IBF for Heat /Cold Wave
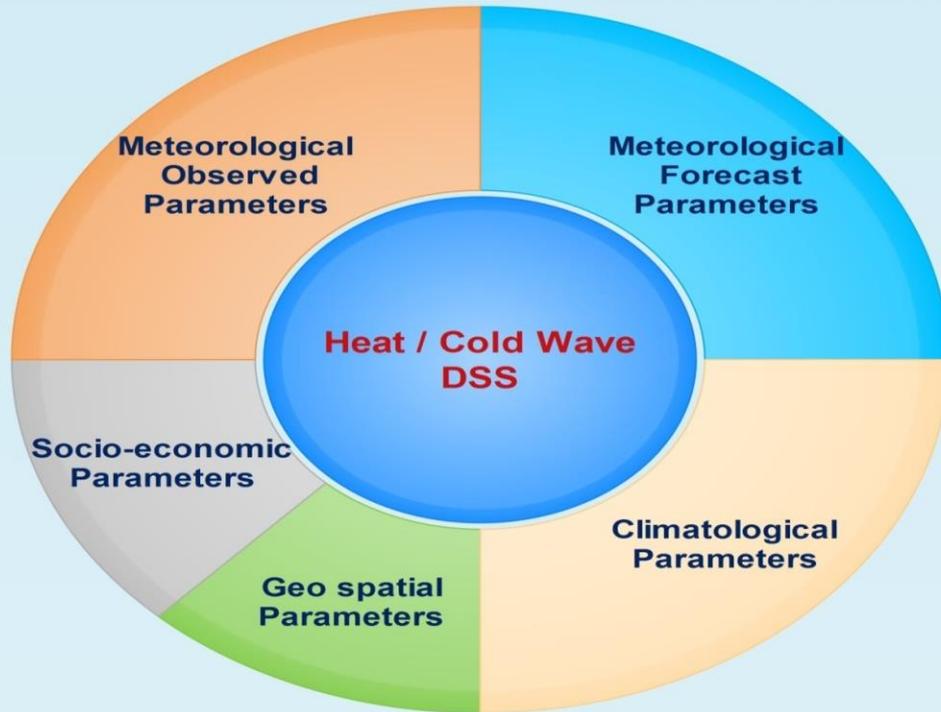
https://dss.imd.gov.in/dwr_img/GIS/heatwave.html

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INDIA METEOROLOGICAL DEPARTMENT

Parameters

Meteorological Observed Parameters

1. Today MaxTemp
2. Today Max Departure from Normal
3. Previous Day Max Temp
4. Previous Day Departure from Normal
5. Today Min Temp
6. Today Min Departure from Normal
7. Past 24hrs Rainfall
8. Relative Humunity at 08:30hrs
9. Relative Humunity at 17:30hrs
10. Previous Day Relative Humunity at 17:30hrs

Meteorological Forecast Parameters

1. Forecast_Max_Temp
2. Forecast_Min_Temp
3. Forecast_Weather
4. Rainfall
5. Thunder Storm
6. Clouds
7. Visibility
8. Every 3hr Temp
9. NWP Models outputs
10. MME

Climatological Parameters

1. Climate Normal
2. Extreme Temperature
3. Lowest Min Temp
4. Lowest Max Temp
5. Observed Wind
6. Forecast Wind
7. Humunity
8. Cold Wave
9. Severe Cold Wave
10. Cold Day
11. Severe Cold Day
12. Cold Hazard
13. Ranges of Temp for 5 days before and after

Socio-economic Parameters

1. Airport
2. Oil Refineries
3. Power Station
4. Power Plant
5. Hospital
6. Railway Network & Stations
7. Sport Stadium
8. Socio Economic Zone
9. Road Network

Geo spatial Parameters

1. Land Use/ Cover (LULC)
2. DEM
3. NDVI
4. Agriculture Prameters

Heat Wave & Warm Night

❖ **Heat wave** is considered if maximum temperature of a station reaches at least 40°C or more for Plains and at least 30°C or more for Hilly regions.

a) Based on Departure from Normal

      Heat Wave: Departure from normal is   4.5°C to 6.4°C

      Severe Heat Wave: Departure from normal is >6.4°C

b) Based on Actual Maximum Temperature

      Heat Wave: When actual maximum temperature ≥ 45°C

      Severe Heat Wave: When actual maximum temperature ≥47°C

❖ Criteria for describing Heat Wave for coastal stations

When maximum temperature departure is 4.5°C or more from normal, Heat Wave may be described provided actual maximum temperature is 37°C or more.

❖ **Warm Night** is considered only when maximum temperature remains 40°C or more. It may be defined based on departures or actual minimum temperatures as follows:

      Warm night: minimum temperature departure is   4.5°C to 6.4°C

   Very warm night: minimum temperature departure is >6.4°C

Real-time observed data

12:00 UTC maximum temperature observed data

03:00 UTC minimum temperature observed data

The maximum temperature departure

The minimum temperature departure

Relative Humidity, Wind speed & direction

❖ The observed RH is measured at 03:00 UTC and 12:00 UTC for morning and evening, respectively. Observed RH at 09:00 UTC is used for the heat index calculation.

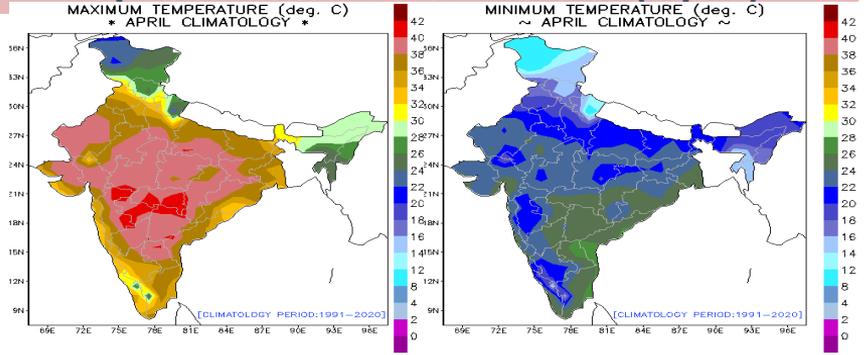❖ The wind speed and direction data are collected from 0900 UTC synoptic observations.

