Assessment and Early Warning of Heat Waves in India: Stakeholder Implementation of Heat Wave Action Plans

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Fig. 5.1. Changes in the role of the land surface on temperature when soils are wet (a) and dry (b). A smaller boundary layer and sensible heat flux, and an enhanced latent heat flux occurs when soils are wet, however this is reversed under dry conditions. This explains in a simple context the coupling of drought and heat waves. Source (Taken from Fig. 1 of Alexander (2011)).
Fig. 5.7. Composite anomalies of (a) Maximum PBL height (Km) (b) Total cloud cover during heat wave events mentioned in Table 5.2.
Fig. 5.9. Composite anomalies of Specific Humidity (kg kg$^{-1}$) at (a) 850 hPa (b) 925 hPa during the heat wave events.
Fig. 5.17 The first canonical mode of the canonical correlation analysis of April-June SST and heat wave duration days for the period 1961-2013. (a) Spatial mode of SST (b) spatial mode of heat wave duration and (c) time series of first mode of SST(Black) and heat wave duration (Red). In (c), the time series of SST averaged over the equatorial Indian Ocean (10°S-10°N, 50°E-100°E) is shown in blue color line. (After Rohini et al. 2016)
Heat waves are anomalous episodes with extremely high surface air temperatures, lasting for several days with serious consequences.

Fig. 1.1. Schematic representations of the probability density function of daily temperatures. Dashed lines represent a previous distribution and solid lines a changed distribution. The probability of occurrence, or frequency, of extremes, is denoted by the shaded areas. In the case of temperature, changes in the frequencies of extremes are affected by changes (a) in the mean, (b) in the variance or shape, and (c) in both the mean and the variance (Source: IPCC, 2014).
To declare a heat wave, the above criteria should be met at least in 2 stations in the meteorological sub-division for at least two consecutive days.
Main Period of Heat Waves: April - June

April

May

June

(d) Normal Maximum Temperature for June
Based on period (1971–2000)
Fig 4.1 a) Heat wave average frequency during March-June for the period 1961-2020, b) HW frequency trends, station wise during the same period.
Fig 4.2 a) Heat wave average total duration (days) during March-June for the period 1961-2020, b) Station wise, HW duration trends during the same period.
Fig 4.3 a) Maximum Duration of Heat Wave days during March-June for the period 1961-2020, b) Station wise, trends of maximum duration of heat waves during the same period.
Fig 4.4. Spatial distribution of average Severe Heat Wave (SHW) days during March-June for the period 1961-2020.
Fig 4.5. Average HW days during a) the El Nino years and b) La Nina years during the period 1961-2020.
Fig. 4.6. a) Station wise longest heat wave spell during 1961-2020 b) Station wise longest Severe heat wave spell during 1961-2020.
Fig 4.7. Spatial distribution of a) heat wave frequency, b) heat wave days and c) heat wave intensity during MAMJ. Period 1961-2021.
Fig 4.8. Spatial distribution of a) Severe heat wave frequency, b) severe heat wave days and c) severe heat wave intensity during MAMJ. Period 1961-2021.
Fig 4.9. Spatial distribution of a) Trend in heat wave frequency (number/decade), severe heat wave days (days/decade) and severe heat wave intensity (°C/decade) during MAMJ. Period 1961-2021. The trends which are statistically significant are shown as dots.
Fig 4.10. Spatial Distribution of a) average maximum HW days (days/season) and b) long term trends. The trends which are statistically significant are shown as dots.
Fig 7.7. Predicted maximum temperatures (°C) for 29 May (left column), 02 June (middle) and 11 June (right) at lead time of 24 hrs (top panel), 72 hrs (middle) and 120 hrs (bottom). These forecasts are from the IMD/IITM GFS model.
Fig 7.8. Predicted maximum temperature departures (°C) for 29 May (left column), 02 June (middle) and 11 June (right) at lead time of 24 hrs (top panel), 72 hrs (middle) and 120 hrs (bottom). These forecasts are from the IMD/IITM GFS model.
Fig 7.9. Predicted Relative Humidity Departures (%) for 29 May (left column), 02 June (middle) and 11 June (right column) at lead time of 24 hrs (top panel), 72 hrs (middle) and 120 hrs (bottom). These forecasts are from the IMD/IITM GFS model.
Impact Based Forecasts as Per Thresholds Provided By The Users

10 cities in 2016

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Example: T.Max for Andhra
(Forecast for 11.3.2018 to 13.3.2018)
Dated 10/03/2018

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* Based on Observed AWS data

* Based on WRF Model Simulations and using Temperature and Humidity Combination
Heat action plan

