rivers and a few canals. He highlighted the heatwave mitigation measures undertaken in the district including the tree plantation drive and work undertaken in Amrit Sarovar Mission. He further shared the works undertaken by different departments such as Horticulture, Animal Husbandry, Transport, Health, Information, Forest, Fire, Education, Electricity, and Urban Development and Panchayati Raj towards heatwave preparation, response, and mitigation.

Management Interventions & Mitigation Strategies for Heat Wave

Shri Ravindra Kumar, DM, Bareilly, UP

Shri Ravindra Kumar presented the work done towards heatwave mitigation in the districts of Jhansi and Bareilly. For Jhansi district, he presented the average temperature and rainfall chart, pre- and post-monsoon groundwater level in the last decade. Over the last two years, INR 10 Cr. has been spent supplying drinking water in the district during the summer season. He explained how an increase in precipitation caused a lowering in mean monthly temperatures and showed the pre-monsoon and post-monsoon groundwater availability in the district.

Sustainable long-term mitigation measures included improvement in forest area. Efforts to improve the groundwater level, included:

i. putting a check on uncontrolled exploitation of ground water by business establishments.

ii. removing encroachments from government lands, digging trenches, and planting on them.

iii. digging trenches around the grasing grounds that were bigger than one acre and planting them. These interventions had resulted in a significant increase in levels of groundwater.

Image. 2. Heatwave mitigation works undertaken in Bareilly District

In Bareilly district, drought-proofing measures undertaken by the Horticulture Department included:

i. installation of drip irrigation over 1350 hectare and sprinkler irrigation over 1285 hectare area,

ii. planting dragon fruit in over ten hectare,

iii. cultivating medicinal crops requiring less water like Satavar and encouraging mulching along with drip irrigation among farmers.

'Dos and don'ts' for protection from heatwave were issued for public awareness.

Heatwave Mitigation Measures

Shri G. S. Naveen Kumar, Relief Commissioner, UP Govt.

In his talk, **Shri G. S. Naveen Kumar** mentioned the two strategies taken by the State for heatwave mitigation, i.e., Relief operations and short- and long-term mitigation measures for climate resilience. He informed that the State government is committed to tackling the issue of climate resilience in a holistic manner.

i. Automated Weather Station (AWS) and Automatic Rain gauge Station (ARG) are being installed at every third ward across the state.

ii. Work is being done towards strengthening data collection, particularly of Urban areas to precisely inform the interventions.

iii. Telemetric Weather Stations are also being installed to capture data related to soil moisture, soil temperature, and solar radiation. This data will inform the remedial measures at a more granular level.

iv. Collaboration with the private sector may be encouraged for creating green spaces in urban areas thus creating a microclimate.

v. The region-specific thresholds may also be defined, keeping in mind the geographical context for issuing heatwave alerts.

vi. Public cooling spaces may be created; these may be designed through design competitions.

vii. Traditional knowledge and wisdom may be utilised/ revived for combating extreme heat situations.

viii. Through the design of buildings, passive cooling may be promoted, lessening the load on air conditioning.

Management Interventions & Mitigation Strategies for Heat Wave in West Bengal

Shri Kunal Agarwal, IG, Department of Disaster Management and Civil Defense, West Bengal

In his presentation, **Shri Kunal Agarwal,** presented the weather and climate

profile of West Bengal, which faces all types of severe weather, including tropical cyclones, heatwave and cold wave, flooding etc. In the state, six districts are prone to heat wave like conditions, especially during March to May. These six districts are geographically adjacent to the Chotanagpur plateau and are located away from coastal areas, making the region very dry and prone to high temperatures during the summer months. Prevention, Preparedness, and Mitigation measures discussed are as follows:

i. SDMA/ DDMA/ Municipal Corporation to prepare Heat Wave Action Plan and local bodies to implement it.

ii. Department of Disaster Management and Civil Defense to disseminate the early warning received from IMD.

iii. Public Health and Engineering Department to construct shelters/ sheds, bus stands and provide drinking water points in cities and worksites.

iv. Department of Health and Family Welfare to stockpile ORS and create medical posts at places of mass gatherings. Deploy rapid response teams and take special care of vulnerable groups.

v. The Department of Disaster Management and Civil Defense, Department of Health and Family Welfare, and District Administration have the responsibility to collect data and information.

vi. Department of Information and Cultural Affairs to create awareness campaigns through print, electronic and social media.

vii. Forest Department to improve forest covers and green areas as a long-term measure.

Image. 3. IEC material publicised in local language

He proposed the following key strategies:

i. Collaboration between IMD and State Health Department to issue health advisory during severe heat conditions.

ii. Establish Early Warning Systems and Inter-agency coordination to alert residents to predicted high and extreme temperatures.

iii. Capacity building/training programme for health care professionals at local level to recognize and respond to HRI.

iv. Public awareness and community outreach on how to protect against extreme heat wave through print, electronic and social media, and IEC materials such as pamphlets, posters, etc.

v. DO's and DON'T's were included in the IEC materials that were distributed and publicised through the media.

Urban Heat Island (UHI) Assessments for Sustainable Cooling and Extreme Heat Urban Planning

Ms Minni Sastry, UNEP

In her presentation, **Ms Minni Sastry**, talked about the work done by UNEP which includes:

i. Creation of Cool Coalition. It is working with its 120+ partners to support countries and industries to take comprehensive action to meet growing demands for cooling in an efficient, climate-friendly manner, contributing to SDGs, Kigali Amendment, and Paris Agreement. The coalition promotes a 'reduce-shift-improve-protect' and cross-sectoral approach to cooling.

ii. 'Beating the Heat: A Sustainable Cooling Handbook for Cities', which includes detailed guidance and an encyclopedia of options to help cool cities sustainably. It consists of eighty case studies from around the world.

The UNEP India Cooling Programme aims to support India at the national and sub-national level in creating an enabling environment for accelerated investment and adoption of sustainable cooling solutions in line with ICAP. The components include:

a. providing targeted technical assistance and technology demonstrations in identified gaps,

b. accelerating an integrated approach to cooling through multi-level coordination,

c. governance and policy delivery, private sector engagement, finance mechanisms and matchmaking,

d. develop standards, guidelines, and methodologies for India on cooling and thermal comfort, knowledge sharing.

e. knowledge sharing and convening (e.g. NIUA Cool Cities Hub)

Case studies of Medellin, Colombia; Cooling Singapore Project; Madrid, Spain were shown. The Urban Heat Island Effect Study – Tamil Nadu was also showcased. The objective is to:

i. Develop and assess a methodology for assessing UHI for national replication.

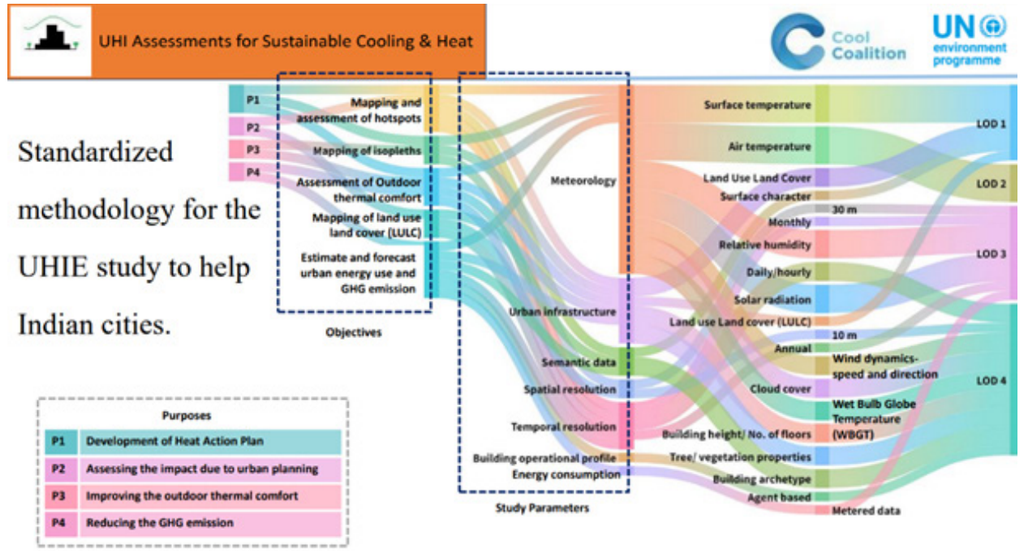

Fig. 12. Standard methodology developed by UNEP for the UHIE study to help Indian cities

ii. Support CMDA to deliver sustainable cooling into various urban plans.

iii. Training and capacity building of urban planners in the State.

In the study, a standardised methodology for the UHIE study was developed to help the Indian cities. Data collection and hotspots identification methodology was developed. The way forward for study is 'development of a plan for the prevention of the UHIE with suggestions for incorporation of results in Chennai Master Plan (2026-46)/ New Area Development Plans.

She shared the benefits of Green Infrastructure on UHIE:

i. The surface temperature of green roofs could be reduced by 15^{0}C in comparison to non-green roofs.

ii. Nearby micro-climate air temperature can be reduced by 2-5^{0}C.

iii. Reduced energy demand depending upon the type of buildings.

iv. The temperature difference between urban areas and big city parks is between 1.5-4^{0}C.

v. Green walls/facades can reduce nearby outdoor temperatures between 0.5-4^{0}C.

She further shared the projects that were under implementation under the Cool Coalition:

i. Comprehensive digital mapping of hotspots, urban nature, and cooling demand in Chennai city.

ii. Stakeholder meetings to achieve extreme heat resilience and sustainable cooling, setting up guidelines, standard methodologies, etc.

iii. Training and capacity building of urban planners of CMDA, local stakeholders on UHIE.