भारत मौसम विज्ञान विभाग
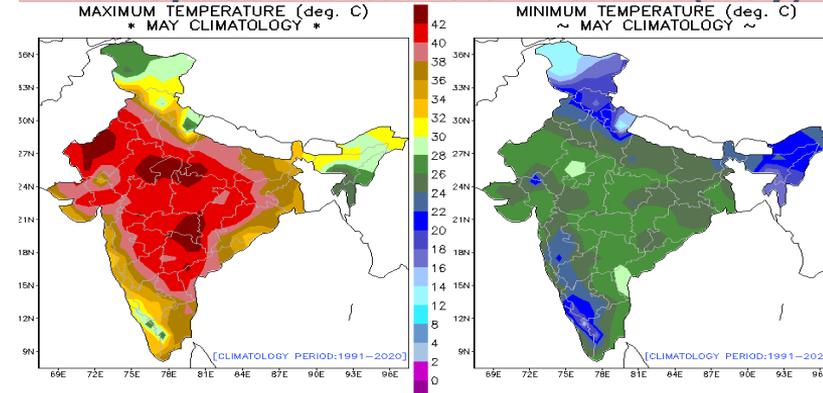**INDIA METEOROLOGICAL DEPARTMENT**
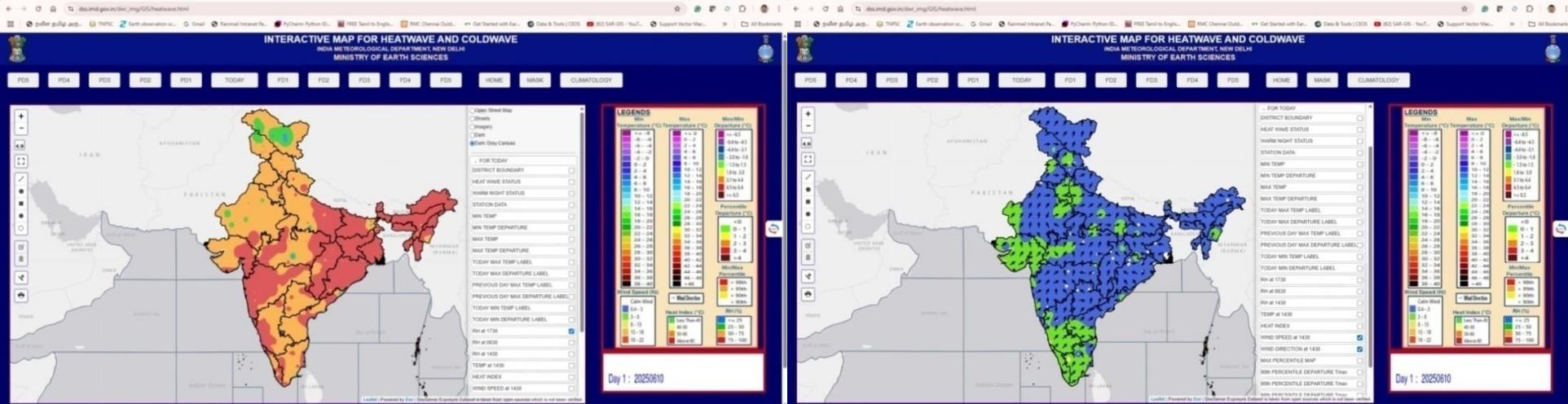
Climatological data
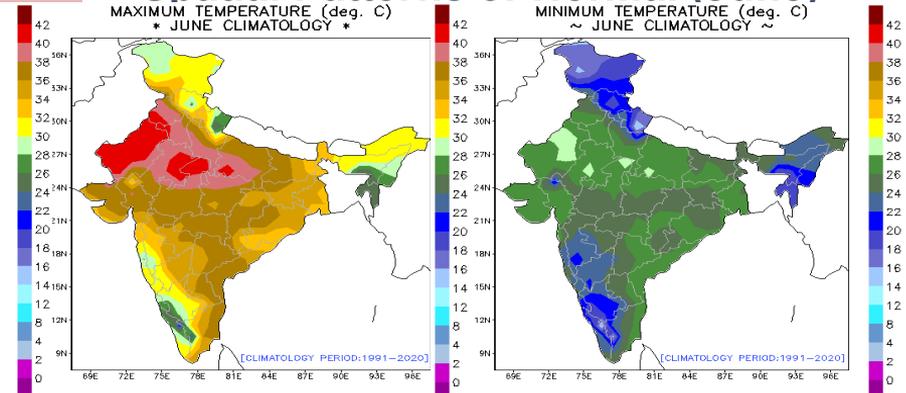
Spatial Patterns of Normal (March)
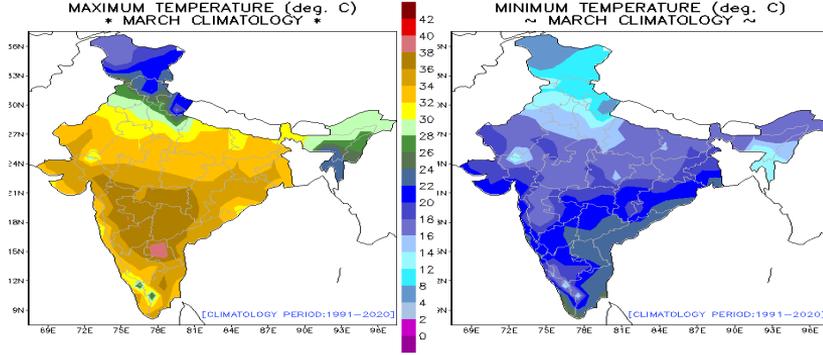
Spatial Patterns of Normal (April)
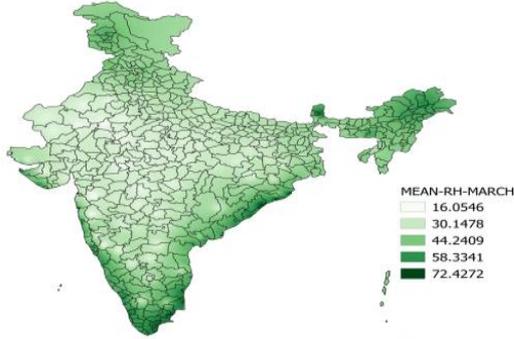

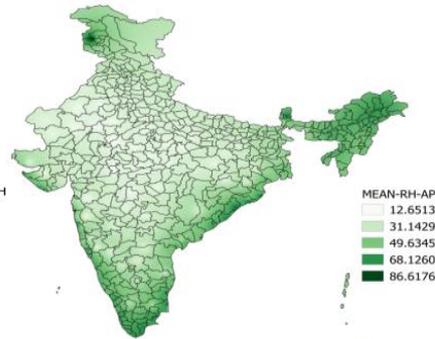## Spatial Patterns of Normal (May)

