



Heat Waves: Climatology, Trends, Impacts and Management System in India

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Ministry of Earth Sciences**

Defining Heat waves

No universal definition. Generally defined as a prolonged period of excessive heat.

- **UKMO:** An extended period of hot weather relative to the expected conditions of the area at that time of year.
- **WMO:** When the daily maximum temperature exceeds the average maximum temperature by 5°C for more than five consecutive days.
- **BOM:** Three or more days of unusually high maximum and minimum temperatures in any area.

The level of heat discomfort is determined by a combination of **meteorological** (temp, RH, wind, direct sunshine), **socio-cultural** (clothing, occupation, accommodation) and **physiological** (health, fitness, age, level of acclimatization) factors.

Heat Wave defined in India

a) Based on Departure from Normal

Heat Wave: Departure 4.5°C to 6.4°C

Severe Heat Wave: Departure $>6.4^{\circ}\text{C}$

b) Based on Actual Maximum Temperature

Heat Wave: Maximum Temperature $\geq 45^{\circ}\text{C}$

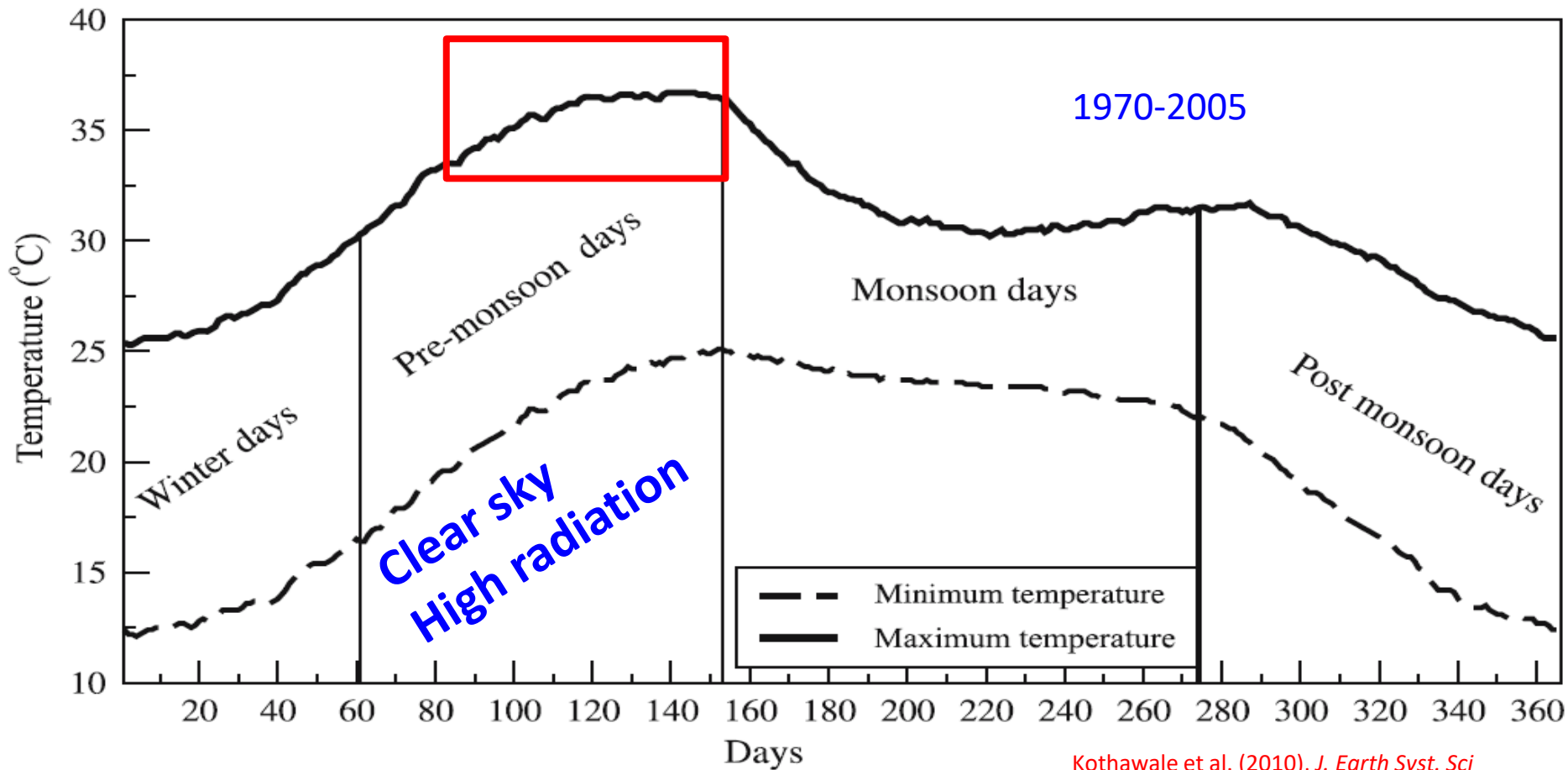
Severe Heat Wave: Maximum Temperature $\geq 47^{\circ}\text{C}$

c) Criteria for describing Heat Wave for coastal stations

When Max Temp departure from normal is 4.5°C or more,

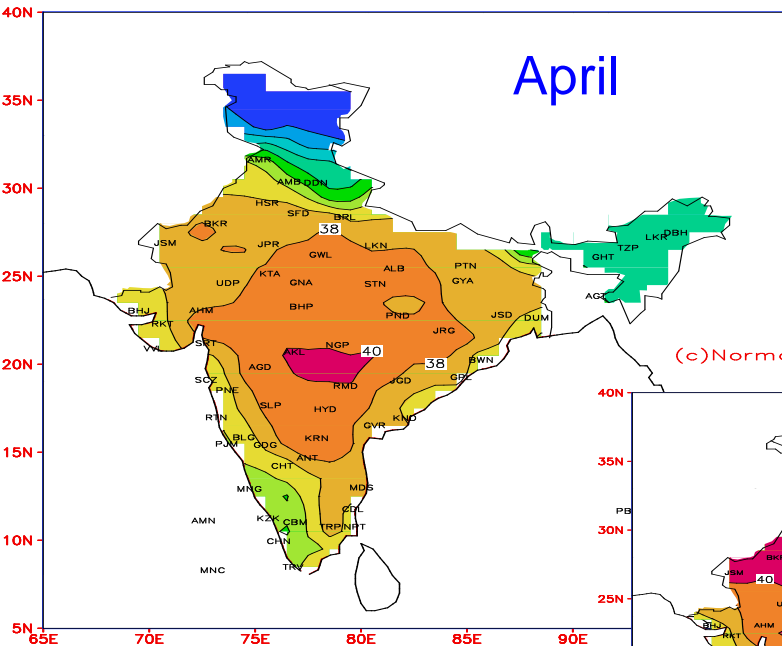
Heat wave considered only when the actual Max. temp. is 40°C or more for Plains, 30°C or more for Hilly regions, and 37°C or more for the Coastal stations.