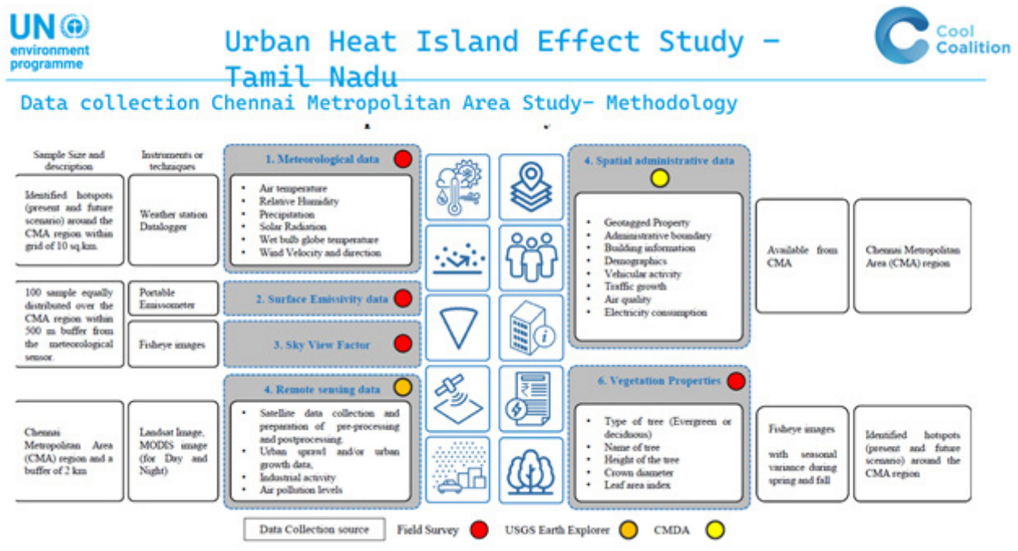

Fig. 13. Data collection methodology developed for Chennai Metropolitan Study as part of UHIE study by UNEP

iv. Integration of sustainable cooling and heat resilience into Chennai's master plan.

v. Suggesting thermal comfort in the affordable building – pilot cool roof at a lighthouse project with RMI

vi. District Cooling and public procurement of sustainable cooling technologies.

The following data are collected for UHIE Study in Chennai – Meteorological data (Air temperature, relative humidity, precipitation, solar radiation, wet bulb global temperature, wind velocity and direction), Surface emissivity data, Sky view data, Remote sensing factor (including urban sprawl data, industrial activity, air pollution levels, satellite data collection), Spatial administrative data (geotagged property, administrative boundary, building information, demographics, vehicular activity, traffic growth, air quality, electricity consumption), and Vegetation Properties (type of tree, name, height of tree, crown diameter, leaf are indexed)

Actionable Points

i. Waterbodies should be included in Urban development and Disaster Managements plans. More Blue-green infrastructure should be planned to mitigate the effects of Urban Heat Island.

ii. Heat Minimising Planning, which includes optimising shape and planning of the built environment, planning land use with open spaces, water bodies, enhanced ventilation, and shading, etc.

iii. Using thermally favourable materials (for the composition of streets, sidewalks, and other surfaces, etc.) by using light-colour surfaces, etc.

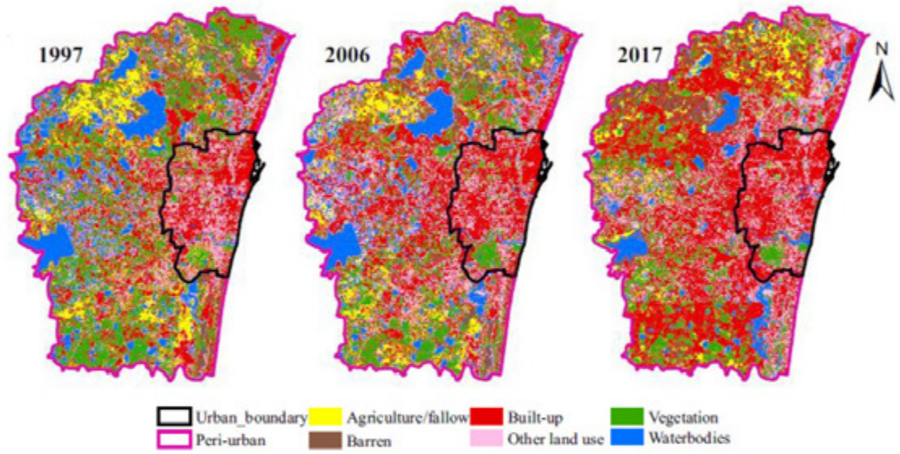

Fig. 14. UHI Assessment for Chennai

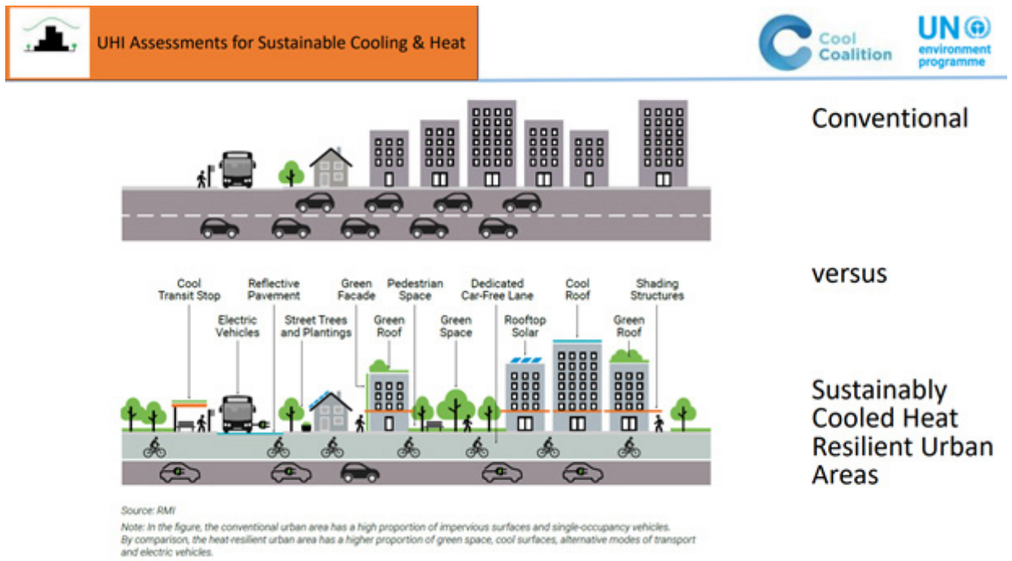

Fig. 15. Comparison between Conventional and Sustainably Cooled Heat Resilient Urban Areas

iv. All departments must make prior provisions to respond to the effects of heatwave in an efficient manner. This may include training of staff and officers, making provision for drinking water, ORS, shaded spaces etc., timely dissemination of information such as dos and don'ts through different mediums etc.

v. In rural areas, plantation drives may be undertaken to increase the groundwater levels.

vi. Drought mitigation strategies such as drip irrigation, sprinkler system, planting drought-resistant fruit and medicinal plants, mulching etc., may be considered.

vii. Data collection related to all aspects of heatwave, such as local weather conditions, population affected, built environment etc., should be strengthened to inform the interventions at a granular level.

viii. Heat minimising planning to reduce anthropogenic heat, encourage nature-based cooling, and use of thermally favourable materials.

ix. Strong collaboration between academia and implementing agencies should be encouraged.

x. By adopting long-term UHI mitigation measures, a reduction in ambient temperature of up to 10^{0}C can be achieved with up to 20% reduction in cooling energy demand & GHG emissions.

TECHNICAL SESSION V: Urban Heat Island (UHI) And Impact on Vulnerable Communities: Preparedness and Mitigation

Chair:
Lt. Gen. (Retd.) Syed Ata Hasnain,
Member, NDMA

Moderator:
Shri Nawal Prakash,
JA, (IT &Comn), NDMA

Rapporteur:
Shri Abhinav Walia,
Sr. Consultant, NDMA

Lt. Gen. (Retd.) Syed Ata Hasnain, Member, NDMA, welcomed all the panellists and participants of the workshop. He stressed the importance of Heat Wave Management Interventions and Mitigation Strategies, noting that it marks a positive beginning for the 2024 heat season. His comments likely emphasised the crucial focus of the workshop and its relevance to disaster management and readiness initiatives. With his wealth of experience in disaster management, Lt. Gen. (Retd.) Syed Ata Hasnain's words set the tone for the session, underlining the significance of tackling the challenges and opportunities associated with heat waves. He aimed to motivate participants and stakeholders to actively participate in discussions and collaborative endeavours to manage heat waves effectively and develop resilience strategies.

Heat-related Diseases Armed Forces Perspective

Brigadier Kuldeep Kumar Astha, VSM, MD(Med) FICP Commandant MH Jalandhar & Prof Medicine

Brig. Kuldeep shared practical experiences from the field regarding heat-related illnesses in high-temperature zones. He started his presentation with the two cases of serving personnel who suffered heat stroke during their postings. The following are some of the dimensions that are covered by Brigadier Kuldeep.

i. Serious illnesses have been observed with high fever, fatigue, nausea, vomiting, mental confusion, weakness, and high pulse rate with dehydration among the officials cited in the case studies. In one of the cases, immediate measures were taken for rapid cooling of the body and providing intravenous fluids in cool room.

ii. Further, he shared the unique host factors, i.e. mixed population, Frequent changes and travel, long leaves, rigorous training, Competitive sports routine, Challenging residential accommodation in the field, Clothing and heavy personal Kit/weapons issues, Lack of rest and medical conditions, Acclimatization issues, and Environmental factors.

iii. He also emphasised the "prevention is better than cure" component for managing heat waves in the armed forces – Education of each personnel, Education of Commanders, SOPs at all levels, maintaining water and hydration discipline, RMO advisors to commanders on training schedules, training of paramedics, training of doctors in environmental emergencies, emphasising disciplined acclimatisation, etc.

iv. The importance of prevention and first aid has also been emphasised as they are essential at each level.

v. Differences between heat stroke and heat exhaustion have also been

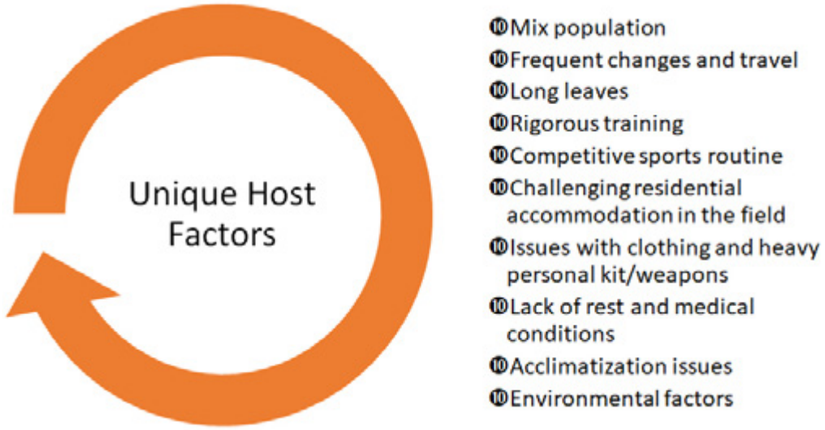

Fig. 16. Unique Host Factors

explained in detail in the context of armed forces serving in vulnerable locations during the heat wave. Ultimately, he highlighted the carry-home message on Hydrate, Rest and Shade.

vi. Ensuring First Aid and Treatment by providing clear airway, external cooling by conduction and evaporation, moving the patient to a cooler environment, by applying ice packs, using a fan, by wetting the body and clothes, and placing the feet in an elevated position.