Spatial Patterns of Normal (June)
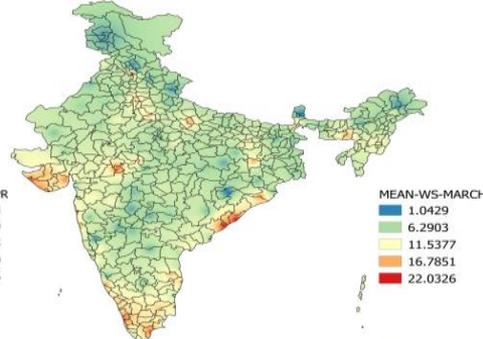
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Monthly mean
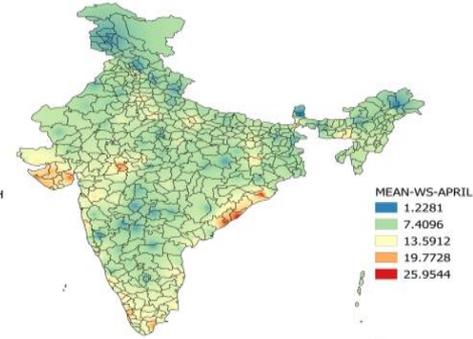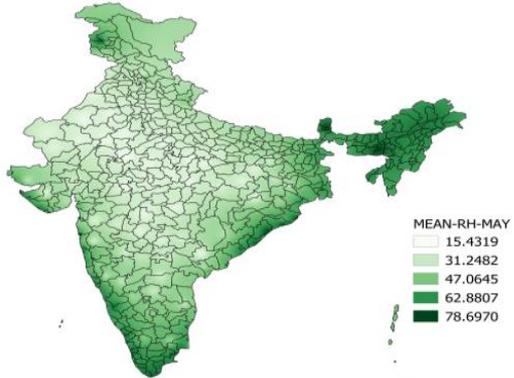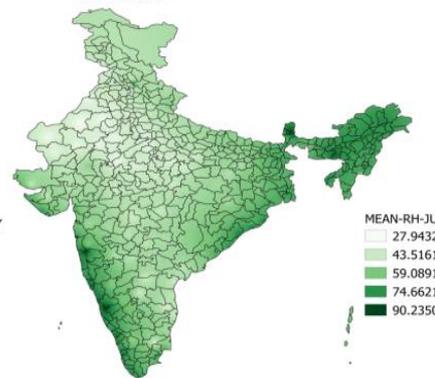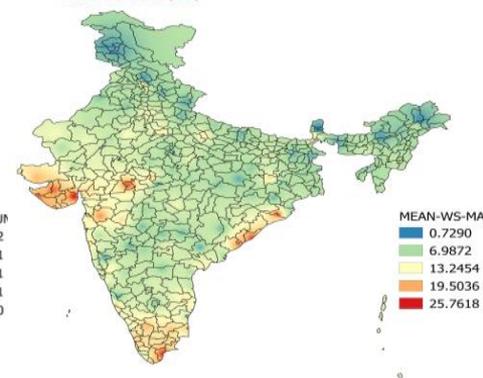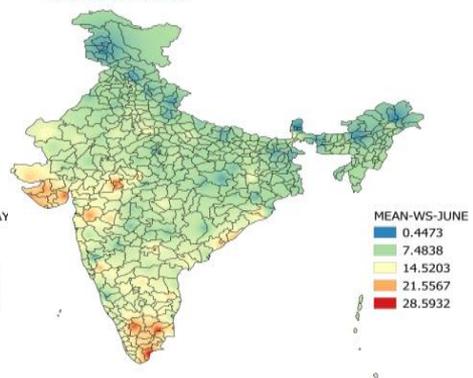
Relative Humidity (%)

Wind Speed (kt)

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Heat wave days

Heat Wave Days in March
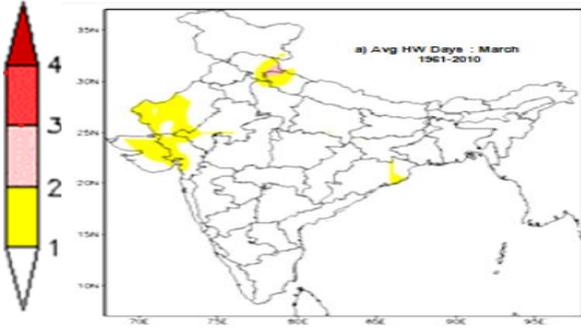
Heat Wave Days in April

Actual Heat Wave Days in Mar-Jun, 2022 and 2023
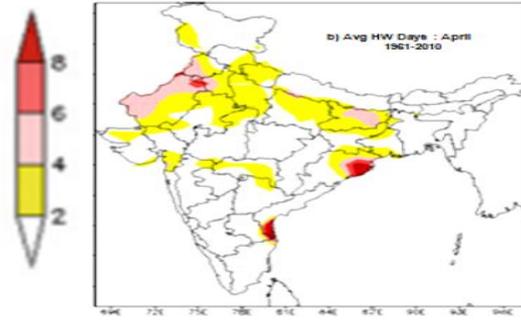
2022

2023

Heat Wave Days in May
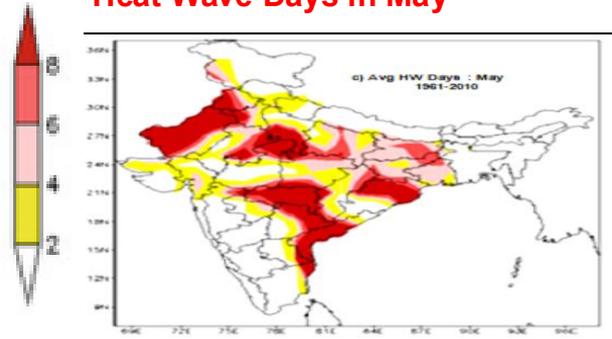
Heat Wave Days in June
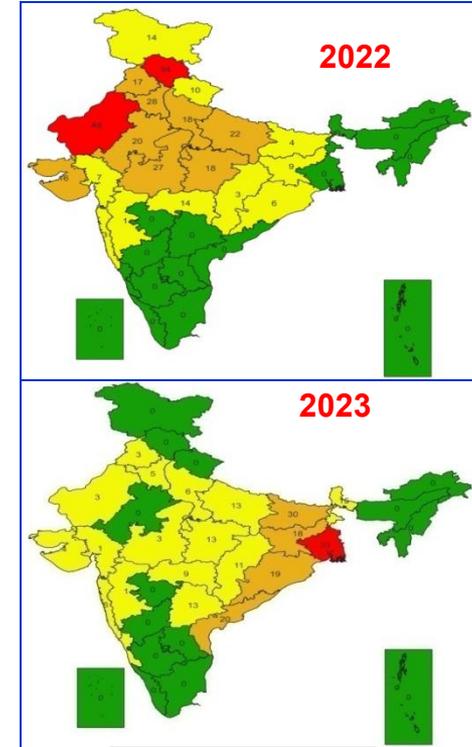
No. of Heat Days
- 🟩 No Heat days
- 🟨 1 to 15 days
- 🟧 16 to 30 days
- 🟥 More than 30 days

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Vulnerability due to heat wave

Total Number of Disasterous Heat Wave Days in Annual During the Period from 1969 to 2019