Annual cycle of All-India daily maximum and minimum temperatures

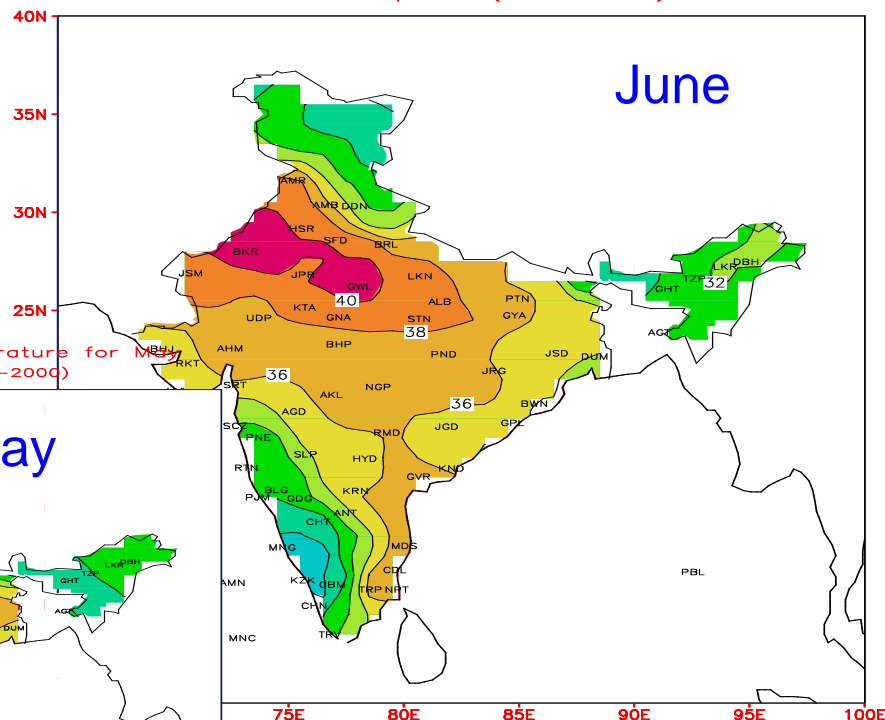


April-June Main Period of Heat Wave

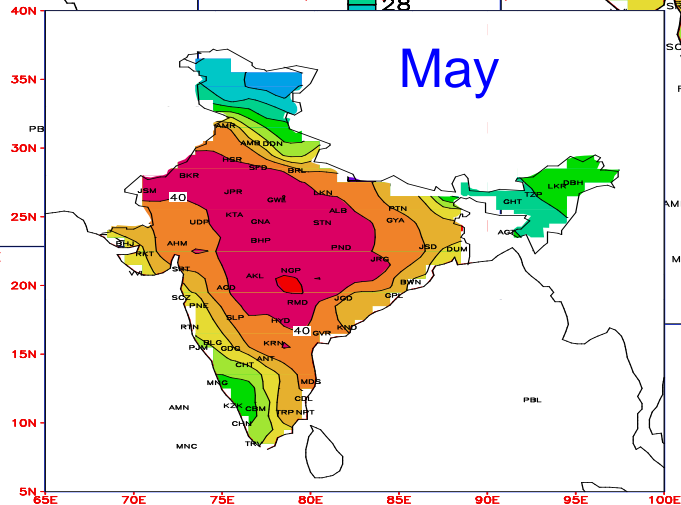
(b) Normal Maximum Temperature for April
Based on period (1971–2000)



(d) Normal Maximum Temperature for June
Based on period (1971–2000)



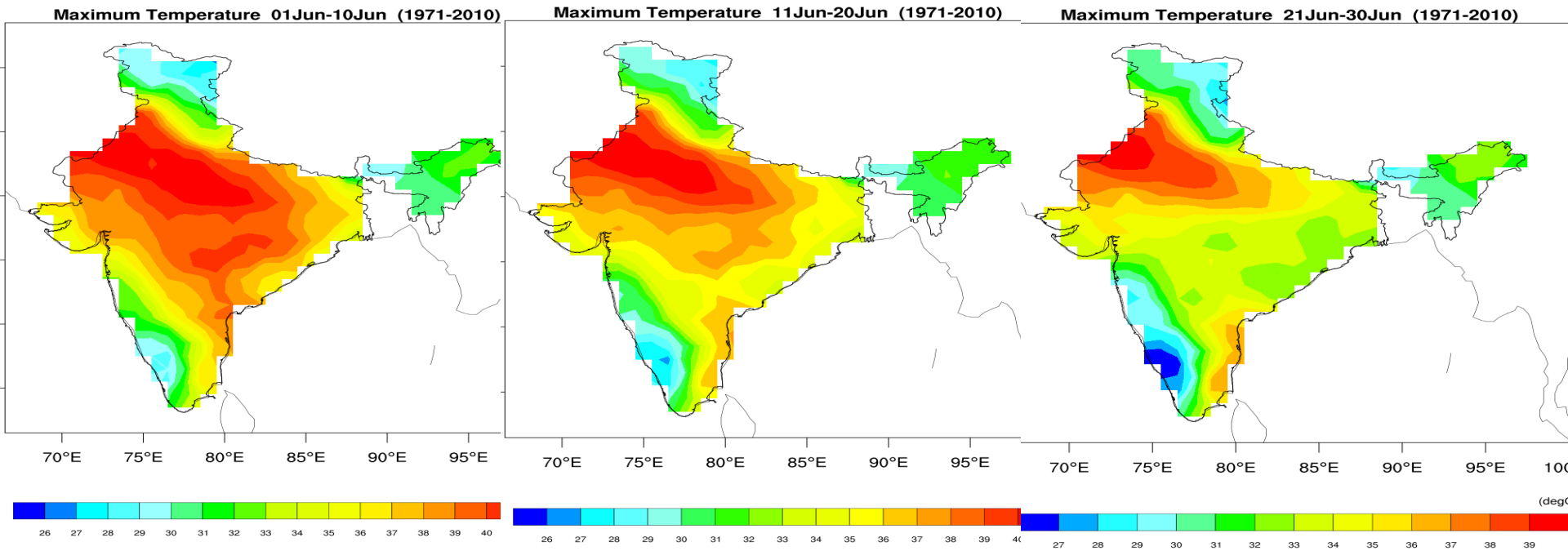
(c) Normal Maximum Temperature for May
Based on period (1971–2000)



Area of High Temp shrinks in the month of June due to onset of SW Monsoon.

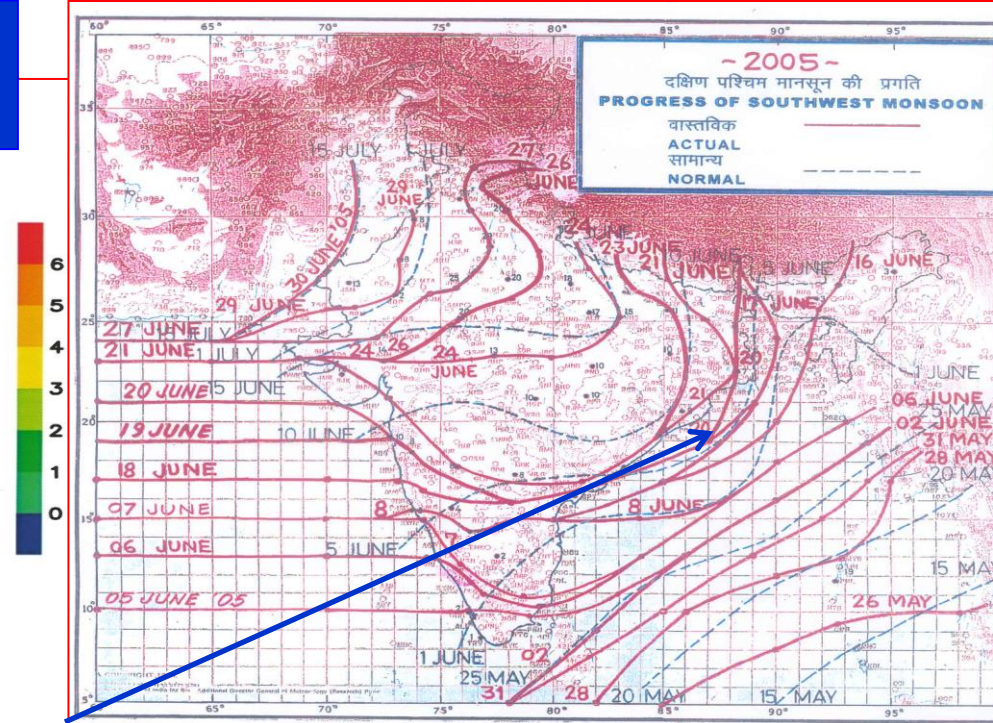
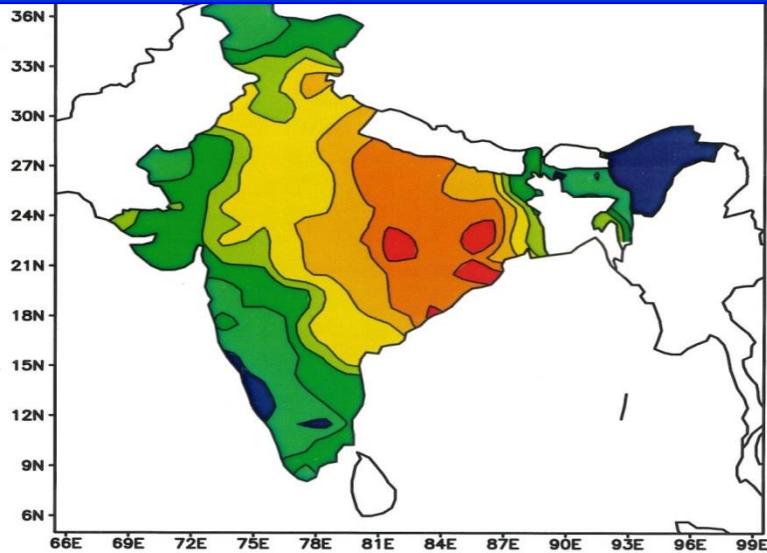
onset of SW Monsoon.