Heat Prevention

Lt. Col Devendra Dodeja, Army Syndicate

Lt. Col. Devendra Dodeja presented on Heat Prevention, emphasising three significant components: Training in Harsh Weather, its Effect on the Armed Forces, and Preventive Measures. Following are the critical points highlighted during his presentation.

i. He highlighted the issues related to training by highlighting the limited training area, multiple formations, no set time of campaigning season, ambient temperature of 45 degrees Celsius, and lack of temperature regulating mechanism.

ii. In the second component, “effect on armed forces”, there are multiple issues in three categories – (1) personal - Heat Cramps, Heat Exhaustion, Heat Strokes, and Reduced efficiency (2) Ammunition its Decreased stability, Compromised performance, Higher Un-serviceability/ faults, Availability of ammunition – challenge, Increased risks for own troops (3) on equipment its Material degradation Reduced efficiency, Rapid deterioration of rubber/ plastic parts, Increased risk of fire and breakdown.

iii. Additionally, he emphasised preventive measures for personnel, equipment, and Ammunition:

a) Storage of infrastructure in the shade wherever possible, ensuring ventilation and use of underground tunnelled storage facilities/trenches.

b) Provision of fire-fighting measures.

c) Inventory management to prevent stockpiles.

d) Lubrication and Cooling System Checks, Rotation of vehicles and equipment, wherever possible.

e) Regular maintenance inspections and regulated working hours.

f) Turnover of unused ammunition at specified intervals.

Prevention of Heat-Related Illnesses

Maj (Dr) Vishnuprasad R, OC, SHO Jodhpur

i. He shared the details about the harsh working environment and aspects of the body’s physical condition of working in such situations. He mentioned the utilisation of the Heat Index Chart of the IMD.

ii. He highlighted that 1000 Kcal of heat is required to be dissipated during a march of 25 km at a temperature of

21^{0}C, and that 2 ml of sweat dissipates 1 Kcal of heat, causing evaporation of about 2 litres of water. Loss of water at 32^{0}C will be 5 liters and at 40^{0}C will be 12 liters.

iii. Further, he briefed about the Work - Adaptations for the Summer season by describing the change of uniforms to combat the heat conditions. Lightweight, loose-fitting, and permeable to water vapour clothing is in practice, and for deserts, personals use a wide-brim hat, neck protection, and long-sleeved shirt.

iv. Additionally, he also briefed about the work adaptations for Summer, which include Restriction of working hours, living accommodation which is spacious & well-ventilated, resting at least ten minutes each hour of walking, Heat Stroke Centers, and Cool rooms.

v. He also mentioned the following components which are in practice to ensure safety from heat waves:

Restriction of working hours
Living accommodation: Spacious & well ventilated.
Rest at least ten minutes each hour of walking.
Heat Stroke Centers and Cool rooms.
Water drinking parade.
Bathing
No Alcohol
Health education, including training in First Aid.

vi. Acclimatisation schedule with PT Dress and Walk during first three days and Jog with Combat Dress in the subsequent three days and Run with Combat Dress in the next three days before running with Full Kit.

vii. IEC material is also being developed for the awareness and sensitisation of

Acclimatization

	Morning (wef 0530 hrs)			
Day	Activity	Dress	Duration	Temperature
1	Walk at 5 km/h	PT Dress	30 min	30 - 32
2	Walk at 6 km/h	PT Dress	40 min	30 - 32
3	Walk at 6 km/h	Combat Dress	40 min	30 - 32
4	Run PPT	PT Dress	Satisfactory Time	30 - 32
5	Walk at 6 km/h	Combat Dress	40 min	30 - 32
6	Walk / Jog at 8 km/h	Combat Dress	30 min	30 - 32
7	Walk at 6 km/h	Full FSMO Kit	40 min	30 - 32
8	Run 5 km	Combat Dress	30 min	30 - 32
9	Walk at 6 km/h	Combat Dress	45 min	30 - 32
10	Walk at 6 km/h	Full FSMO Kit	45 min	30 - 32
11	Run BPET	Full FSMO Kit	Satisfactory Time	30 - 32
12	Walk at 6 km/h	Combat Dress	30 min	30 - 32
13	Walk at 6 km/h	Combat Dress	30 min	30 - 32
14	Run BPET	Full FSMO Kit	Ideal Time	30 - 32

Image. 4. Acclimatisation Schedule

the personnel for overall safety from the heat waves.

Impact of Heat on Vulnerable Slum Communities & Possible Solutions

Shri Siraj Hirani, MHT

Mr Siraz Hirani highlighted the mission of MHT, which is to organise and empower women working in the informal economy, equipping them with technical services and capacity building to improve their habitat, environment, and access to essential services. He also highlighted the organisation's aim to uplift women in the informal sector by providing them with the necessary tools and resources to enhance their living conditions and economic opportunities. Through the initiatives, MHT seeks to foster sustainable development, gender equality, and social inclusion in the communities that they serve.

MHT described as to why slum communities are more vulnerable to heat wave by mentioning the following:

1. Geographical disadvantage
2. Inadequate housing quality and poorly ventilated dwellings
3. Low access to basic services like water, sanitation, energy, etc.
4. Occupation risk – construction workers, rag pickers, home based workers, etc.
5. Information barriers (about Climate Change)
6. Lack of access to cooling technologies
7. Social, political, and financial marginalisation

During a heatwave, the above factors can cause increased mortality among the elderly and children, causing increased stress, fatigue, and illnesses. These slum communities are faced with dual burden of work, reducing their productivity.

Following are the critical issues he has discussed during the presentation:

a. Mahila Housing Trust (MHT) addressed vulnerability drivers in slum communities, focusing on socio-economic and environmental factors.

b. The organisation also examined gender-specific vulnerabilities and emphasised community-led implementation for sustainable solutions. MHT used a Community-Based Vulnerability Assessment Toolkit to build a Resilience Action Plan and corresponding Surveillance Mechanism by generating awareness among the community regarding water quality and weather situations in slums and providing hands-on training to capture real-time slum-level data.

c. MHT discussed the Pro-poor climate resilient solution i.e., Solar reflective White Paint which can reduce the indoor temperatures up to 4^{0}C to 5^{0}C costing at INR 25 per square feet. Solar paint is durable for 4 years without maintenance and is easily available in markets.

d. MHT is piloting a Cooling Station in Jodhpur as a part of the Heat Action Plan. Such Cooling Stations play an important role in protecting vulnerable populations, especially the poor, homeless, construction workers, commuters etc., by providing a safe and accessible space for these individuals to seek temporary relief from the heat and reduce the risk of HRI or death.

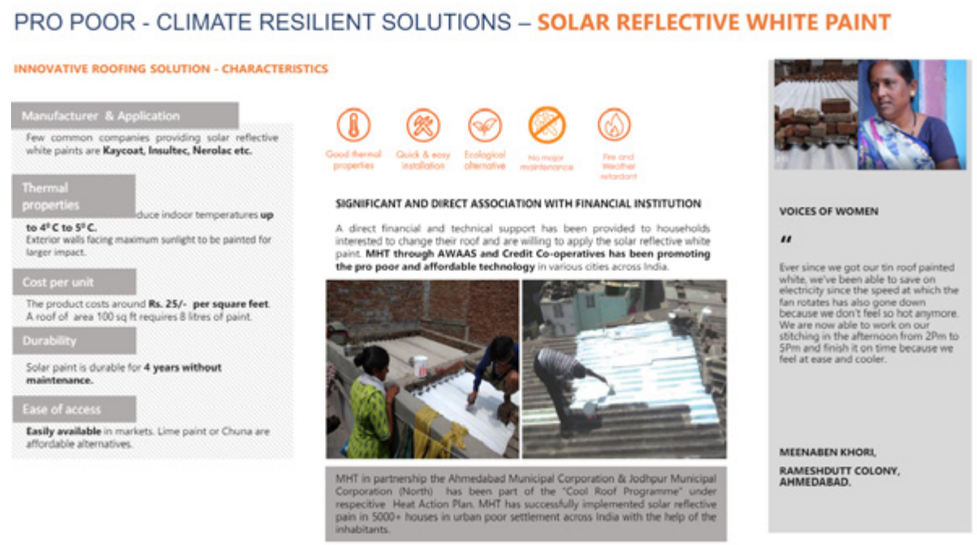

Fig. 17. Climate Resilient Solutions – Solar Reflective White Paint

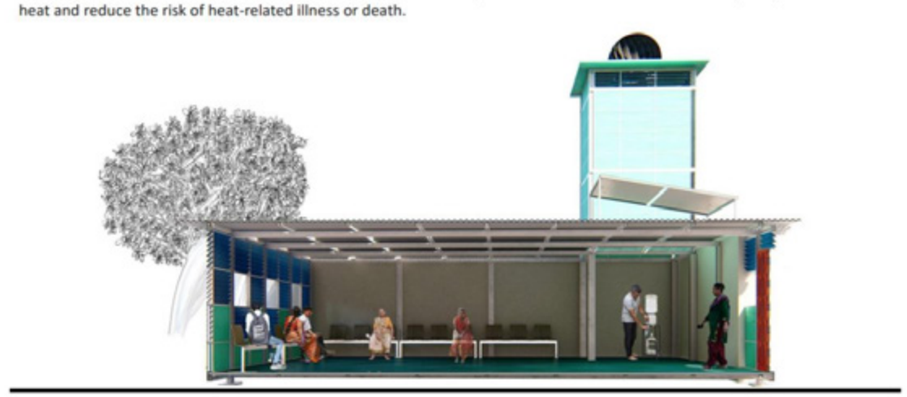

Image. 5. Piloting Cooling Station

e. MHT's approach includes capacity building on climate change and showcasing adaptation solutions like solar reflective paint and Mod roofing.

f. He also discussed the Jodhpur Heat Action Plan that integrates these solutions, emphasising cooling stations for informal sector workers.

g. Lastly, MHT stressed the importance of access to finance for implementing climate adaptation measures in urban poor communities.

Participants from the MHT-focused community also shared their experiences and issues related to the heat wave.