Number of Heat Wave Days
- 1 - 50
- 51 - 200
- 201 - 400
- 401 - 700
- 701 - 1113
- India District
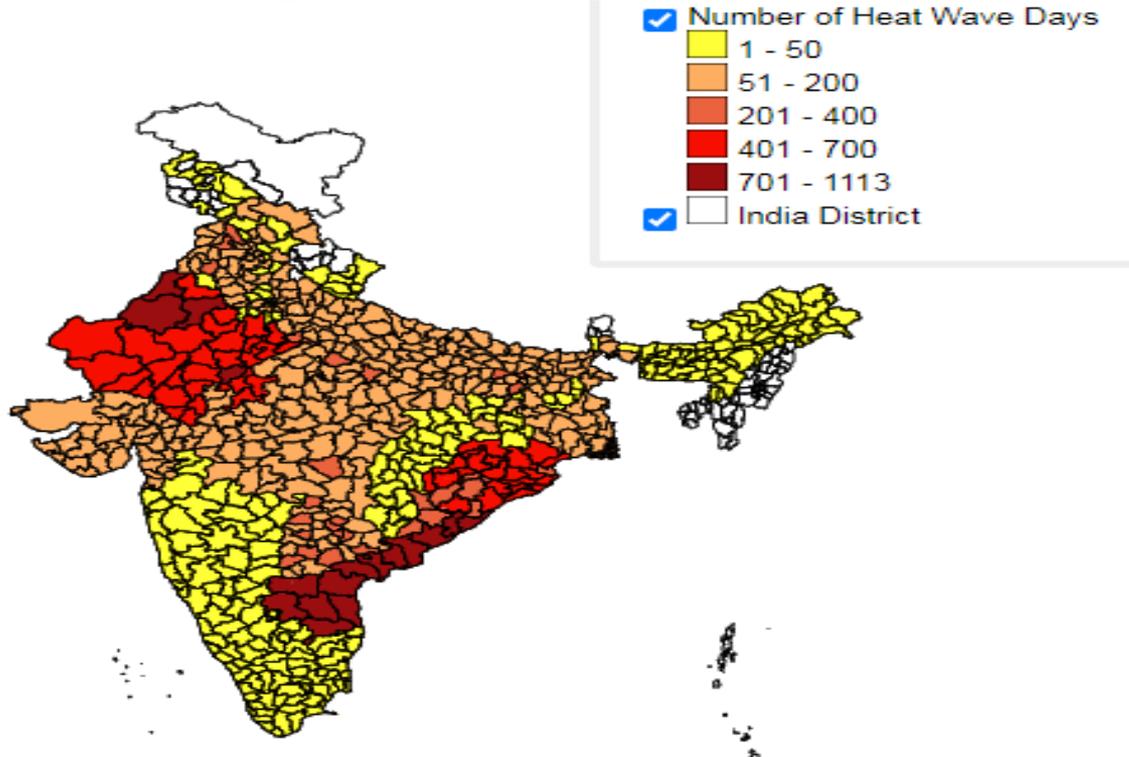
(Based on data from IMD Publication Annual Disaster Weather Report. Disclaimer: Considered the events with atleast 1 human death as per media reports.)

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Vulnerable Zones due to heat wave

April

MAY

JUNE

JULY
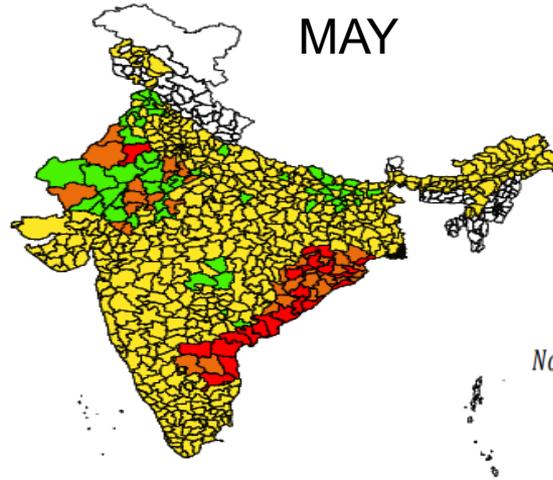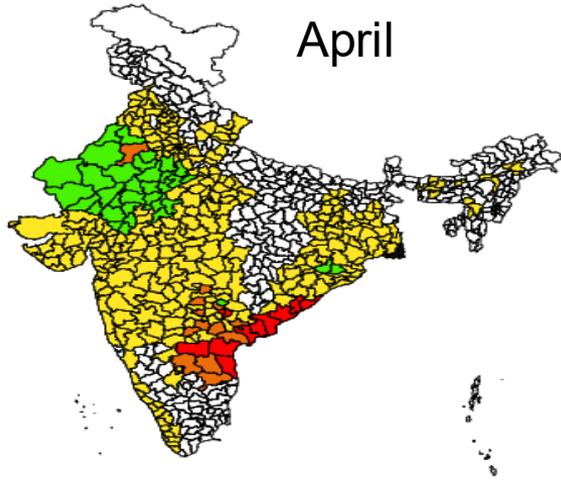
Normalized Vulnerability Index

The Normalized Vulnerability Index standardizes the disaster values to the range between 0.0 to 1.0 following formula is used:

$$Normalized\ Value = \frac{Actual\ Indicator\ Value - Minimum\ Indicator\ Value}{Maximum\ Indicator\ Value - Minimum\ Indicator\ Value}$$
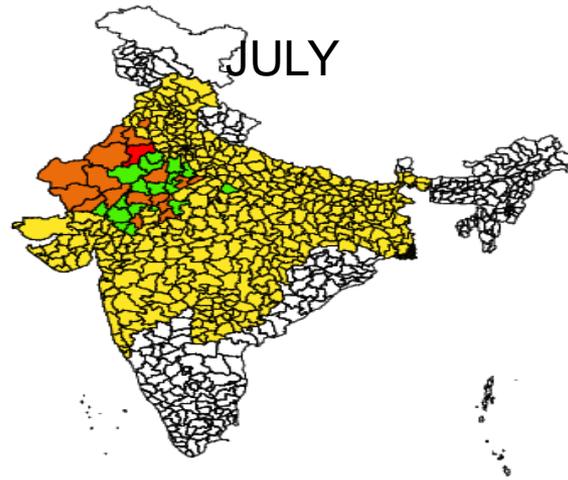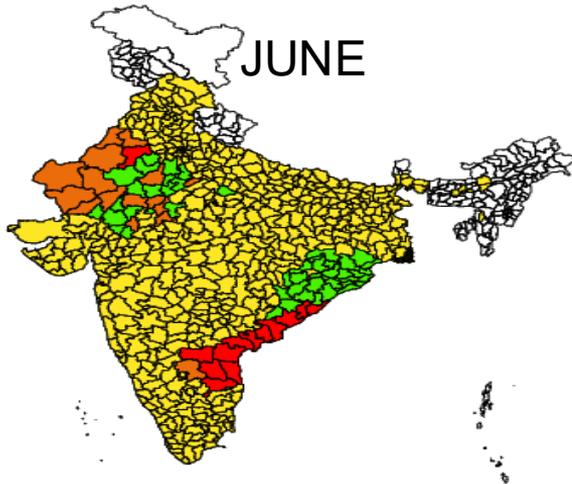
Normalized Vulnerability Index
☑ Normalized Vulnerability Index
☐ Nil (0)
☐ Low (> 0 and <= 0.25)
☐ Moderate (> 0.25 and <= 0.50)
☐ High (> 0.50 and <= 0.75)
☐ Very High (> 0.75 and < = 1)
☑ India District

Temperature Percentile Map & Departures

❖ The maximum temperature percentile of a station refers to the ranking of the maximum temperature of any particular day with respect to all the maximum temperatures recorded for all the days of that month in the record.

❖ For example, suppose there were 100 maximum temperature value records arranged in ascending order. In that case, the highest 90th value, 95th value and 98th value are termed as the 90th, 95th, and 98th percentile, respectively.