Central & Eastern parts, however, remain quite HOT during first decade of June in normal onset years



AND may remain HOT upto quite late in case of delayed onset of monsoon

Maximum Temperature Anomalies (14-22 June, 2005)



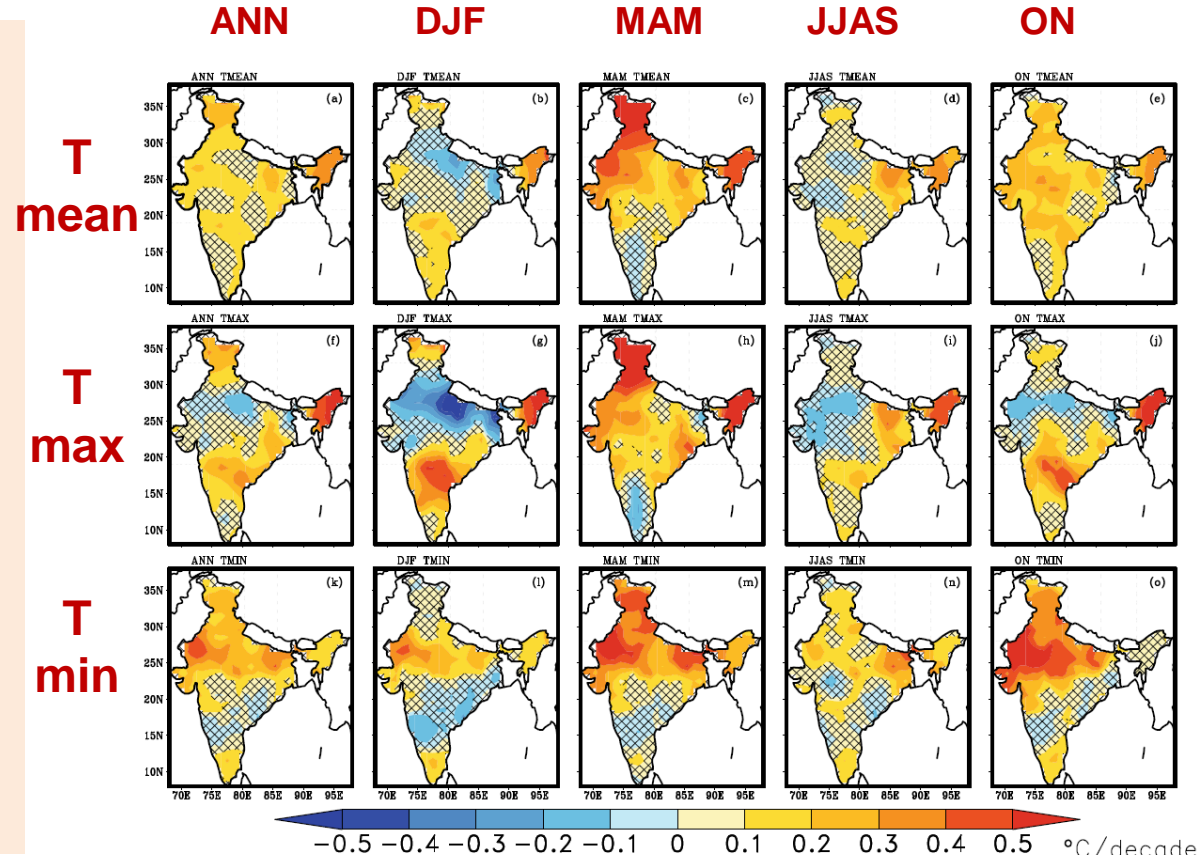
Stagnation of Monsoon from 9 to 19 June 2005

Climate Change: Spatial distribution of observed annual and seasonal trends ($^{\circ}\text{C}$ per decade) during the period 1986–2015

Krishnan *et al.* (Eds)

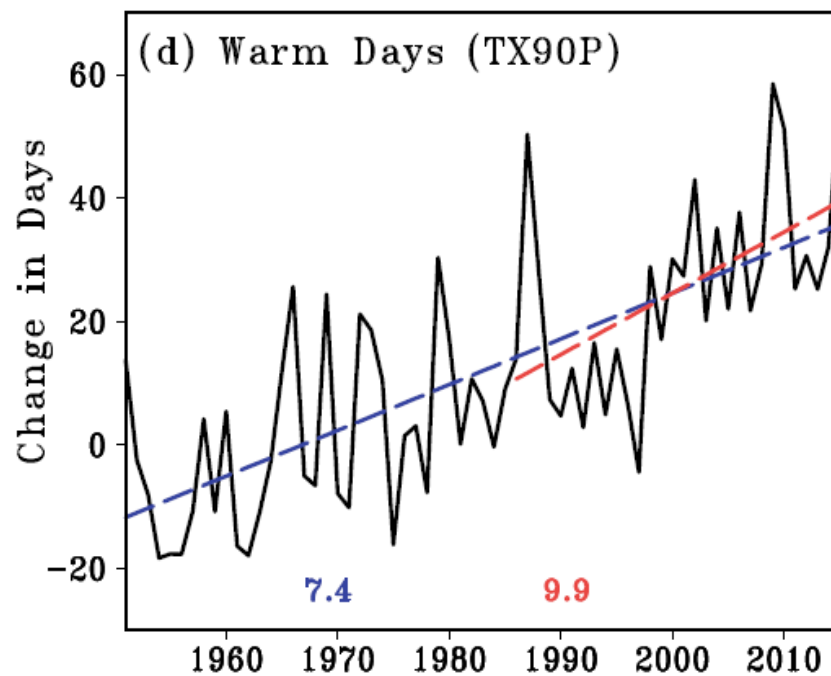
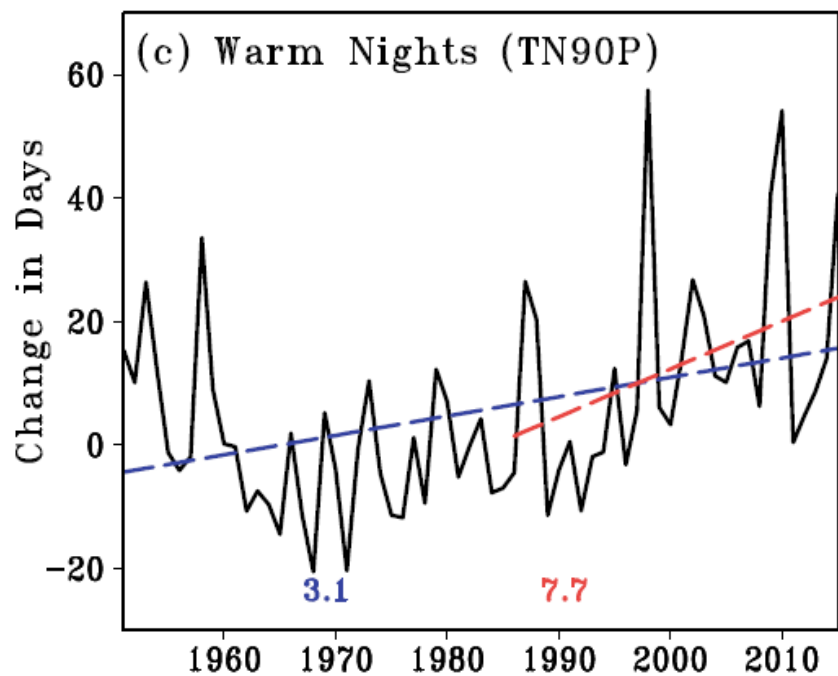
DOI: <https://doi.org/10.1007/978-981-15-4327-2>

- Accelerated warming in recent years.
- Uneven distribution of observed warming.
- Largest increase in annual mean temp of more than 0.2°C per decade are observed in some areas of north India.
- Winter warming is limited to peninsular India.
- Summer season shows predominant warming of more than 0.5°C per decade over north India.