Community-Based Heat Assessment and Actions for Vulnerable Community

Shri Manu Gupta, SEEDS

Shri Manu Gupta highlighted about the rapidly rising temperatures that is indeed a concerning trend, posing significant challenges related to heat waves, climate change, and public health. As temperatures continue to increase, it's crucial to prioritise efforts to mitigate the impacts of extreme heat on communities.

He emphasised the toll on urban slum dwellers due to various health impacts is significant, as revealed by responses from 484 individuals. Major health issues reported include: health issues not only cause physical discomfort and suffering but also have secondary impacts, such as loss of productivity at work and in learning. This loss of productivity can further exacerbate poverty and hinder social and economic mobility among urban slum dwellers. Addressing these health challenges requires comprehensive interventions that prioritise access to healthcare, improved living conditions, and measures to enhance occupational safety and environmental quality in urban slums.

Further, he presented strategies for tackling heat waves, emphasising the importance of preparedness, early warning systems, and community engagement.

i. Many of the slum dwellers suffer from fainting, skin problems, breathlessness, body pain, eye infections, backache, and injuries. A secondary impact is the loss of productivity – at work and in learning.

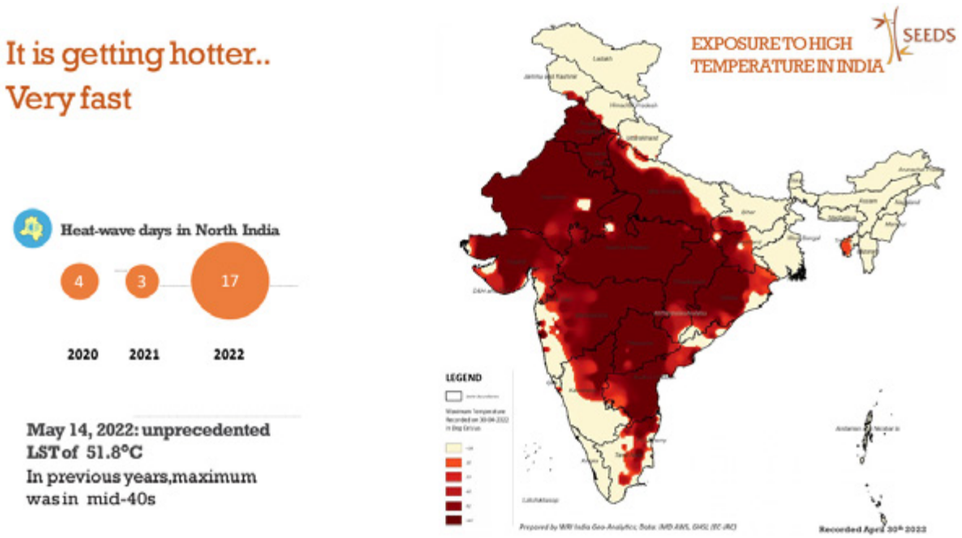

Fig. 18. Heat Wave days in North India

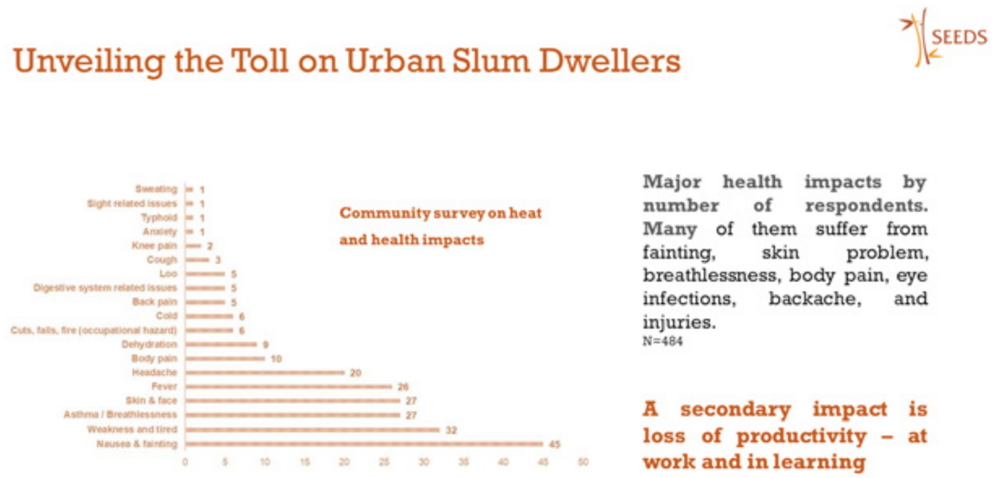

Fig. 20. Unveiling the toll on Urban Slum Dwellers

ii. He emphasised that maximum of heat gain (up to 80% occurs from the roof) and the indoor temperature can be as high as 47°C when outdoor temperature is still at 40°C, given the fact that individuals spend at least 13 hours per day or 90% of their week indoors.

iii. Increased humidity and temperatures are posing indirect health risks for

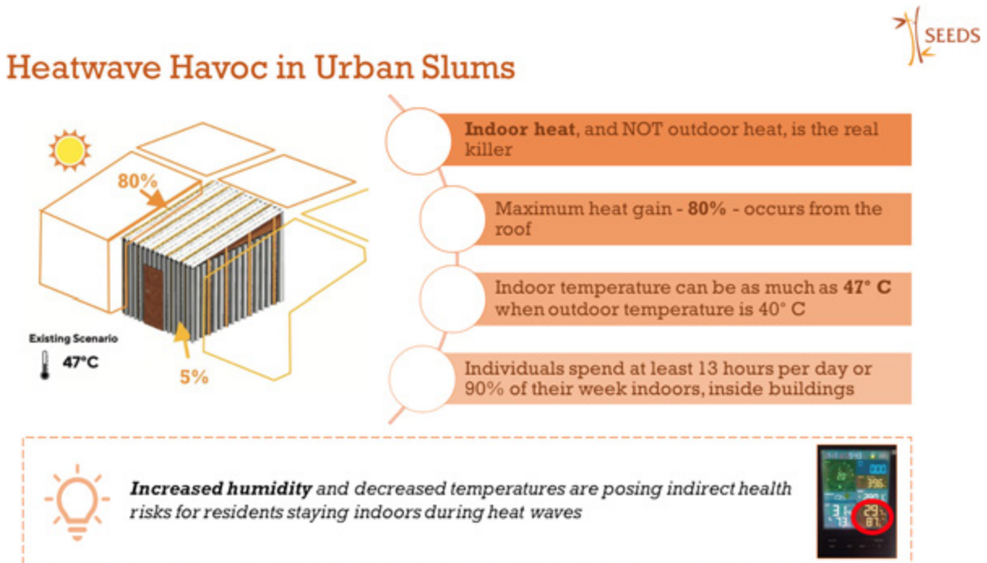

Fig. 21. Heatwave Havoc in Urban Slums

residents staying indoors during heat waves.

iv. He spoke about Technology as an enabler for scale and impact. He mentioned about how AI-powered models can provide EWS to alert communities about impending disasters and how machine learning can inform effective forecasting and automate decision-making in optimising the building's heating and cooling systems based on external weather and usage patterns.

v. Proposed Multi-Prolonged Approach includes creating cooler buildings, getting people to communicate and help one another, besides introducing Climate Tech which:

a. Identifies Vulnerable Hotspots and Climate Zones

b. Impact Assessment

c. Aids in outreach and communication

d. Facilitates on-ground Weather Station Installation

e. Provides a single-window relief support.