❖ The maximum temperature above the 90th /95th/98th percentiles indicates an unseasonably warm day of any month.

❖ The departure from the percentile is also calculated by subtracting the temperature value from the 98th, 95th, and 90th percentile marks.

❖ Similarly, the same applies to the minimum temperatures.

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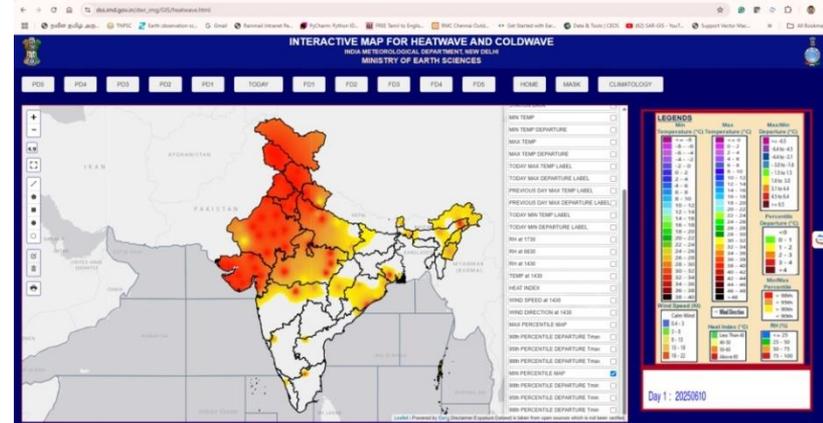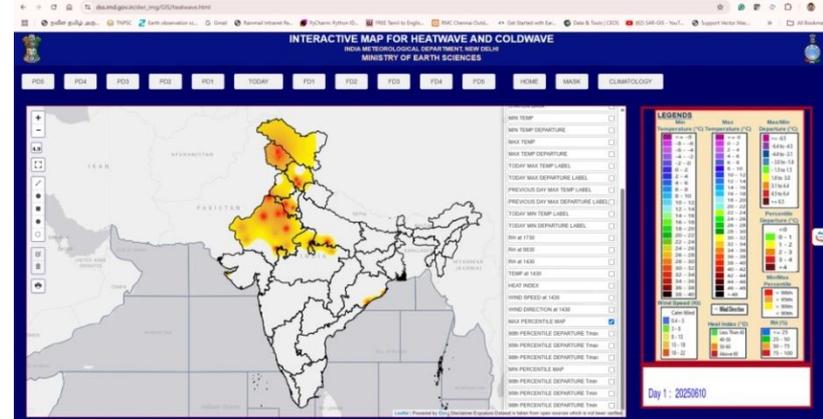
Heat Index

❖ The heat index for today is calculated using the dry bulb temperature and relative humidity from 0900UTC synoptic data. For the next five days, the heat index is calculated using the forecast temperature and relative humidity.

❖ Heat index formula: https://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml
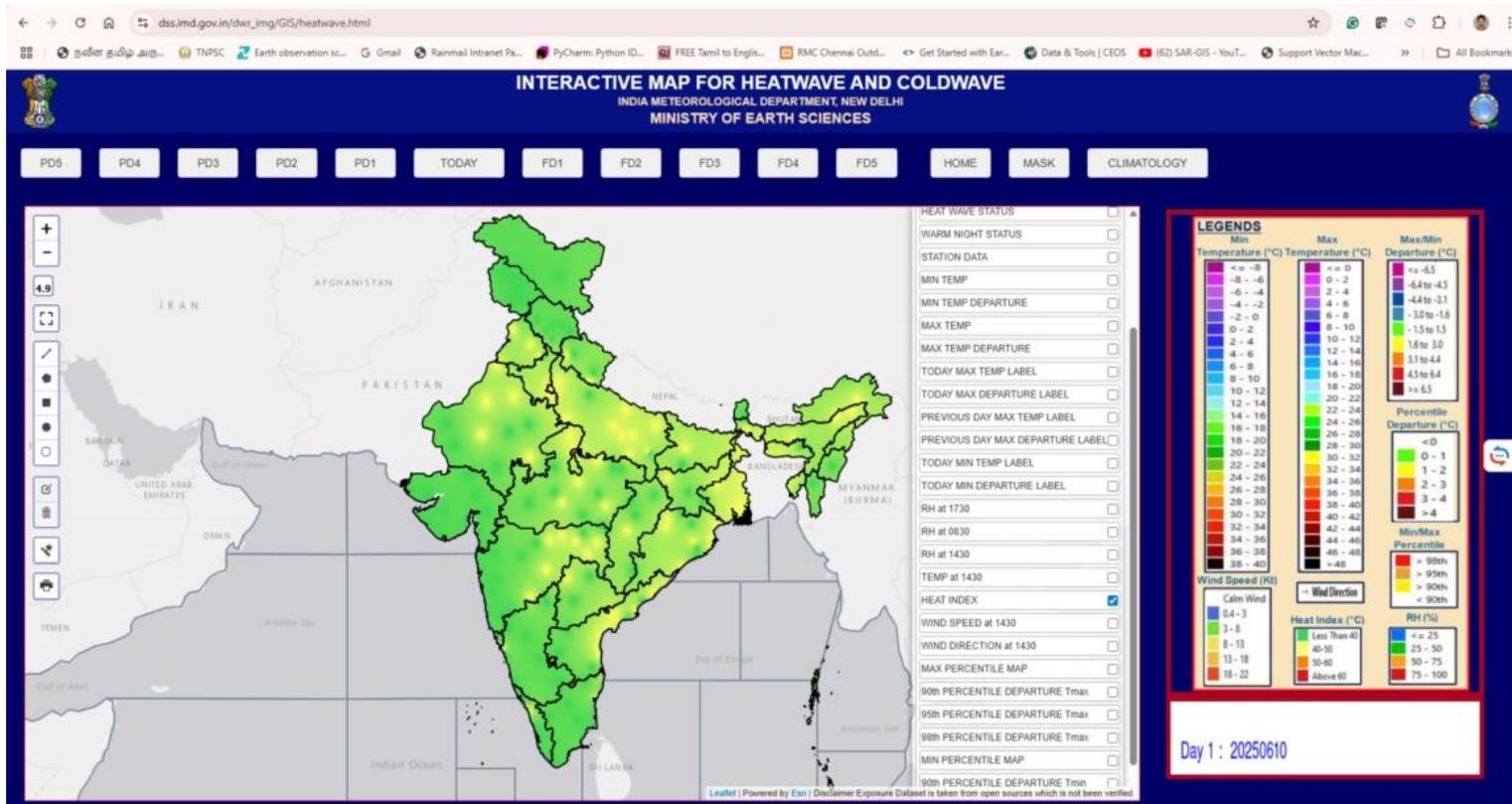
Heat Indices prepared daily by IMD

Heatwave and Severe Heatwave

NIL	1	
Hot & Humid Weather	2	
Heatwave	3	
Severe Heatwave	4	

Warm Night and Severe Warm Night

NIL	1	
Appreciable Above Normal(dep 2.5-4.4)	2	
Warm Night	3	
Severe Warm Night	4	