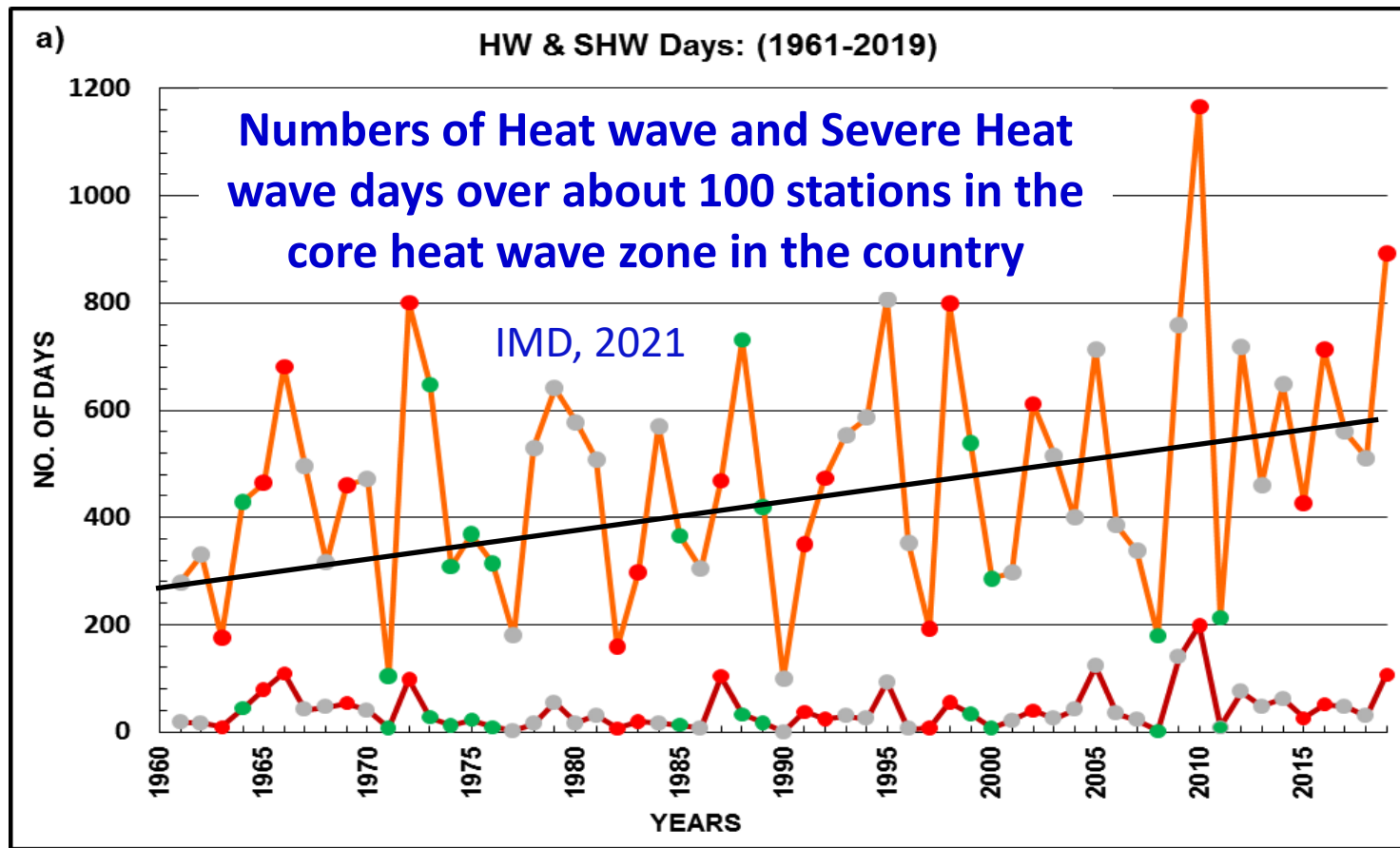
Time-series of all India averaged annual frequency of warm nights (TN90p), and warm days (TX90p).

The dashed blue and red lines indicate the linear trends (per decade) for the periods 1951–2015 and 1986–2015, respectively.



Trends in occurrence of Heat Waves

Numbers of Heat wave and Severe Heat wave days have increased from less than 4 in early 1960s to about 6 in 2010s



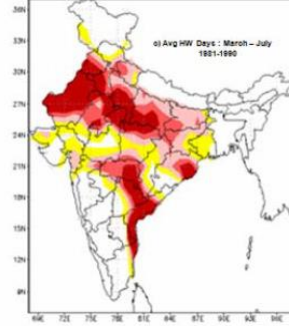
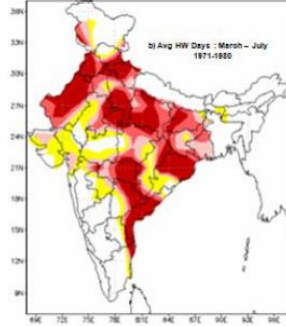
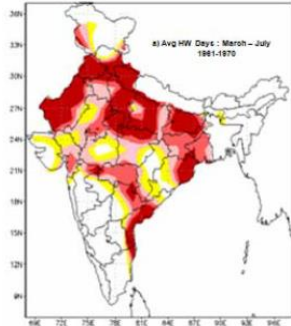
Also, the mean Temperatures and incidence of Heat Waves are projected to increase under all climate change scenarios

Observed Trends: Newer Areas and Early onset

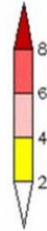
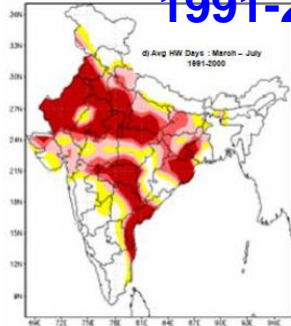
1961-70

1971-80

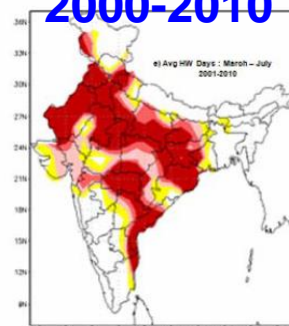
1981-90



1991-2000

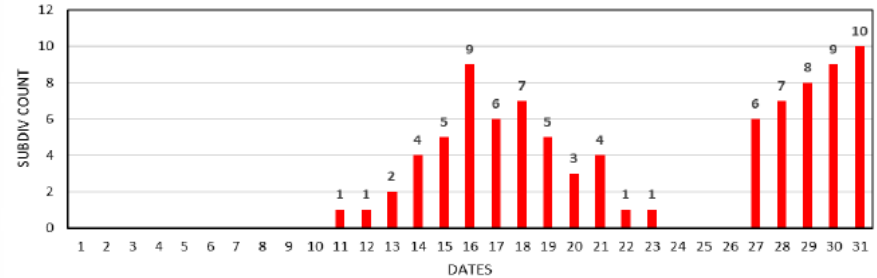


2000-2010

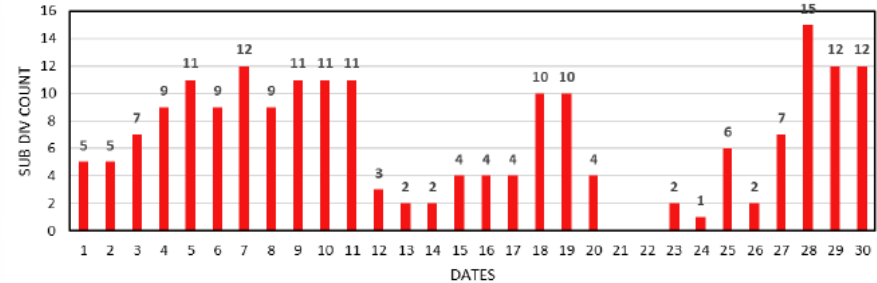


Average No. of HW days/year (Mar-July) during last 5 decades (Pai et al. 2013)