f. Helps in locating the nearest Emergency/Incident Response Centre

vi. AI-based Heatwave High Risk Area Visualizes low-income highly dense

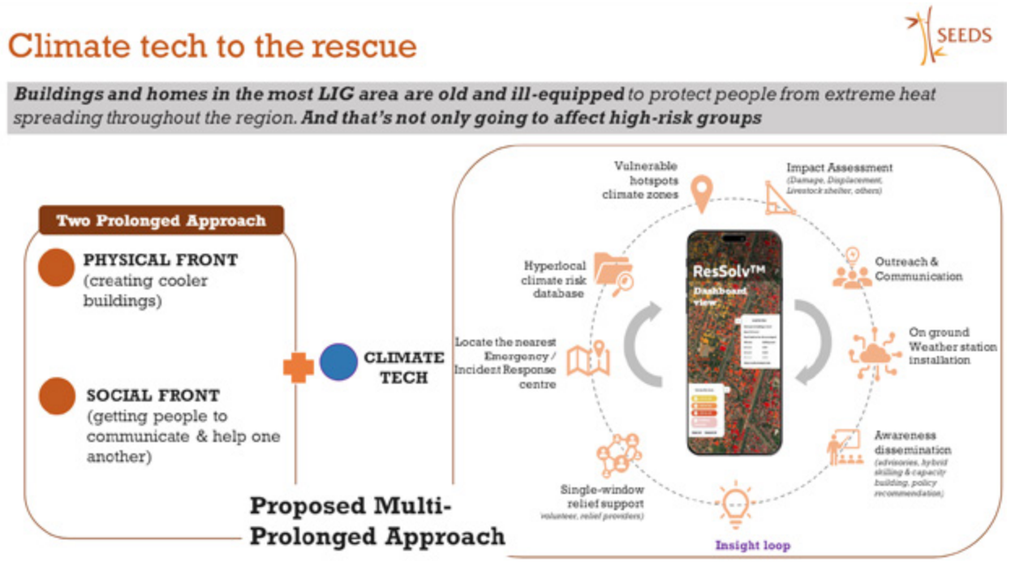

Fig. 22. Proposed Multi - prolonged approach

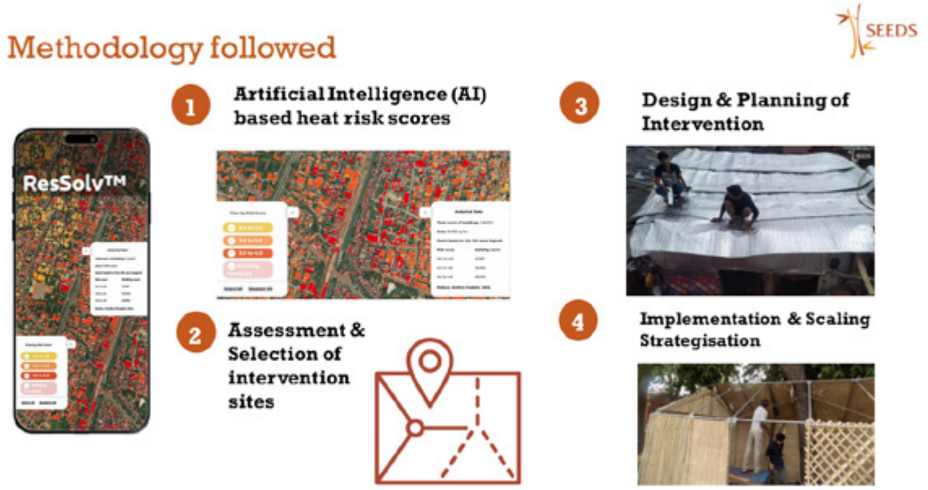

Fig. 23. Methodology for Multi - prolonged approach

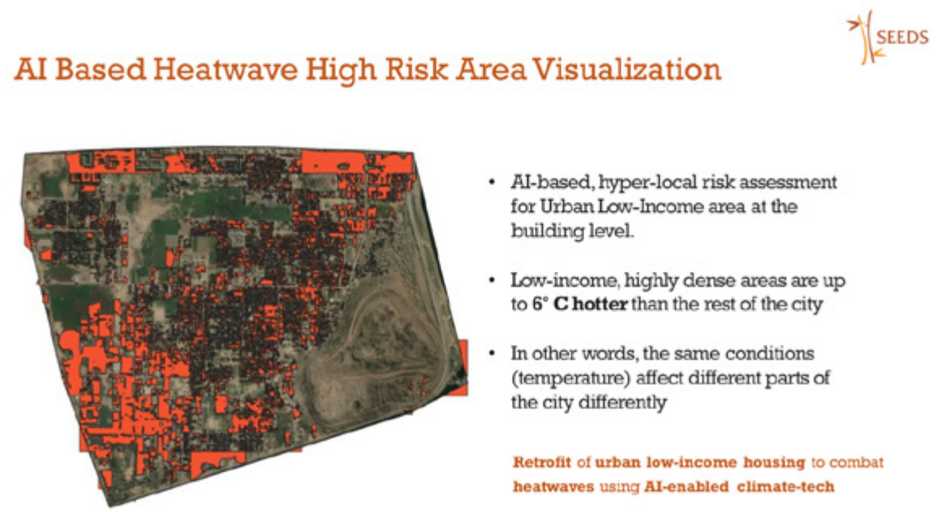

Fig. 24. AI Based heatwave high-risk area visualization

areas which can be hotter than the rest of the city.

vii. He highlighted the need for urban planning to include heat-resilient infrastructure and green spaces.

viii. Three models of low-cost, sustainable, local cool roof solutions were designed, prototyped, and tested in collaboration with the community which can reduce up to 12°C than existing roof (control temperature). Besides, Cool Roofs, an innovative approach to creating shelter by using plastic bottles, recycled fabrics, etc. was adopted.

ix. Awareness is created at the community-level sessions, with

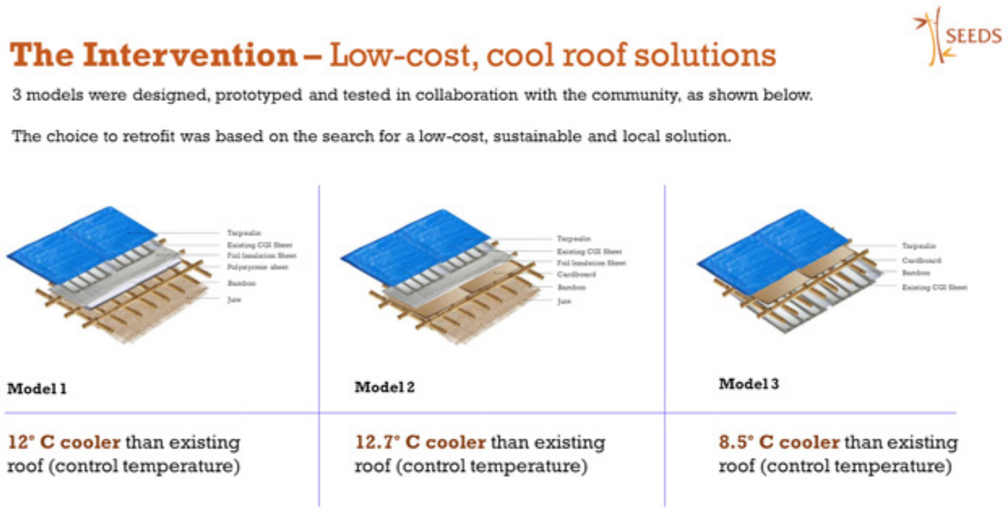

Fig. 25. Low – cost, cool roof solutions

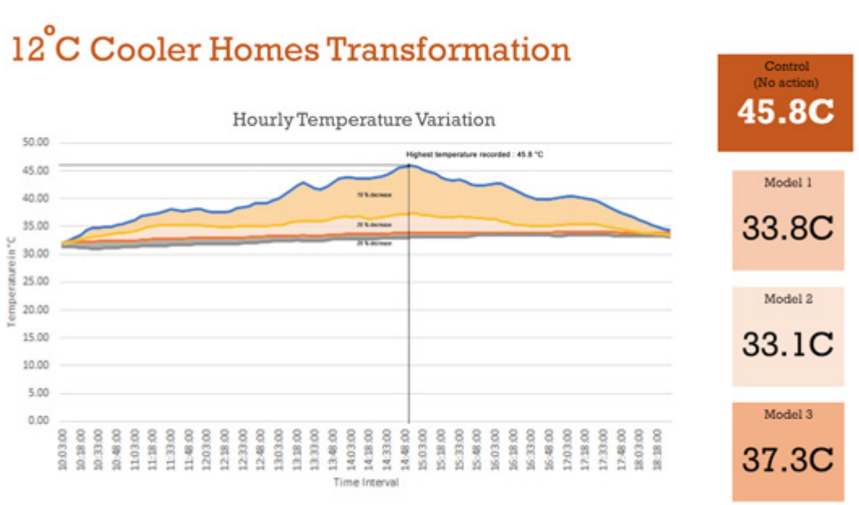

Fig. 26. Cooler homes transformation

women-children-focused group discussions, etc.

x. Additionally, he stressed the significance of public health measures, such as providing access to cooling centres and educating vulnerable populations about heat-related risks.

xi. Overall, the presentation emphasised a holistic approach to mitigating the impacts of heat waves on communities.

Participants from the community and local-level officials from SEEDS also shared their experiences and issues related to the heat wave.

Voices from Communities – SEEDS and MHT

The voices of women from the communities directly affected by heat waves provided invaluable insights into their lived experiences and daily challenges. During the sharing sessions, community-based speakers shed light on the daily issues and offered glimpses into the community-level interventions facilitated by SEEDS & MHT.

These firsthand accounts offer a deeper understanding of the multifaceted impacts of heat waves, including the toll on health, livelihoods, and overall well-being. By amplifying the voices of these women, we gain a clearer perspective on the urgent need for tailored solutions and targeted interventions to address the unique vulnerabilities faced by marginalised communities, particularly women, during extreme heat events.

Additionally, the community-level interventions implemented by SEEDS and MHT provide examples of effective strategies for mitigating the impacts of heat waves and building resilience at the grassroots level. These initiatives underscore the importance of community engagement, local empowerment, and collaborative partnerships in fostering sustainable solutions to climate-related challenges.

Actionable Points

a. The importance of prevention, early warning systems, and community involvement in managing heat waves are the essential components of Heatwave Risk Management.

b. The need for tailored solutions addressing unique vulnerabilities faced by different communities is an important dimension to focus on.

c. Emphasis on education, training, and awareness-raising to mitigate the adverse effects of heat waves is also essential.

d. The critical importance of preventing heat-related diseases, especially within armed forces, emphasising proactive measures over treatment. It underscored the significance of understanding the distinctions between heat stroke and heat exhaustion, alongside the necessity of hydration, rest, and seeking shade.

e. Challenges such as limited training areas and extreme temperatures were identified, impacting personnel and equipment.

f. Preventive strategies encompassed acclimatisation protocols, hydration strategies, and equipment maintenance.

g. The impact of heat on vulnerable slum communities, proposing solutions like improved water and sanitation, sustainable energy, affordable housing, and livelihood initiatives have been emphasised.

h. Community-based approaches were emphasised, advocating for early warning systems, urban planning for heat-resilient infrastructure, and tailored interventions based on insights from affected individuals, particularly women.

i. Overall, the presentations emphasised the holistic nature of addressing heat-related challenges, advocating for proactive prevention, community involvement, and practical solutions to mitigate risks.

TECHNICAL SESSION VI: Heat Action Plans (HAPs) - Preparedness and Mitigation Strategies

Chair:
Shri Safi Ahsan Rizvi,
Advisor, NDMA

Moderator:
Ms. Sumita Singh,
Joint Secretary (International Cooperation), NDMA

Rapporteur:
Shri Amit Tuteja,
Sr. Consultant, NDMA

The speakers of the session were Shri Anand Malligavad, Lakeman, Bengaluru; Shri Kurt Shickman, Urban Heat Resilience Expert, Washington DC; (Dr) Mahaveer Golechha, IIPH Gandhinagar; Shri Sanjay Kumar Shukla, I/C NAEB, Green India Mission, MOEFCC; Shri Rohit Magotra, Deputy Director, IRADe, New Delhi; Shri Aditya Valiathan Pillai, Sustainable Futures Collaborative; Shri Ashok B. Lall, Architect; and Dr Aditya Narayan Singh, Scientist F, Ozone Cell, MOEFCC.

The Chair highlighted the significance of HAPs in the current context from practitioner and user perspectives. He also highlighted the need to understand the administrative importance of Heat Action Plans (HAPs), at the National, State and District levels.

Extreme Heat Management Through Preserving Lakes

Shri Anand Malligavad, Lakeman, Bengaluru

i. Shri Anand Malligavad highlighted

the importance of preserving lakes, which play a very significant role in reducing the temperature of the surroundings and balancing local biodiversity.

ii. He shared his experiences and key challenges faced in the revival of lakes, such as the issues of deforestation, encroachment, land mafia and administrative hurdles.

iii. He mentioned that it is vital to sensitize the concerned stakeholders, especially the communities, and very important to win over the mindset of people and engage them as well.

iv. He briefly explained the process of lake rejuvenation and key steps to be followed, including the identification of catchment area, engaging the surrounding community, carry out de weeding, de watering, de silting, bund strengthening, inlets and outlets reconditioning, silt traps & lagoons, native trees plantation, developing agriculture etc.

v. He ended with the statement that clean water lakes won't generate methane gas at all, which may be very harmful and dangerous, due to more absorption of heat. Therefore, we need to save our lakes, save our forests, and automatically heat will come to town.