Persistence of heatwave/severe heat wave

Historical Condition	Today's Index	Result
No HW or SHW in the past 2 days	HW or SHW	1
Yesterday is HW or SHW	HW or SHW	2
Continuous HW for 2–3 days or continuous SHW for 2 days	HW or SHW	3
Continuous HW for 4–5 days or continuous SHW for 3+ days	HW or SHW	4

Persistence of warm night / severe warm night

Historical Condition	Today's Index	Result
No WN or SWN in the past 2 days	WN or SWN	1
Yesterday is WN or SWN	WN or SWN	2
Continuous WN for 2–3 days or continuous SWN for 2 days	WN or SWN	3
Continuous WN for 4–5 days or continuous SWN for 3+ days	WN or SWN	4

Tmax Percentile

LESS THAN 90TH PERCENTILE	1	
GREATER THAN 90TH PERCENTILE	2	
GREATER THAN 95TH PERCENTILE	3	
GREATER THAN 98TH PERCENTILE	4	

Tmin Percentile

LESS THAN 90TH PERCENTILE	1	
GREATER THAN 90TH PERCENTILE	2	
GREATER THAN 95TH PERCENTILE	3	
GREATER THAN 98TH PERCENTILE	4	

Relative Humidity

BELOW NORMAL	1	
1-33RD PERCENTILE	2	
34TH -66TH PERCENTILE	3	
67TH -100TH PERCENTILE	4	

Heat index

LESS THAN 40	1	
40-50	2	
51-60	3	
GREATER THAN 60	4	

COMPOSITE INDEX BASED HEAT WAVE WATCH AND WARNING

No warning

Heat wave Watch

Heat Wave Warning

Severe Heat Wave Warning

District: Jodhpur

INTERACTIVE MAP FOR HEATWAVE AND C
INDIA METEOROLOGICAL DEPARTMENT, NEW DELHI
MINISTRY OF EARTH SCIENCES

EXPOSURE | PD5 | PD4 | PD3 | PD2 | PD1 | TODAY | FD1 | FD2 | FD3
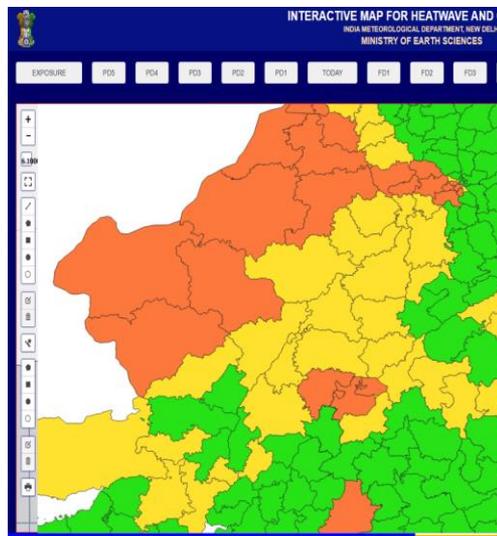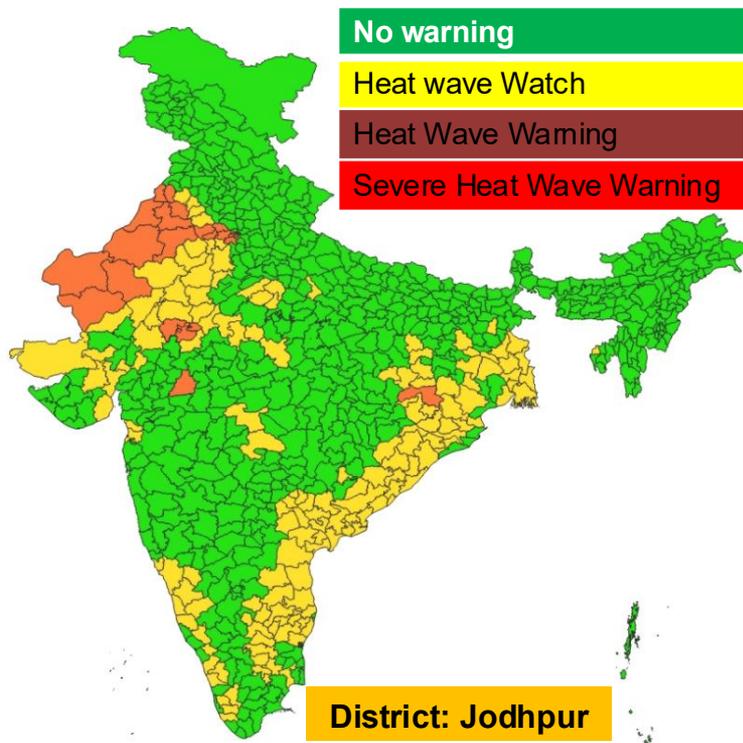
District: JODHPUR: ORANGE Warning
(Be prepared)

IMPACTS

•**Human Health**: Increases risk of heatstroke, dehydration, and cardiovascular issues; vulnerable populations suffer most.

•**Agriculture**: Reduces crop yields, causes drought stress, disrupts planting/harvesting cycles.

•**Livestock**: Causes heat stress, reduced productivity, higher mortality.

•**Transport**: Damages roads/railways, causes delays and accidents, affects worker safety.

•**Economy**: Disrupts labor productivity, increases health and infrastructure costs.

•**Water Resources**: Increases evaporation, reduces freshwater availability, worsens droughts.

ACTION

•**Human Health**: Improve heat warning systems, expand access to cooling centers, promote hydration and public awareness.

•**Energy**: Boost energy efficiency, diversify energy mix, upgrade grids for heat resilience.

•**Livestock**: Provide shade, ventilation, ample water; modify feeding times.

•**Transport**: Upgrade infrastructure for heat resilience, adjust work hours, enhance maintenance.
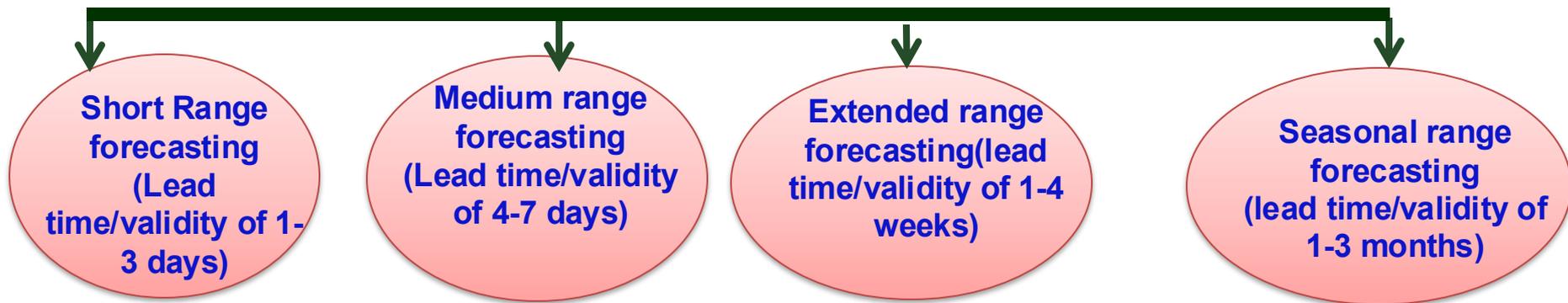
•**Economy**: Invest in heat-resilient jobs and technology, support heat-impacted sectors.