MAR 2022



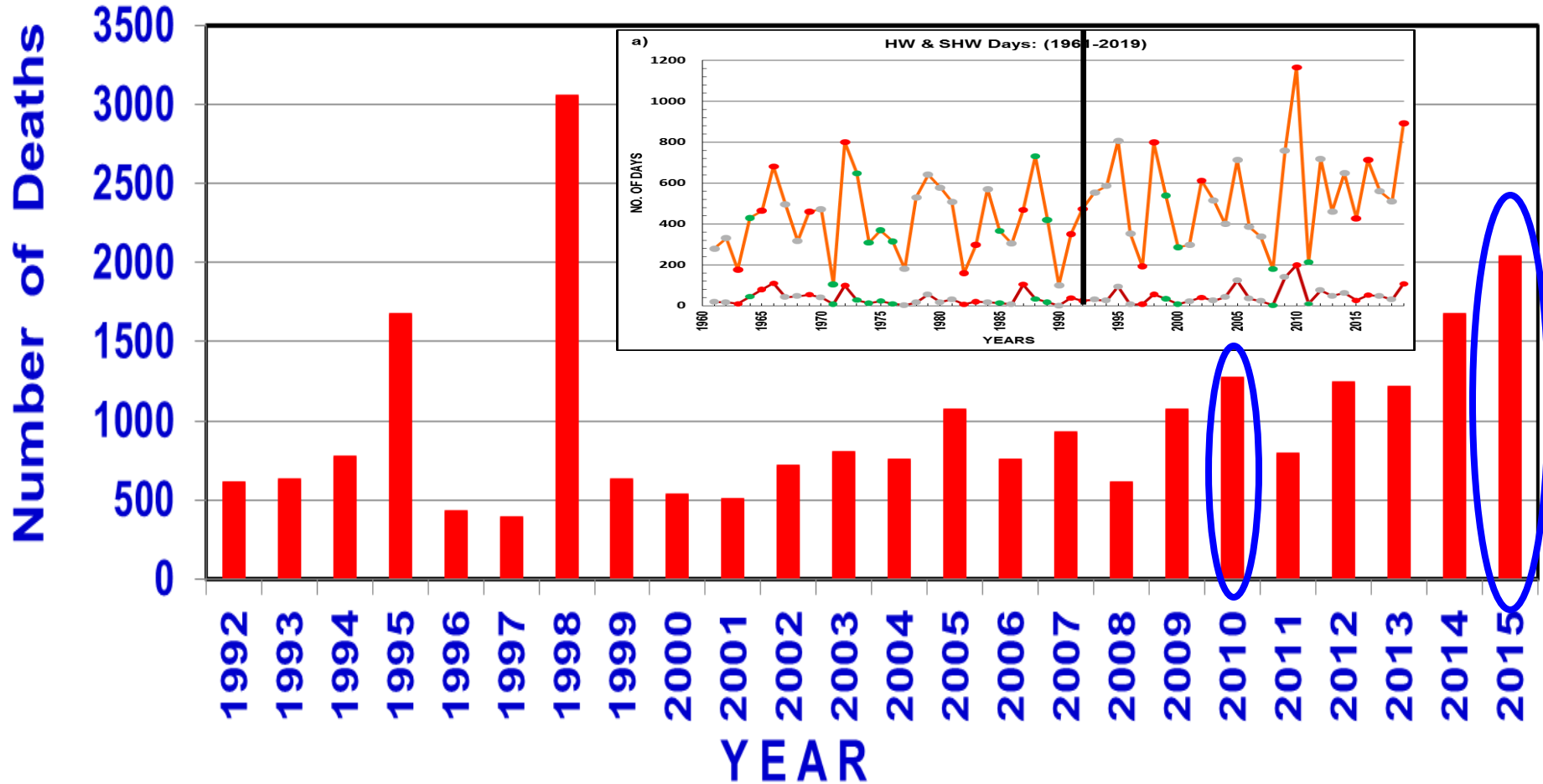
Apr 2022



Number of Met Sub-divisions reporting HW/SHW during March and April, 2022

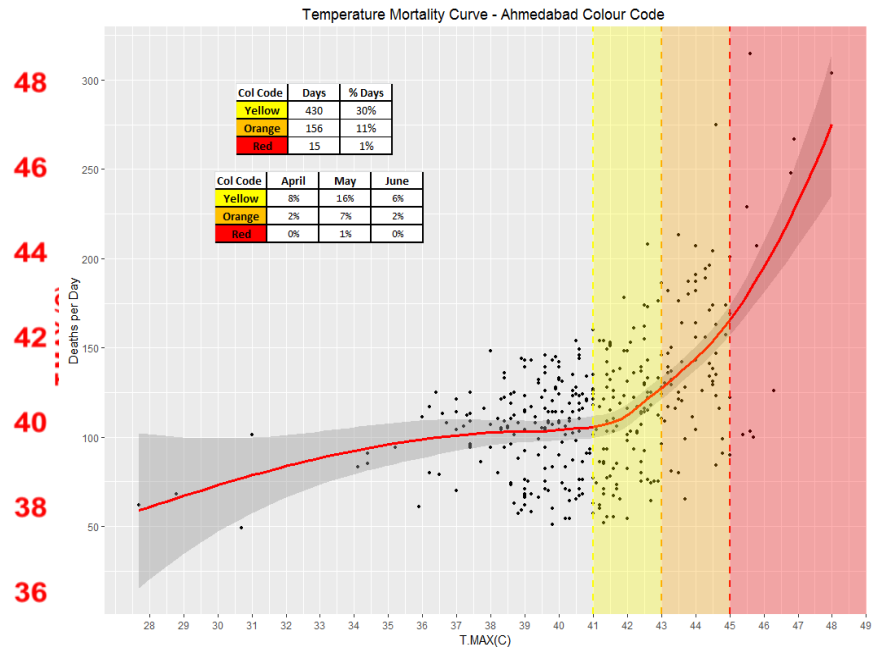
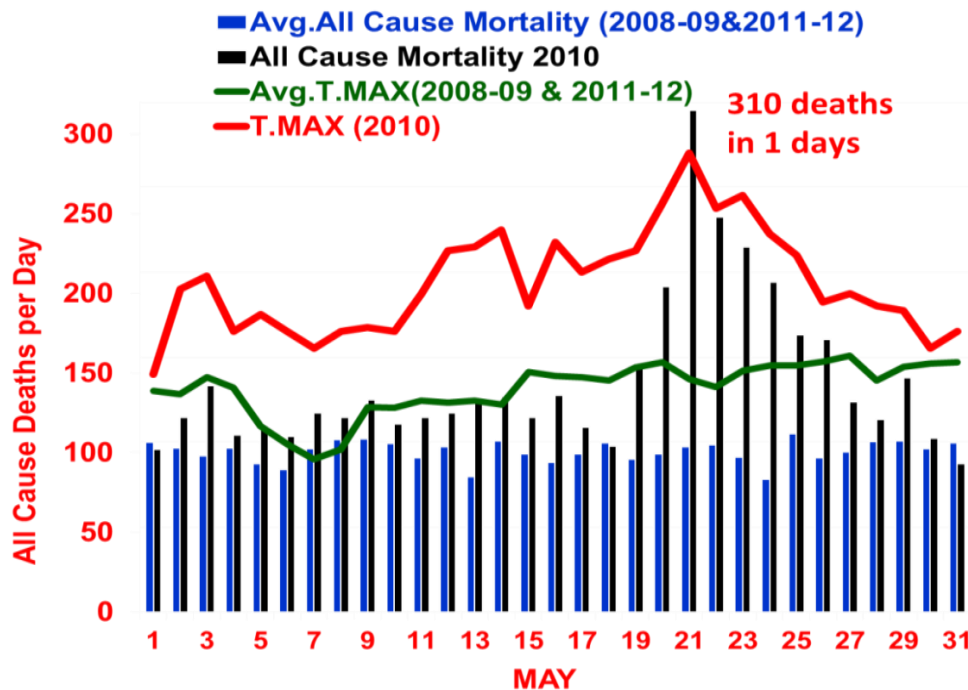
Impacts of HW

Deaths due to Heat Wave in India



Heat Wave Management System: Threshold based warnings

City HAP Triggered by 2010 Severe Heat Wave in Ahmedabad City



First HAP in the country for Ahmedabad city in 2013 which assigned severity to the forecast HWs Mortality based thresholds.

AMC IIPHG and NRDC

Components of Ahmedabad HAP



Early Warning System and Inter-Agency Coordination to alert civic agencies, health officials, hospitals, emergency responders, local community groups, and media outlets of forecast temperatures



Public Awareness and Community Outreach to communicate the risks of heat waves and implement practices to prevent heat-related deaths and illnesses



Capacity Building Among Health Care Professionals to recognize, respond to and to effectively prevent and manage HRI cases to reduce mortality and morbidity



Reducing Heat Exposure and Promoting Adaptive Measures awareness on impacts, prevention methods, access to potable water and cooling spaces during extreme heat days.

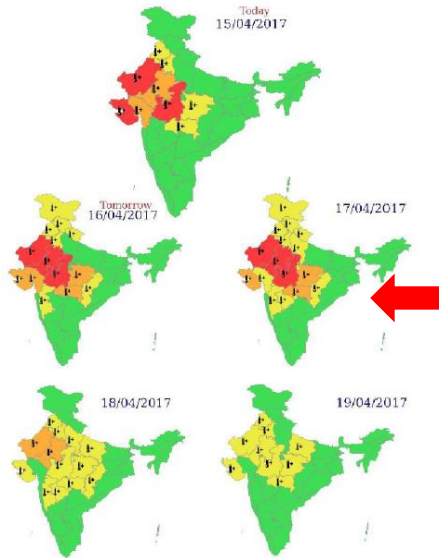
National efforts were Triggered by 2015 Severe Heat Wave in the country when more than 2000 people died due to Heat Waves

Heat Wave Early Warning System

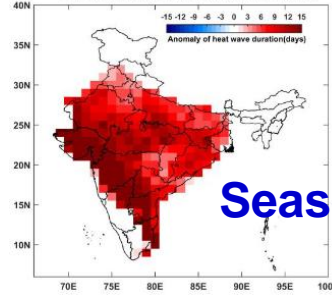
Forecasts/Warnings: NWP+ based (WRF 3 km, GFS 12 km)

1. Seasonal Outlook (twice in the season), & Monthly F/C
2. Extended Range FC (every week, 4 weeks, Spatial)
3. Detailed weekly Press Release (for next 2 weeks)
4. Short & Medium Range (sub-Division, District, City)

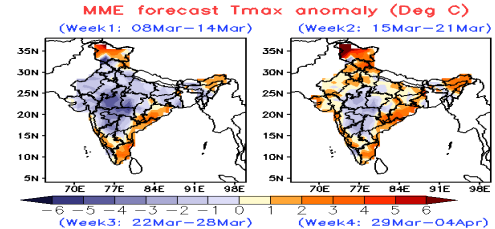
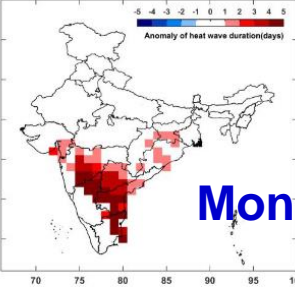
Forecast to Power Sector for assisting HW Management