Heat Action Platform and Heat Resilience

Kurt Shickman, Urban Heat Resilience Expert, Washington DC

i. **Shri Kurt Shickman** connected from Washington DC through online mode, and he threw light on the overall institutional mechanism of the heat wave action platforms and allied aspects.

ii. He explained about heat wave solutions as well as dovetailing of the heat wave policies and heat wave actions, at the National and State level. He highlighted the importance of multi-departmental cooperation.

iii. He emphasised the importance of standardisation of heat wave solutions, in the current context.

iv. He further suggested drawing more attention towards the requirement of concurrent research for robust heat action planning.

Past Learning and Next Generation City Heat Action Plan

Prof (Dr) Mahaveer Golechha, IIPH, Gandhinagar

i. **Dr Mahaveer Golechha** briefed about the journey of the Heat Action Plan in India. He further laid emphasis on the critical role of political and administrative leadership in implementing heat action plans at different levels. He also highlighted the importance of stakeholder engagement, including localised governance, ward heat stress management committees, religious leaders, NGOs, urban planning department in public awareness, regular monitoring and need of HAP Nodal Officer, inter-agency coordination between various line departments at the State level, where in some States, the State Revenue Department is the nodal agency,

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where in some States, it is the State Disaster Management Authority while it is the Health Department in some other States, etc. There is, hence, an urgent need to define clear cut roles, responsibilities, and accountability of each agency at various levels.

ii. Dr Golechha highlighted that at the political and administrative level, it is very essential for setting the priority for heat health. He emphasised that the urban planning department should be involved in building sustainable and heat resilient buildings promoting cool roofs.

iii. He shared examples of heat hotspots within city and district, and city specific threshold determination (Ex Rajkot, Nagpur etc), which would help to determine local area specific actions.

iv. He highlighted the governance challenge that currently the urban environment is governed by the Forest Department whose current focus is on wild animals, and conservation of forests in rural areas.

v. On availability of all-cause mortality data, he emphasised the need to correlate all-cause mortality data with temperature – to establish the link between extreme heat and human health. He also highlighted the need for city-specific threshold determination.

vi. He advocated carrying out an economic evaluation of the Heat Action Plans (HAPs) to better understand the economic impacts of these HAPs, at local level/ on ground.

He suggested to adopt the concept of blue-green infrastructure for solving urban & climatic challenges through a combination of infrastructure, ecological restoration, and urban design to connect people with nature. Along with this, he also necessitated that cities which have implemented HAP should analyse the impact of HAP on human health in terms of reduction of HRI and deaths.

vii. He mentioned that research on health should be promoted, and a special call for research should be called involving ICMR and DST.

viii. He encouraged to focus on Heat Action Plans for Rural areas as well because Rural areas are also facing many challenges due to extreme heat events. Under the Rajasthan Climate Change Project, the Heat Action Plan suggests the development of HAP and Cold Action Plan for rural settings in 3 blocks of Rajasthan.

ix. He further advised to tap the potential of the private sector and engaging them as well in carrying out the heat action planning.

x. Identifying a nodal person for HAP implementation, monitoring and evaluation is critical. It is also important to have a disaster expert at the district-level in each State (example, Uttar Pradesh). He suggested that NDMA could fund capacity building of officials around environmental public health. Short-term training can be organised for health officers (1-3 months) at the State level under the National Health Mission Programme.

Nagar Van Yojana – Role in Heat Wave Management

Shri Sanjay K. Shukla, I/C NAEB, Green India Mission, MoEFCC

Shri Sanjay Kumar Shukla started with the importance of nature-based solutions, which can be very useful in addressing Urban Heat Islands (UHIs) and other allied issues as well.

He differentiated between Surface Heat Islands and Atmospheric Heat Islands. Surface Heat Islands are man-made surfaces like roadways and rooftops which absorb and emit significantly more heat than natural surfaces like grass and soil. Surface Heat Islands tend to be most intense during the day when the sun is shining. Atmospheric Heat Islands are defined as the warmer air found in urban areas as compared to the cooler air in less heavily settled areas. Typically, weaker during the late morning and throughout the daytime hours, they form because of the slow release of solar heat that has been absorbed by buildings, concrete surfaces, and other built materials throughout the day.

He shared that the National Afforestation and Eco-development Board (NAEB) is implementing Nagar Van Yojana (NVY) since 2020 which envisages developing 1000 Nagar Vans/ Vatikas in the country during the period of 2020-21 to 2026-27.

The speaker elaborated on the main objectives of the scheme, which are creating green spaces in urban setup and contributing to the environmental improvement of cities by pollution mitigation, facilitating in-situ conservation of important flora of the region, providing cleaner air, noise reduction, water harvesting and reduction of Urban Heat Islands effect.

He further emphasised that trees and vegetation are most useful as a mitigation strategy when planted in strategic locations around cities. Therefore, now, there is a significant opportunity for cooling by increasing the urban forest cover through Nagar Van Yojana and similar initiatives.

SOPs for Developing Climate Adaptive and Ward Level Heat Action Plans

Shri Rohit Magotra, Dy Director, Integrated Research Action for Development (IRADe), New Delhi

Shri Rohit Magotra explained the purpose of SOP for developing Climate Adaptive and Ward level Heat Action Plans, which is mainly to provide step wise methodology to develop and implement gender-sensitive, vulnerable community focused action plans.
He further elaborated that the SOP would also help in the identification of heat hotspots, targeted interventions in cities, sensitize stakeholders on emergency preparedness, and enhance participation of stakeholders in addressing challenges posed by heatwaves.

i. The speaker explained the process of developing SOP, which would include the following steps: (a) City profile; (b) Climatological variance of city; (c) Scenario based thermal hotspot mapping of city; (d) Vulnerability mapping and assessment; (e) Heat stress impact assessment; (f) Stakeholder mapping & capacity building; (g) Mitigation & adaptation strategies and (h) Dissemination, monitoring & evaluation.

ii. City Profiling includes collection of data like heat stress, incidents of heat waves in the last 30 years, climatological average, impact of climate change on heat wave incidents in the city, status of infrastructure services (like water supply, housing, sanitation, electricity, etc.)

iii. Understanding the Climatological Variance includes collecting data (maximum temperature, and minimum temperature), and relative humidity (between 10-30 years) from State and National Meteorological Departments, analysing the climate projections of the city and lay down pre/during/post hot months of the city, etc.

iv. Thermal Hotspot Mapping includes collecting information on Land Surface Temperature (LST) and ambient air temperature, Wet and Dry bulb temperatures at the municipal ward level to determine the intra-city variations and analyze the spatial heat extreme variability with various influencing factors of the urban environment. This helps us in identifying wards/areas that may become heat hotspots due to temperature variations in future.

v. Vulnerability mapping involves identifying vulnerable groups and their respective heat health risks by carrying out a ward-level cumulative heat wave vulnerability study in the city which includes assessment of people's health, livelihood, and productivity and assessment of quantum of wage loss due to heat stress. Assessing geographic variability in heat wave vulnerability forms the basis for planning appropriate targeted adaptation strategies. Vulnerable areas include slums, and scattered settlements, areas which have minimal access to water and sanitation, UHIs, industrial belts, etc. Vulnerable groups include economically weaker sections, elderly, children, women, pregnant women, sections of people with co-morbid (diabetes, kidney, and heart-ailments), working individuals (construction workers, factory workers, sweepers, etc.).

vi. Training modules need to be prepared for HAP training of different stakeholders and such modules should be built keeping in mind the local context and language.

vii. He presented the short term, medium term, and long-term strategic measures specifically for buildings, slums, communities, workplace etc. which included improving the urban landscapes through vertical greenery, roof gardens as short-term measures, larger parks with adequate tree canopies, building blue and green infrastructures as medium-term measures, and initiating research on micro-climate, building evidence-based cooling strategies as some of the long-term measures.

viii. At the building level, rooftop sprinklers, vegetated surfaces, cool roofs minimize heat retention (short-term), besides natural cross ventilation, retrofitment of

roofing of buildings with high reflective coatings (medium-term) and introducing passive cooling techniques, and vernacular architecture (long-term).

ix. At the slum level, roof painting, placing wet gunny bags on the roof could be short-term measures, whereas open fires or planned ventilation, understanding heat risks could be medium-term measures while improving water quality and sanitation, avoiding heat-trapping building materials, ensuring thermal comfort through PMAY interventions could be long-term measures.

x. Regulated working hours with appropriate work-to-rest ratios to be introduced alongside hydration monitoring, and access to drinking water constitutes a strategy.

xi. He also highlighted the need for developing measurable indicators to evaluate the implementation of gender-sensitive HAP.

xii. He also shared a template for data collection with reference to heat mortality/ morbidly.

xiii. The speaker emphasised the significance of the Gender-Sensitive Heat Action Plan and suggested a framework of the same, for consideration.

Evaluation of Heat Action Plans (HAPs)

Shri Aditya Valiathan Pillai, Sustainable Futures Collaborative, Delhi

Shri Aditya V. Pillai made an elaborate presentation on the evaluation of heat action plans towards better implementation. The speaker talked about setting the minimum requirements for heat action plans.

i. He cited a CPR Study which highlighted the gaps in 37 HAPs in India that they are sufficiently localised with only a few of them having localised heat thresholds and only 2 out of the 37 of them conducted vulnerability assessments to address localised vulnerabilities. Lack of finance, legal grounding, and insufficient consultation, and evaluation may be the reason for the lag in its implementation.

ii. He touched upon core structural fixes on which clarity is required, such as funding, legal foundations, monitoring & evaluation mechanism, inadequate data on mortality, local temperature, central repository.

iii. He suggested that centrally sponsored schemes (CSSs) could help solve HAP financing shortfalls. The speaker also indicated the overlap between CSSs and HAP solutions. He further mentioned that few CSSs comprise the bulk of convergence with HAP interventions, such as MNREGS, AMRUT, and JJM Schemes.18 of the 72 Schemes (CSS) contained direct links to HAP solutions, with 7 of the 18 schemes unlocking finances for 2/3rd of all listed solutions. If such schemes are modified, it could provide major gains for heat resilience. For example, ensuring shelter and water to reduce heat stress/deaths, promoting rainwater harvesting, ensuring drinking water supply, constructing/ maintaining natural water bodies, etc. under MGNREGS have convergence with HAP interventions.

iv. He recommended further research to expand the scope of financing analysis to all CSSs, CSRs, state schemes, Finance Commission funds and private partnerships.

v. He further recommended concurrent research to identify bottlenecks in long-term heat adaptation.