•**Water Resources**: Improve water conservation, build reservoirs, enhance drought planning.

Total Population Affected :15.43 lakh	Hospitals affected: 35
	Total No of SEZ affected: 1
Total No of Airport Affected :1	Total No of Power Station affected:6
Railway Station affected: 10	Total No of Power Plants affected:4
Railway affected :North Western Railway	Major Towns affected:9

Heat Wave Forecast and Warning Process

Short Range forecasting (Lead time/validity of 1-3 days)

Medium range forecasting (Lead time/validity of 4-7 days)

Extended range forecasting(lead time/validity of 1-4 weeks)

Seasonal range forecasting (lead time/validity of 1-3 months)

SEAMLESS HEAT WAVE FORECASTING FROM SEASON TO DAYS

An array of Numerical Models are used for forecasting

Warnings to: MHA, NDMA, SDMA, Chief Secretaries, State Emergency Operation Centres (SEOC), District Authorities, Health Department, Agriculture Department, Indian Railway, Road Transport and press & electronic media and Heat Action Plan Authorities at City, District and State levels.

through: website, e-mail, Common Alert Protocol, whatsApp, facebook, twitter

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Seasonal Forecast (An example): Probabilistic Forecast for the Maximum Temperature March to May season 2023 .
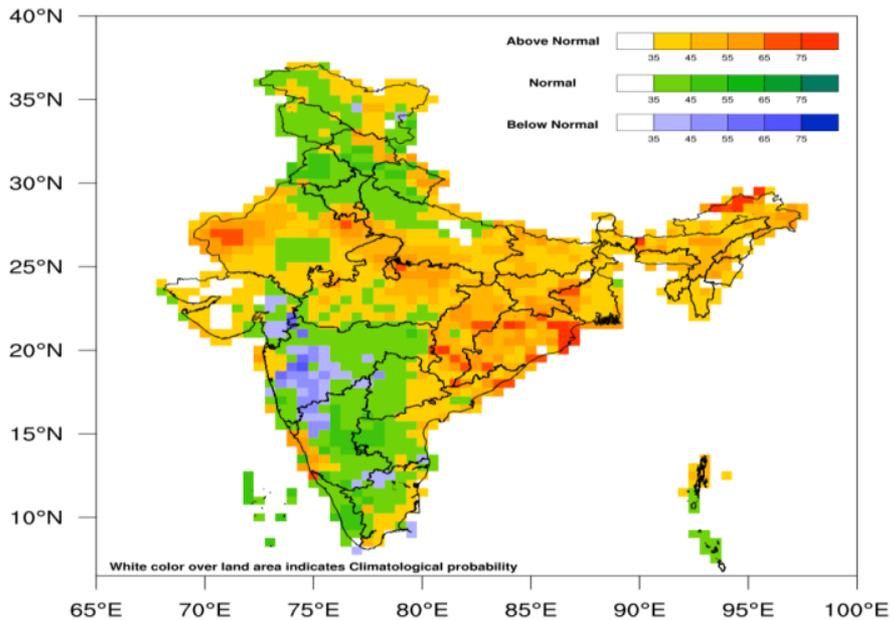
Maximum temperature

Minimum temperature

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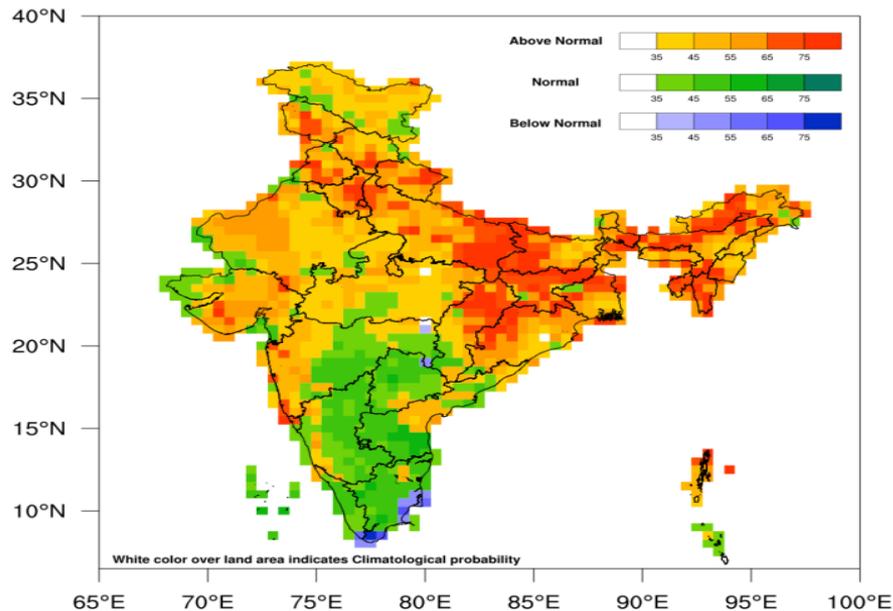
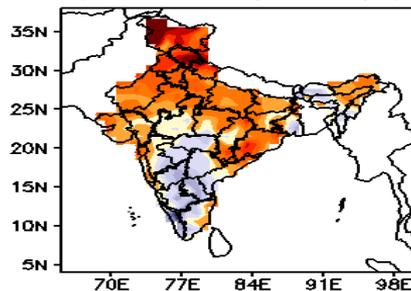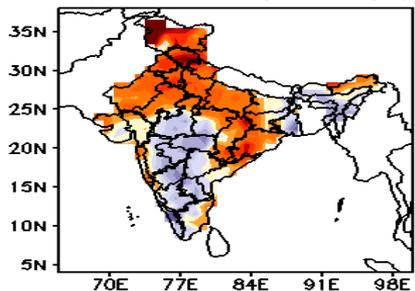# Extended Range Forecast of maximum temperature (Tmax) anomaly for 4 weeks

MME forecast Tmax anomaly (Deg C)

(Week1: 01Apr–07Apr) (Week2: 08Apr–14Apr)
(Week3: 15Apr–21Apr) (Week4: 22Apr–28Apr)

NCMRWF CNCUM Experimental Extended Range Forecasts–20220331
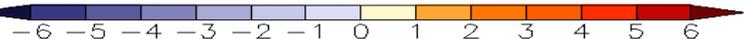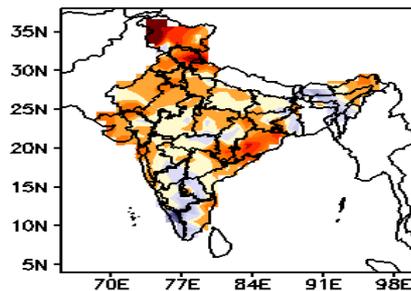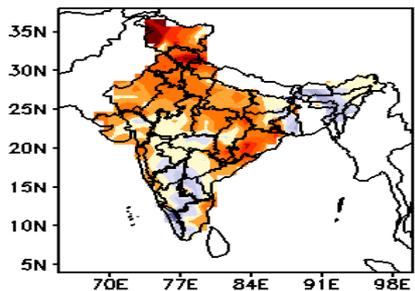Tmax Anomaly (deg C)