Outlook for Heat wave duration during March to May 2024



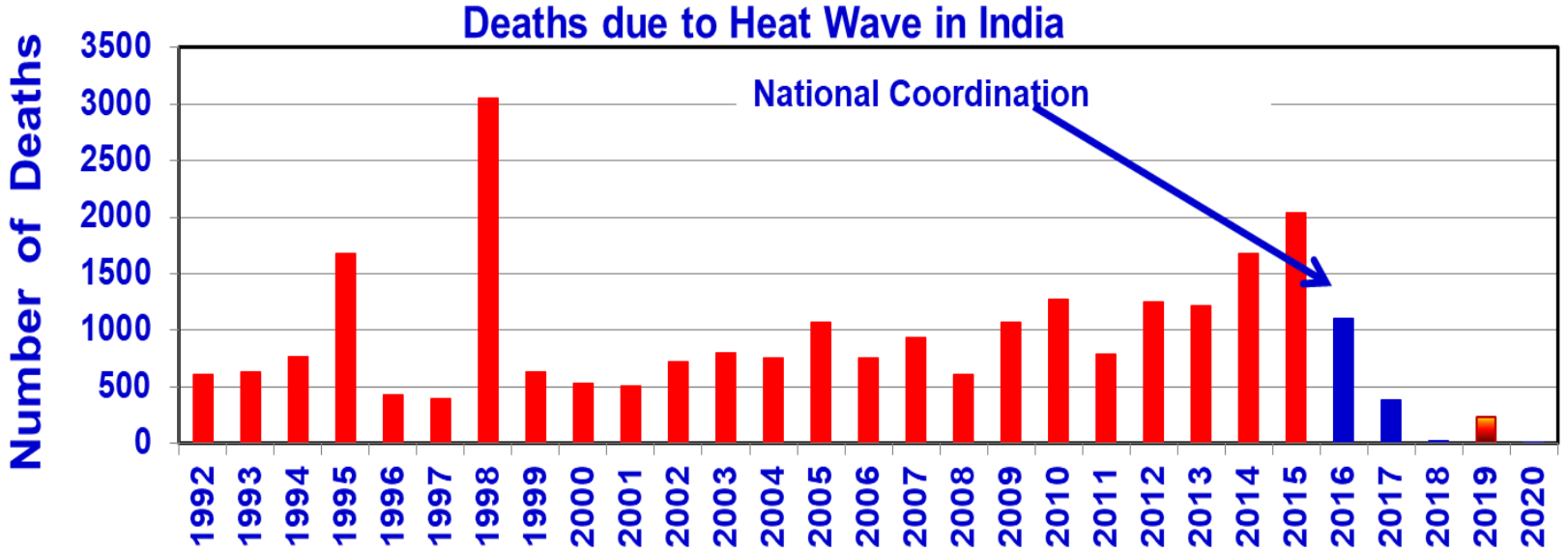
Outlook for Heat wave duration anomaly during March 2024



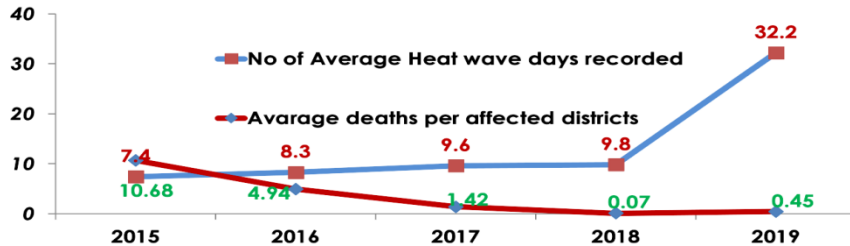
- Main National Level FC product issued around 16 IST. Part of a detailed bulletin having past 24H obs, their deviations, areas under HW/SHW, descriptive FC- 5D
- Also a FC for the day is issued at 0800 for action.
- HW FC is part of multi hazard EWS around noon.
- Similar warnings for districts and for 1100+ cities (7 days)

www, TV, Radio, Press, Health, DM, IMA, Red Cross, Special, AMFU

Impacts of National Coordination



Increased no. of heat wave days year while reduced number of deaths



Year	Heat wave deaths
1992 -2020	25692
2011-2015	6973
2016-2020	1739

Other impacts of Heat Waves

- Extreme heat can increase the risk of other heat related illnesses, and consequent economic burden.
- Heat can exacerbate drought, and may lead to wildfire; Urban Heat Islands in cities.
- Loss of livelihood and Decrease in Industrial Productivity
- Agriculture: Decrease in Agriculture/Livestock Productivity. Decreased water, nutrient and chemical use efficiency in agriculture. Increased agriculture insurance costs and premium
- Energy: Increased demand and the reduced production and transmission efficiency with possible adverse impacts on grid stability
- Transport and Tourism
- Increase in water demand by all socio-economic sectors

Heat-Related Illness Surveillance Report, India - 2022

NPCCHH, NCDC

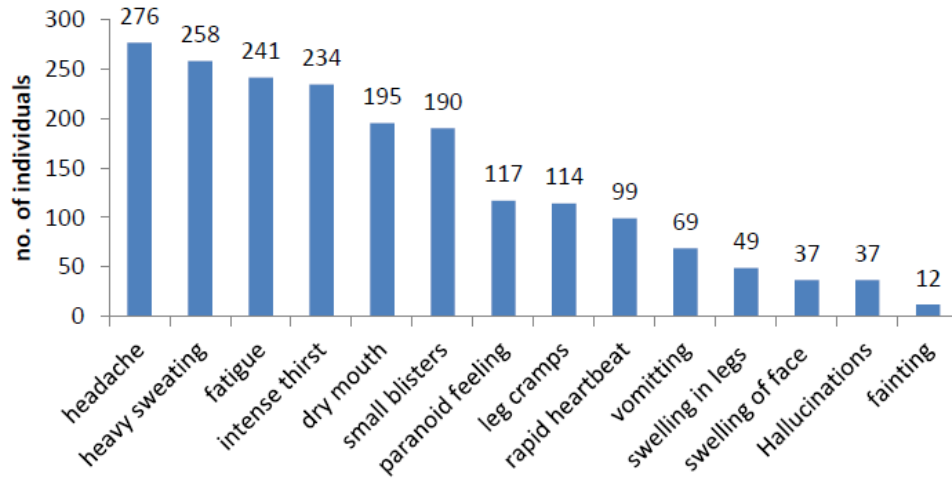
Month	Total emergency OPD	New cases of Heat- stroke
March	219875	59
April	3696882	1,498
May	4641244	1,856
June	3778727	1,045
July	3606976	23
Total	1,59,43,704	4,481

Other Health related impacts of HW

Heat Stress Vulnerability health impacts and coping strategies in rural communities in the semi-arid region of Maharashtra India CARIAA-ASSAR

Working Paper <https://www.researchgate.net/publication/324596793>

Heat related symptoms reported by the sample individuals

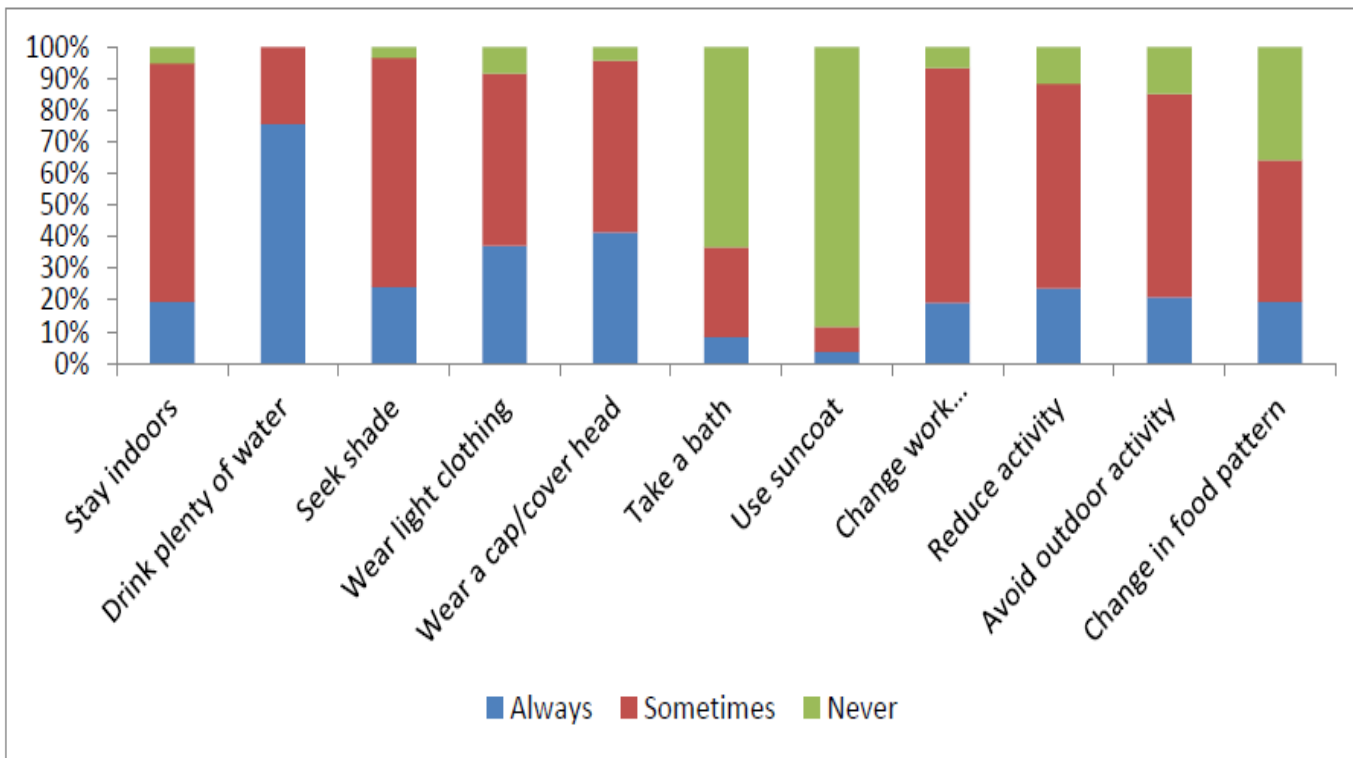


Heat Related Symptoms reported by the sample individuals

Parameter	Odds Ratio (unadjusted)
Summer occupation	
- Non-income generating activities (ref)	
- Farming	2.05
- Agricultural and non-agricultural labour	3.35
- MGNREGS labour	3.71