- Heat action plan is extended to seven cities across Central India.
- Letter written by HMoES to all chief Secretaries for preparing Heat Action Plan
- Daily Bulletin on Heat Wave issued during April to June
- Indian Medical association and power sector among other were provided forecast

![Temperature Forecast: Specific Range, Time duration and area]

3.3 Identification of Color Signals for Heat Alert:

<table>
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<th>Alert Type</th>
<th>Description</th>
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<td>Red Alert (Severe Condition)</td>
<td>Extreme Heat Alert for the Day</td>
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<tr>
<td>Orange Alert (Moderate Condition)</td>
<td>Normal Maximum Temp increase 4°C to 5°C</td>
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<tr>
<td>Yellow Alert (Heat-wave Warning)</td>
<td>Hot Day</td>
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<tr>
<td>White (Normal)</td>
<td>Normal Day</td>
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3 Ahmadabad Heat Action Plan 2015
Heat-Health service of IMD has resulted in significant reduction in number of deaths due to heat.

(Source: NDMA)
“JSW- The Times of India 8th Earth Care Awards 2018” in the category of “Leadership in Urban Climate Action” was jointly awarded to IMD, IIPH, Gandhinagar and Ahmedabad Municipal Corporation for Ahmedabad Heat Action Plan

The Awards was given away by the Hon’ble Union Minister of Science & Technology, Earth Sciences, Environment, Forest and Climate Change Dr. Harsh Vardhan Ji in New Delhi on 17 April 2018.
Fig. 8.5 State-wise distribution of thunderstorm events in India for the period 1978–2012. Source IMD, see also Bharadwaj et al. (2017)

Fig. 8.6 Number of thunderstorm days in India: mean frequency during different Indian seasons for the period 1951–1980 and 1981–2010. Source IMD; Adopted from Bharadwaj and Singh (2018) under CC BY-NC 4
Growing interest in monitoring lightning globally

In India, there is a growing global interest in monitoring lightning activity closely, sparked by concerns over climate change, of which lightning is seen as a symptom as well as a cause.

Quoting previously published studies, a September 2018 research paper, *Lightning: A New Essential Climate Variable*, made two important points.

- "Lightning frequency is changing, as climate is changing. Lightning’s close relationship to heatwave abatement - thunderstorms and precipitation makes it a valuable indicator for storminess."
- "Lightning is not only an indicator of climate change; it also affects the global climate directly. Lightning produces nitrogen oxides, which are strong greenhouse gases."
- "Model calculations suggest an increase in lightning flashes in a warmer climate"
- "Some studies indicate a 10-12% increase in
Need to make adaptation choices to reduce the impact of heat waves

- Increasing public awareness
- Improving the built environment
- Providing cool shelters
- Changing work schedules
- Developing early warning systems linked to response actions

- Recurrent heat waves, already a problem in the rapidly growing and urbanising countries of South Asia will most likely worsen in a warming world.

- However, coordinated adaptation measures can reduce the negative health impacts of heat. Across India, state and district governments have responded by creating Heat Action Plans (HAPs) that prescribe a variety of preparedness activities and heat wave response measures across government departments to reduce the impact of heat waves

- To address this problem in Ahmedabad (Gujarat, India), a coalition was formed to develop an evidence-based heatwave preparedness plan and early warning system.

- Knowlton et al. (2014) discussed the details of developing and implementing South Asia's first Heat Health Action Plan in Ahmedabad (Gujarat).
Aditya Valiathan Pillai and Dalal (2023) published a report critically analyzing 37 heat action plans at city (9), district (13) and state (15) levels in 18 states.

- Identified several opportunities to strengthen India's HAPs.
- Documented a wide range of solutions (covering 62 different types of interventions) prescribed in these HAPs, from promoting green roofs to federal school awareness programs.
- The HAPs provide for a balanced mix of short- and long-term measures, although it is unclear to what extent these measures will be implemented.
- Long-term transformational measures such as climate-sensitive urban planning and changing cropping patterns are likely to have higher implementation costs than immediate measures, but could significantly reduce heat stress in the long term and facilitate the implementation of HAP.
- Found that most HAPs are not tailored to the local context and have an oversimplified view of the hazard.
- Almost all HAPs are inadequate in identifying and targeting vulnerable groups.
- HAPS are underfunded, lack transparency and have a weak legal basis.

Debnath et al. (2023) addressed the issues of heat wave impacts on public health, agriculture and other socio-economic and cultural systems. They argue that these impact can hinder or reverse the country’s progress in fulfilling the sustainable development goals (SDGs).