Address the cause of Urban Heat Island (UHI)

Shri Ashok B. Lall, Architect, Delhi

Shri Ashok B. Lall, addressed main causes of urban heat islands in. He further mentioned that the Town Planning regulations and development control regulations are exacerbating the urban heat islands in recent times and exacerbating the impact of heat stress on citizens and their homes.

i. He also explained that the heat released by air conditioning in high-density high rise urban fabrics surrounded by crawling traffic compounds the rising temperatures and heat waves. Increased UHI results in increased air conditioning, which in turn increases the heat, thereby creating a vicious cycle.

ii. The speaker shared one of the examples of affordable housing project of Rajkot city, which is climate responsive Insulated reflective roofing, and Insulated walls.

iii. He threw light on the importance of mandating the roof cooling and enforcing building codes.

iv. He emphasised that for the anticipated urban growth, Town Planning regulations and development control regulations (DCR) must limit FSI, ground overage, and reduce the requirement for parking and vehicular access.

India Cooling Action Plan

Dr Aditya Narayan Singh, Scientist F, Ozone Cell, MOEFCC

Dr Aditya Narayan Singh shared the insights about India's Cooling Action Plan. He informed that India is the first Country in the World to develop a comprehensive cooling action plan. India Cooling Action Plan was launched in March 2019.

He emphasised to follow the Energy Conservation Building Code 2017 (ECBC 2017), its effective implementation will be the key. The speaker informed about the India Cooling Action Plan Goals, to be achieved by the year 2037-38, which included a reduction of cooling demand by 20% to 25%, reduction of cooling energy requirements by 25-40%, among others. It has an objective to provide thermal comfort for all using sustainable cooling technologies/interventions.

He described seven core thematic groups on which the actions are being taken:

a. Space Cooling in Buildings.

b. Air-conditioning Technology.

c. Cold-chain and Refrigeration.

d. Transport Air-conditioning.

e. Refrigeration & Air Conditioning Servicing Sector.

f. Refrigerant Demand & Indigenous Production; and

g. Research & Development.

Actionable Points

i. All the heatwave experts need to come together for next generation heat action plans, which should align with new imagination, effective use of technology in simple manner, and inclusion of localised governance, NGOs, private partners, Urban Development and other key Deptts. There should be Nodal Officer/s responsible for Heat Action Plans. Leadership is important.

ii. There is need for substantive research, to expand scope of financing issues, analysis of CSSs, and look at the other feasible options as well. Further, there is need for matchmaking between policy, implementation and research. The research should be more purposeful.

iii. There is need for dovetailing of heat wave policies, heat wave actions, at National & State level, requirement for the standardization of heat wave solutions, central repository and constant monitoring & evaluation of the ongoing heat wave initiatives to achieve set targets. All States review their HAPs, and include vulnerability assessment, local thresholds and partnerships etc.

iv. The unplanned development and rapid construction of buildings/ structures also lead to the problem of urban heat islands, which needs to be addressed as a priority. Thrust may be given to nature-based local solutions, such as rejuvenation of lakes, promotion of Nagar Van Yojana etc.

v. There is a need to follow the Energy Conservation Building Code 2017 (ECBC 2017), its effective implementation will be the key.

WRAP-UP SESSION: Mainstreaming Mitigation Strategies

Chair:
Shri Rajendra Singh,
Member, NDMA

Moderated:
Ms Rakhee Sadhu,
DS, NDMA.

Rapporteur:
Dr Vazeem Iqbal,
Consultant Grade, NDMA

The session had three presentations/ comments:

i. Key Takeaways from all the Sessions: Shri Kunal Satyarthi JS, NDMA and Shri Abhiyant Tiwari, NRDC India, Delhi

ii. National Heatwave Mitigation Strategy: Dr Krishna S. Vatsa, Member, NDMA

iii. Concluding Remarks: Shri Kamal Kishore, Former Member and HoD

Key Takeaways from All the Sessions

Shri Kunal Satyarthi JS, NDMA and Shri Abhiyant Tiwari, NRDC India, Delhi

During the recap of the season, **Shri Kunal Satyarthi**, JS PP, highlighted the diverse participation of 34 speakers, including vulnerable community members and Army officers. The first and second technical sessions covered an array of variant topics. These encompassed Early Warning and Climate Services, Health

Impacts of Heatwave, Effects on Infrastructure and Production Sectors, as well as Mitigation Strategies. The discussions delved into Sectoral Burden due to Rising Heat, shared experiences of Heatwave Management from the field, and explored the nexus between Urban Heat and the preparedness of vulnerable communities. Additionally, the session addressed the Heat Action Plan, focusing on Preparedness and Mitigation Strategies. This comprehensive overview showcased the breadth of expertise and insights shared throughout the event. He also mentioned that 22 States, along with MHA, NIDM, NDRF, and 18 different ministries / Departments like AIIMS and, the Indian Army have come for the first time to discuss Heatwave and collaboration. Abhiyant Tiwari conveyed his gratitude to all the institution and participants and thanked NDMA for organisation of Heatwave workshop.

National Framework for Heat Wave Management and Mitigation

Shri Krishna S. Vatsa Member, NDMA

Shri Krishna S. Vatsa Member, NDMA presented a comprehensive National Framework for Heat Wave Management and Mitigation, a crucial initiative to address the growing challenges posed by rising temperatures and heat waves. The session focused on various aspects of heat wave management, highlighting the need for a unified approach to mitigate the impacts on individuals, communities, and various sectors.

1. Global Trends in Rising Temperature and Heat Waves:

The session commenced with an overview of the alarming global trends in rising temperatures and the increasing frequency and intensity of heat waves. The evidence presented underscored the urgency for effective heat wave management strategies on a national scale. February 2023 was India's hottest February since 1901, with widespread heat waves impacting multiple States. IMD highlighted an increase in both frequency and duration of heat waves, especially in northern India. Data from 1961 to 2000 shows a significant rise in the occurrence and duration of HW across India, with some experiencing more than four events per season and durations extending beyond 8 days.

2. IMD Advisories and Alerts on Heat Waves:

The Indian Meteorological Department's (IMD) role in issuing advisories and alerts was emphasised which include Heat Wave Criteria, Coastal HW Criteria, IMD Alert Systems, Heat Index and Wet Bulb temperature. Timely and accurate information dissemination is crucial for enabling communities to take preventive measures and for authorities to implement responsive actions.

3. Heat Wave-Related Deaths in India:

Statistics on heat wave-related deaths in India were presented, highlighting the severity of the issue. The need for comprehensive measures to prevent casualties became evident, urging a reevaluation of existing strategies.

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Data sources include IMD Data (meteorological conditions), MoH&FW data (2015-19) on death reporting, clinical reports and health outcomes, NCRB Data (2011-2020), which documents heat-stroke deaths based on police records and trend analysis.

4. Salient Impacts of Heat Waves on Various Sectors:

The session delved into the far-reaching impacts of heat waves on sectors such as agriculture, water resources, energy, and public health. The discussion emphasised the importance of sector-specific strategies to build resilience against heat-related challenges. Consequences include Health risks, HI, increase in demand for air conditioning, affect crop yields, cause drought conditions, among others.

5. Key Principles for Heat Wave Management:

A set of key principles, including early warning systems, community engagement, and adaptive urban planning, were identified as foundational to effective heat wave management. These principles served as a guide for developing comprehensive strategies. Key principles include Decentralization (localised strategies, granting autonomy to the local government), Participation (involving community members in decision-making), Adaptation (combining traditional wisdom, established practices with modern technologies) and multi-sectoral collaboration.

6. The Role and Evolution of Heat Action Plans:

The evolution of Heat Action Plans (HAPs) was traced, highlighting their role in preventing heat-related illnesses and fatalities. The session emphasised the need for continuous improvement and adaptation of HAPs to evolving climatic conditions. HAPs should provide an essential framework for mitigation, dynamic tools for preparedness, targeted interventions to protect vulnerable populations, ensure district administration and municipalities embrace it as their own, and provide funding mechanisms for implementation.

7. Framework Components for Heat Wave Management:

A detailed discussion unfolded around the essential components of the National Framework, emphasising the integration of meteorological data, urban planning, health services, and community engagement to form a holistic approach. Framework components include local-level weather network (in collaboration with IMD), automatic weather stations (to supplement IMD advisories, providing hyperlocal weather information for urban planning) and multi-channel forecasting and warning.

8. Urban Planning and Infrastructure for Heat Wave Mitigation:

The significance of sustainable urban planning and resilient infrastructure in mitigating the urban heat island effect was underscored. Integrating these aspects into city development plans emerged as a critical strategy. It includes urban greening, cool roof interventions and ventilated housing as strategies.

9. Health System Preparedness for Heat Waves:

The session highlighted the importance of strengthening the health system's capacity to deal with heat-related illnesses. Preparedness, training, and resource allocation for healthcare professionals were emphasised. It includes equipping healthcare facilities to manage HRI with adequate staffing, cooling devices, hydration facilities, and emergency services.

10. Community-level Interventions for Heat Wave Resilience:

Empowering communities through awareness campaigns, community-based adaptation strategies, and local-level capacity building were identified as essential components of heat wave resilience through Community Cool Centres, Shaded Spaces, Distributing Reusable Water Bottles, Water Refill Points, Engaging Community Health Workers, especially during Extreme Heat Events.

11. Public Awareness and Capacity Building:

The session stressed the need for widespread public awareness campaigns and capacity-building initiatives to ensure that individuals are well-informed and equipped to cope with extreme heat events. These include Community Training on Heat Wave Preparedness through interactive sessions educating communities on recognising heat wave signs, first-aid for HRI, preventive measures, with a focus on engaging vulnerable groups, Preparing IEC Materials in local languages, etc.

12. Multi-sectoral Collaboration for Heat Wave Mitigation:

Encouraging collaboration across sectors, including government agencies, NGOs (for organising training, monitoring the effectiveness of heat wave mitigation efforts), academia, and private entities (implementing flexible work arrangements, providing hydration and cooling facilities, and enhancing workplace infrastructure for employee safety) were identified as a key strategy for effective heat wave mitigation.