Occurrence of HRS in relation to demographic variables

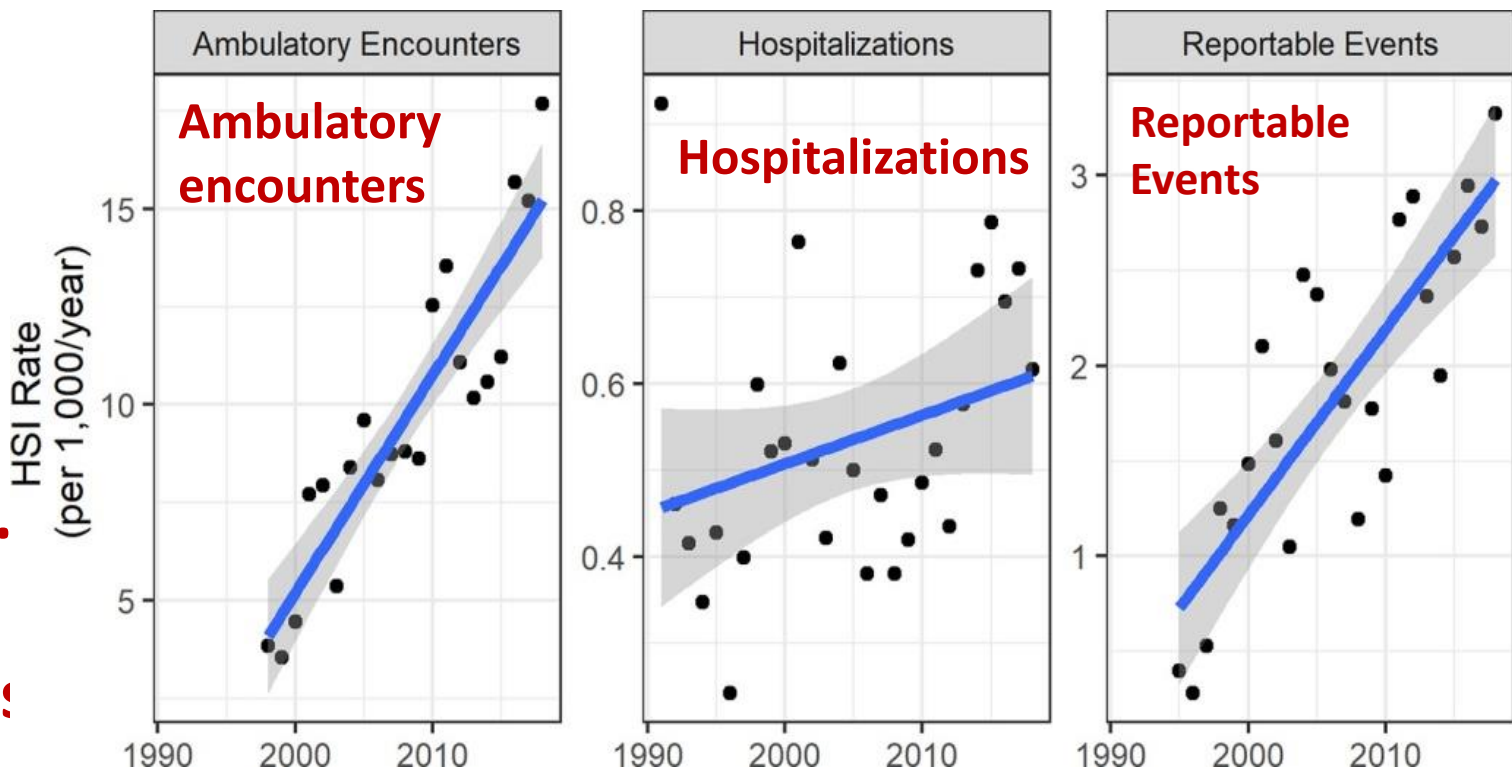
Coping strategies employed by respondents during very hot weather



- **Drinking more water.**
- **Seeking shade,**
- **Staying indoors**
- **Wear protective clothing,**
- **Change work schedule,**
- **Avoid outdoor activity**
- **Use sun coat**
- **Take a bath**

Some of these coping strategies have economic implications

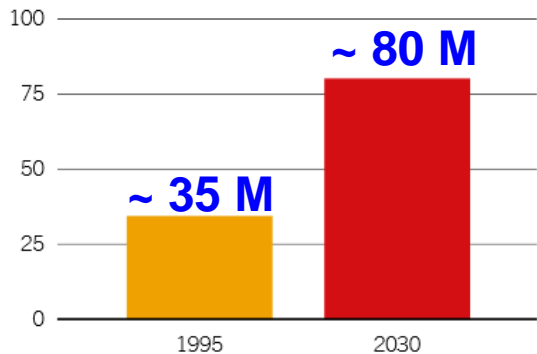
Trends in Heat stress illness outcomes of outdoor heat at U.S. Army installations:



A one-degree °F increase in mean temperature between May and September was associated with a 1.16 times greater rate of ambulatory encounters

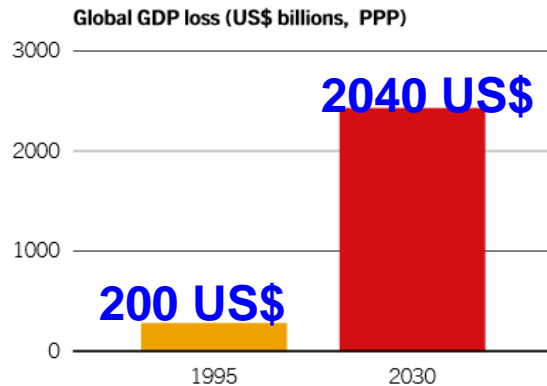
Full-time jobs and GDP lost to heat stress (1995) and projections (2030)

Global equivalent full-time jobs lost (millions)



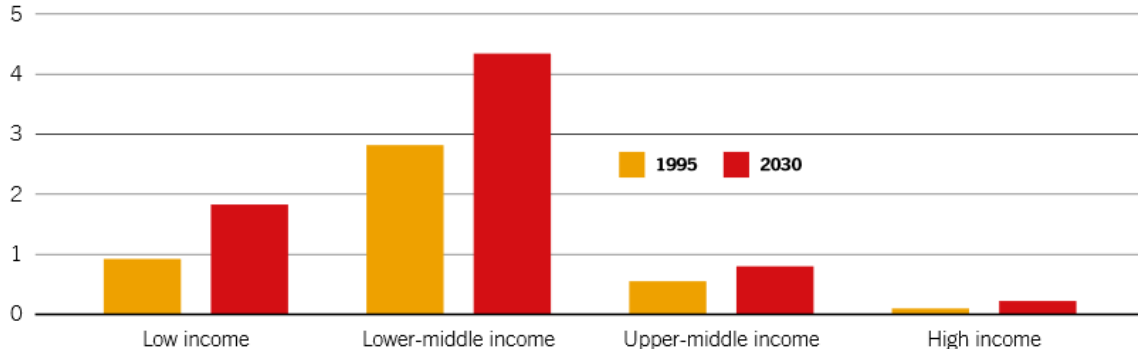
Global

Global GDP loss (US\$ Bn)



country
income
group

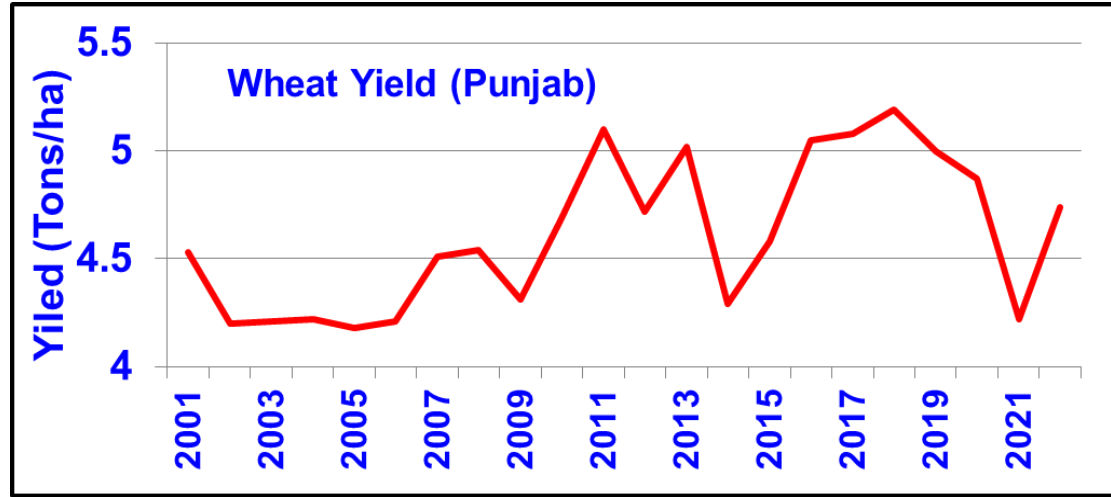
Share of GDP Loss by country income group (percentage)