13. Financing Mechanisms for Heat Wave Mitigation:

Exploration of various financing mechanisms, including public-private partnerships and international collaborations, took place to ensure adequate resources for implementing comprehensive heat wave mitigation strategies. Strategies for Sustained Investment include NDMA/SDMA funds, Local Government Allocations (Municipal Budgets), PPP for Community Resilience Projects, Grants and Donor Funding (Community-based Adaptation)

14. Scaling and Replicability of Heat Wave Mitigation Strategies:

The session emphasised the importance of scalable and replicable strategies to ensure widespread implementation and adaptation across diverse geographical and socio-economic contexts. A phased and collaborative approach which includes: phased pilot deployment (based on heat severity, vulnerability and local government interest allowing customization of cooling interventions) , building an online knowledge platform, providing foundational principles while emphasising local knowledge and adaption, with a modular design that offers consistency and customization), Targeting Replication (using vulnerability index to identify cities with the greatest need for the framework)

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15. Monitoring and Evaluation of Heat Wave Mitigation:

Establishing robust monitoring and evaluation frameworks was discussed, emphasising the need for data-driven assessments to continuously improve heat wave management strategies. Measurable Indicators include Process Indicators (establishment of cooling centres, heat mapping coverage, outreach to vulnerable populations), Outcome Indicators (health impacts like reduction in HRI and deaths, behavioural changes in public awareness, etc.), Data Collection Methods (utilising health statistics, meteorological data, etc.), Annual Reviews and Adaptability (conducting review sessions to analyze results, adapt strategies based on feedback and consider evolving risk factors)

16. Enabling Mechanisms for Heat Wave Mitigation:

Policy enablers and regulatory frameworks were discussed, highlighting the role of government bodies in creating an environment conducive to effective heat wave mitigation. This includes appointing a heat officer, organising technical assistance (in adapting the framework and interpreting data for effective mitigation) with appropriate funding guidance to support the implementation of HAP interventions.

17. Role of NDMA, SDMAs, and DDMAs in Heat Wave Management:

The role of National Disaster Management Authority (NDMA), State Disaster Management Authorities (SDMAs), and District Disaster Management Authorities (DDMAs) in coordinating and implementing heat wave management strategies was outlined. Disaster Management Authorities at all levels provide a strategic framework, expertise, resources, and encourage coordination for effective planning and implementation.

18. Conclusion: Unified Approach to Heat Wave Mitigation

The session concluded by reiterating the importance of a unified and comprehensive approach to heat wave mitigation. It was emphasised that collective efforts at the national, state, and local levels are crucial to building resilience against the impacts of rising temperatures and heat waves. It should engage all stakeholders, from local communities to national authorities, in a collective effort to combat heat wave impacts, valuing traditional knowledge alongside scientific advancements. The actions should focus on prevention, preparedness, and adaptive responses to evolving heat wave risks, ensuring robust resilience mechanisms are in place.

In conclusion, the National Framework for Heat Wave Management and Mitigation sets the stage for a concerted effort to address the challenges posed by climate change. The session provided valuable insights into the multifaceted aspects of heat wave management, laying the groundwork for a resilient and adaptive approach to safeguarding communities and sectors from the impacts of extreme heat events.

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Concluding Remarks

Shri Kamal Kishore, Former Member and HoD

Shri Kamal Kishore, Former Member and HoD, expressed gratitude to Shri Krishna S. Vatsa Member, NDMA for presenting a comprehensive approach to the National Heatwave Mitigation strategy. He emphasised the need to consult and refine this strategy with other stakeholders.

i. Acknowledging the significance of the in-person national workshop on heatwaves, he highlighted the expansion of its scope beyond disaster risk management, public health, and meteorology. He commended various sectors for their awareness of heatwave issues, particularly praising the railway and power sectors. He urged stakeholders to transform the workshop into a continuous engagement series with IMD, Health, and other sectors. As part of the heatwave workshop, Shri Kamal Kishore stressed the importance of regularly updating states in the coming four months, emphasising the need for short-term strategies to reduce mortality in the next session. He underscored the necessity of both long-term and short-term measures, calling for the training of public health officials to address impending heatwaves. He emphasised the importance of public awareness programs, urging states to monitor and support vulnerable communities to achieve zero mortality.

ii. Shri Kamal Kishore emphasised that such deliberations can't be kept as once a year event. It must be a continuous process involving all the states concerned and other stakeholders.

iii. He further pointed out that review of preparedness for heat wave season 2024 should be done every fortnightly for the next 3-4 months.

iv. A small Technical Advisory Group (TAG) should be constituted for developing next generation HAPs and mitigation framework.

v. Shri Kamal Kishore highlighted the immense nature of the heatwave problem, emphasising that neither disaster managers nor IMD alone could handle it. He identified three major areas for focused advocacy. He advocated meeting with Urban Development Authorities at the Union Government and State level to discuss turning building codes into building bylaws in urban designing for disaster risk reduction.

vi. Addressing the issue of financing for different mitigation solutions, particularly for cooling solutions and cool roofs, he stressed the need to create a market and collaboration with the private sector for mass production of cool roofing materials.

vii. Seeking financial protection for the urban poor vulnerable community affected by heat, especially construction workers, Shri Kamal Kishore questioned whether there is a system to provide compensation if construction sites are closed for a few days due to extreme heat, leading to unpaid wages for workers.

viii. While summing up his concluding remarks, Shri Kamal Kishore set the target of zero mortality for the upcoming heat wave season.


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5.	**Shri Rupesh Kumar Sinha, Deputy Secretary**	Ministry of Women & Child Development
6.	**Ms Kalyani Mishra, Joint Secretary**	Department of Rural Development
7.	**Shri Utkarsh, Executive Director**	Ministry of Railway
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48.	**Shri Banwarilal Maharaniya**	NDRF
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69.	**Shri Sameer Kwatra**	NRDC
70.	**Ms Ritika Kapoor**	NRDC
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75.	**Shri Abhinash Mohaly**	IPE Global
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81.	**Shri Aditya Narayan Singh**	Scientist F

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94.	**Ms Neha Praveen, National Coordination**	Delhi
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99.	**Shri Suresh Kumar, Project Officer**	Haryana
100.	**Shri Amresh Kumar, Special Executive Officer**	Jharkhand
101.	**Ms Snober Jameel, Under Secretary**	Jammu & Kashmir
102.	**Shri NG Keerthy, Project Scientist**	Karnataka
103.	**Shri Adarsha Gowda MT, Project Scientist**	Karnataka
104.	**Dr Dileep Singh, Deputy Coordinator**	Madhya Pradesh
105.	**Ms Kamalnath Dhurve, District Commandant, SDRF**	Madhya Pradesh
106.	**Shri Parikshit Dongarsane, Sr. Analyst**	Maharashtra
107.	**Smt Lipika Das, Joint Special Relief Commissioner**	Odisha
108.	**Shri Jaya Jagat Sahu, Deputy General Manager**	Odisha
109.	**Shri Meghanad Behera, Sr. DRR Consultant**	Odisha
110.	**Shri Vivek Sharma, Sr. Consultant (DM)**	Punjab

S. No.	Name/Designation	Organization
111.	**Shri Makkhan Lal Khateek, OSD-I Disaster Management Relief & Civil Defence Deptt.**	Rajasthan
112.	**Shri S.A. Raman, Director and Head of Disaster Management**	Tamil Nadu
113.	**Shri N.C. Sekar, Asst. Commissioner-DRR**	Tamil Nadu
114.	**Dr R. Murugananth, Capacity Building Expert**	Tamil Nadu
115.	**Shri N. Prakash Reddy, Director**	Telangana
116.	**Shri G.S. Naveen Kumar, Secretary (Revenue)**	Uttar Pradesh
117.	**Smt Aditi Umrao, Project Director**	Uttar Pradesh
118.	**Shri Pervez Akhter Ansari, SOC, HQ**	Uttar Pradesh
119.	**Shri Shashank Chauhan**	UP SDMA
120.	**Shri Dushyant Nariala, Principal Secretary**	West Bengal
121.	**Shri Kunal Awarwal, DIG, WBNVF**	West Bengal
122.	**Shri Praveen Bhardwaj, Disaster Management Specialist**	Himachal Pradesh
123.	**Shri Kamal Thakur, Supervisor**	Himachal Pradesh
124.	**Shri Ravindra Kumar, District Magistrate**	Bareilly, Uttar Pradesh
125.	**Dr Sujeet Kumar Yadav, Chief Medical Superintendent**	Ballia, Uttar Pradesh
126.	**Shri Ambrish Kumar Bind, Addl. Municipal Commissioner**	Municipal Corporation, Prayagraj, Uttar Pradesh

Other Participants

S. No.	Name/ Designation	Organization
1.	**Shri Anand Kumar**	DD News
2.	**Shri Anand Kashyap**	DD News
3.	**Shri Rajesh Raj**	DD
4.	**Shri Dilip Jha**	AIR Delhi
5.	**Shri Sumit Katiyar**	AIR Delhi
6.	**Shri Ashok Kr. Mishra**	AIR Delhi
7.	**Shri Pradeep Singh**	Hon'ble Minister office
8.	**Shri Suraj Kumar**	Hon'ble Minister office
9.	**MD Sajid**	DD
10.	**Shri Ashutosh Bhardwaj**	AIR

NDMA
Officers

S. No.	Name	Designation
1.	**Shri Kamal Kishore**	Former Member and HoD
2.	**Shri Rajendra Singh**	Member and HoD
3.	**Shri Syed Ata Hasnain**	Member
4.	**Shri Krishna Swaroop Vatsa**	Member
5.	**Shri Safi Ahsan Rizvi**	Advisor Mitigation
6.	**Shri Kunal Satyarathi**	Joint Secretary
7.	**Ms Sreyasi Chaudhari**	Joint Secretary
8.	**Ms Sumita Singh**	Joint Secretary
9.	**Shri Sanjay Upreti**	Joint Secretary
10.	**Col. K.P. Singh**	Advisor (OPS)
11.	**Shri Rakesh Kataria**	Director
12.	**Ms Mrinalini Shrivastava**	Director
13.	**Shri Ambuj Bajpai**	Deputy Secretary
14.	**Ms Rakhee Sadhu**	Deputy Secretary
15.	**Shri Biswarup Das**	JA (MP/P)
16.	**Shri Nawal Prakash**	JA (IT, Comm)
17.	**Dr S.K. Jena**	Joint Advisor
18.	**Lt. Col. Surya Prakash Pandey**	JA (CBT)
19.	**Shri Manoj Kumar Jangir**	Under Secretary
20.	**Shri Vivek Jayaswal**	Under Secretary
21.	**Shri Chandan Singh**	Under Secretary
22.	**Shri Subhash Chand**	Under Secretary
23.	**Shri R.K. Mishra**	Under Secretary

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30.	**Ms Antika Jain**	Sr. Consultant (IEC)
31.	**Ms Shalini Singh**	Sr. Consultant (Museum)
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33.	**Col. Nadeen Arshad**	Consultant (Operation)
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