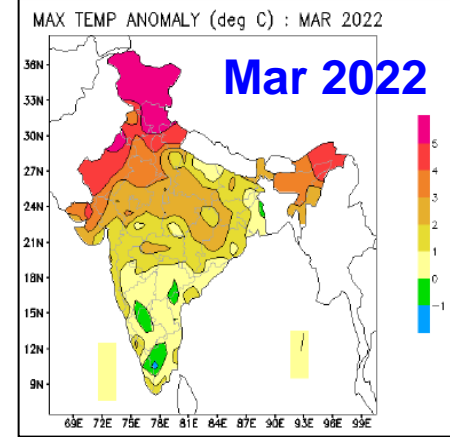
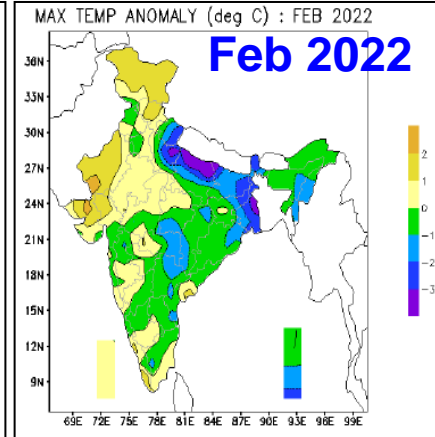
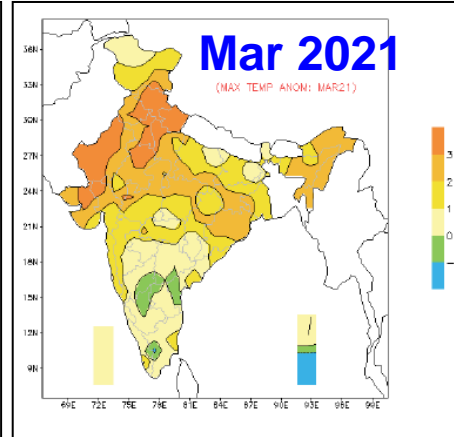
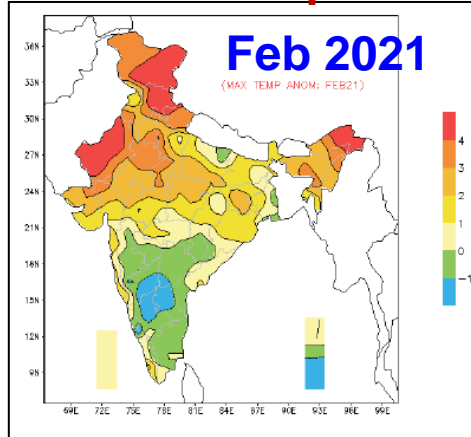
Working on a warmer planet
The impact of heat stress on labour productivity and decent work.

ILO, 2019

Impacts of Heat Stress on Crop Yields



Maximum Temperature Anomalies Feb & March



Issues to be addressed - Temperature Thresholds

- **HW forecasts (except for cities having thresholds) are based only on deviations of Maximum Temperatures from their normal values**
- **Need evidence based thresholds to provide impact based forecasts on which advisories/actions can be initiated at different levels**
- **Though IMD is providing impacts and suggested actions, users need to quantify the sector, gender, age & occupation specific impacts, vulnerabilities and coping strategies & convey the same to the EW agency (IMD) for effective IBF**

Issues to be addressed - Engage

- **Stakeholder Engagement, Outreach/Feedback/Awareness**
 - Interpretation of warnings; and other R&D issues such as identifying thresholds, Mitigation strategies.
 - **Community Education/awareness**
 - **Vulnerability assessment**
 - **Identifications of nodes and Process (HAP)**
 - **Identifying and Transferring Successful Community Intervention Strategies**

Issues to be addressed – Tailoring of Information

- **As actions at the end of different target groups are different, advisories should also be specific to these groups.**
- **Levels of warnings for actions at different levels and Emergency Response Mechanism.**
 - ✓ **A particular level of a warning may need immediate action on part of one stake holder (health system preparedness, ambulance maintenance, arrangements for drinking water) BUT not by an Anganwadi worker**
- **De-warning process also need to be part of EWS**

Issues to be addressed

✓ Involvement of local authorities

Municipal Councils (water, electricity, construction, cooling centres, schools, vendors/ hawkers etc.)

District Medical Officer (for all medical related issues including stock of medicines, rehydration, cooling packs, ambulances etc.)

District Magistrate to ensure appropriate coordination at local and state level

Co-production

An effective Early Warning and Impact Management System requires that the **INFORMATION** is **Co-designed, Co-produced and co-disseminated to help**

- bring together the producers of weather and climate information with those who use the information to make decisions,
- Design easy to understand warnings with Suggested Actions (at different Levels & for different groups)
- encourage better use of these services in a range of decisions across many sectors

Involve intermediaries help connect various stakeholders

Issues to be addressed- Warning Dissemination

- **Multi-stages (during the season), multi-target (for different actions by nodes & lead period.) and Multi-Channel Dissemination**
- **Easy to understand & act upon**
- **Information to Individuals (SMS/Email/ Whatsapp) – with special attention to the vulnerable sections and action takers**
- **Customization of messages with visuals and graphics**
- **Timeliness: Neither too early nor too late**
- **Coordinated or single source dissemination**

Issues to be addressed- Warning Dissemination

An example of dissemination of Hailstorm warning of IMD by Maharashtra Admin

शेतकरी बांधवांनो, सावधान!!

मराठवाडा, विदर्भ

10 ते 13 फेब्रुवारीदरम्यान विजांच्या कडकडाटासह गारपिटीची शक्यता शेतकरी बांधवांनो, आपल्या शेतमालाचे नुकसान टाळा



शेतमाल सुरक्षित ठिकाणी साठवून ठेवावा.



बाजार समितीमध्ये शेतमाल विक्रीसाठी आणला असेल किंवा तसे नियोजन केले असेल तर तो माल व्यवस्थितपणे झाकून ठेवावा.



विजेपासून बचावासाठी सुरक्षित ठिकाणी आश्रय घ्यावा.



मोकळं मैदान, झाडाखाली, पत्र्याच्या शेडमध्ये, विजवाहिनी अथवा ट्रान्सफॉर्मर जवळ थांबू नये.



अतिवृष्टीमुळे शेती मालाचे नुकसान टाळण्यासाठी शेतकरी बांधवांनी नियोजन करावे.



गडचिरोली, गोंदिया, भंडारा, चंद्रपूर, नागपूर, नांदेड, लातूर, तसेच अमरावती, यवतमाळ या जिल्ह्यांत विशेष काळजी घ्यावी...

- आपले महाराष्ट्र शासन



Visual Warnings for Public by the State

IMD also issued warnings with suggested actions to the planners and **ALSO DIRECTLY TO THE FARMERS THROUGH SMS** (Forecast Based)

4 Pillars of Early Warning System for an effective HW management system

1. Risk Knowledge

Systematically collect the data and undertake the risk assessment

- Are the hazards and the vulnerabilities well known?
- What are the pattern and trends in hazards and vulnerabilities?
- Are risk maps and data widely available?

2. Monitoring and warning services

Develop hazard monitoring and early warning services

- Are the right parameters being monitored ?
- Is there a sound scientific basis for making forecasts?
- Can accurate and timely warning be generated?

4. Dissemination and communications

Communicate risk information and early warnings

- Do warning reach all of those at risk?
- Are the risks and warnings understood?
- Is the warning information is clear and useable?

3. Response capability

Build national and community response capabilities

- Are response plans up to date and tested?
- Are local capacities and knowledge made use of?
- Are people prepared and ready to react to warnings

Thanks