(Week1: 01APR–07APR) (Week2: 08APR–14APR)
(Week3: 15APR–21APR) (Week4: 22APR–28APR)

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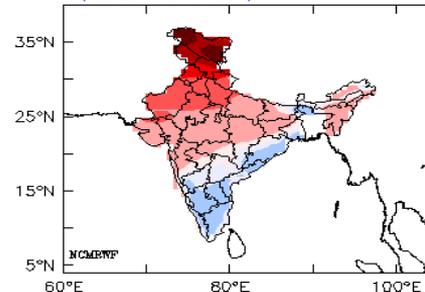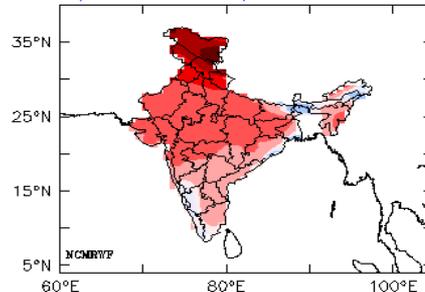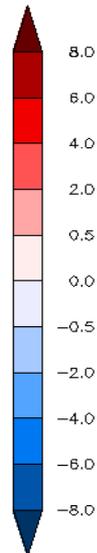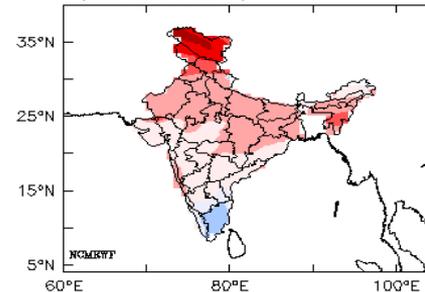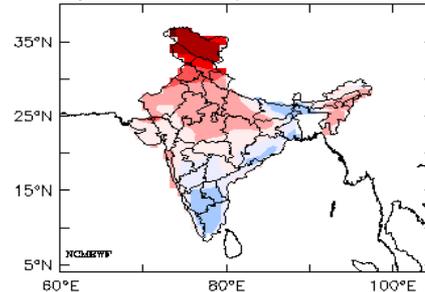
Heat Wave Impact Based Forecasting by IMD

- Heat Wave and Warm Nights are characterized by abnormally high surface air maximum (minimum) temperatures.
- Co-existence of Heat Waves/Warm Nights aggravate their impact.
- Humidity aggravates the impact of hot weather by affecting the perspiration mechanism.
- Hot and dry winds aggravate the impact of heat waves.
- Persistence of abnormal temperatures and above conditions lead to cumulative effect.

IMDs Colour Coded Impact based forecast uses the following:
a) Absolute Maximum Temperatures, their departures and percentile status.
b) Absolute Minimum Temperatures, their departures and percentile status.
c) Relative Humidity Forecast.
d) Wind Speed Forecast.
e) Persistence of Above.

WARNING

| WARNING (TAKE ACTION) |
| ALERT (BE PREPARED) |
| WATCH (BE UPDATED) |
| NO WARNING (NO ACTION) |

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Objective Heat Wave IBF

Hot Weather Hazard Analysis for entire country considering different meteorological

Operational Experimental Heat Index

GIS based Heat Wave forecast and warning Services products

GIS based Socio Economic exposure products

Percentile based extreme temperature information.

Vulnerability Atlas with respect to Heat Waves for India.

DSS →

Impact & Action Suggested

Colour code	Alert	Warning	Impact	Suggested Actions
Green (No action)	Normal Day	Maximum temperatures are near normal.	Comfortable temperature. No cautionary action required.	No cautionary action required
Yellow Alert (Be updated)	Heat Alert	Heat wave conditions at isolated pockets persists on 2 days	Moderate temperature. Heat is tolerable for general public but moderate health concern for vulnerable people e.g. infants, elderly, people with chronic diseases	(a) Avoid heat exposure. (b) Wear lightweight, light coloured, loose, cotton clothes. (c) Cover your head: Use a cloth, hat or umbrella
Orange Alert (Be prepared)	Severe Heat Alert for the day	i. Severe heat wave conditions likely to persist for 2 days. ii. With varied severity, heat wave is likely to persist for 4 days or more.	High temperature. Increased likelihood of heat illness symptoms in people who are either exposed to sun for a prolonged period or doing heavy work. High health concern for vulnerable people e.g. infants, elderly, people with chronic diseases.	a) Avoid heat exposure— keep cool. Avoid dehydration. (b) Drink sufficient water- even if not thirsty. (c) Use ORS, homemade drinks like lassi, torani (rice water), lemon water, buttermilk, etc. to keep yourself hydrated
Red Alert (Take Action)	Extreme Heat Alert for the day	i. Severe heat wave likely to persist for more than 2 days. ii. Total number of heat/severe heat wave days likely to exceed 6 days.	Very high likelihood of developing heat illness and heat stroke in all ages.	Extreme care needed for vulnerable people.

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150
1875 2025
Years of Service to the Nation
राष्ट्र सेवा के 150 वर्ष

Heat Wave Warning

In medium range (upto 5 days) issued twice a day

Heat Wave Warnings for Next 5 Days

DAY-1:- Heat Wave to severe heat wave conditions very likely in some pockets over Bihar and West Bengal and heat wave conditions in isolated pockets over Odisha, Jharkhand, Konkan & Goa and Coastal Andhra Pradesh.

DAY-2:- Heat Wave conditions very likely in isolated pockets over Odisha, West Bengal and Bihar.

DAY-3:- Heat Wave conditions very likely in isolated pockets Gangetic West Bengal.

DAY-4:- NIL.

DAY-5:- NIL.

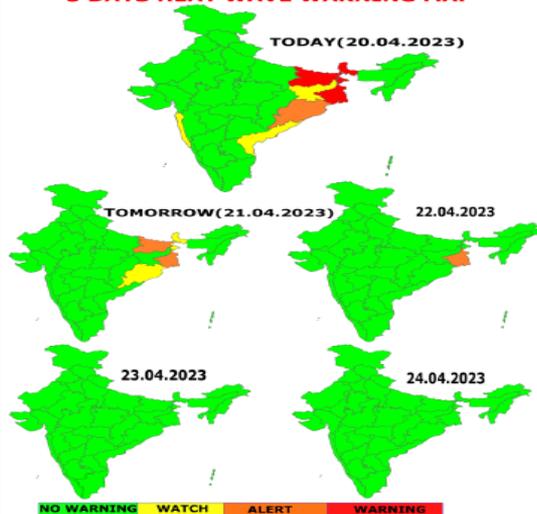**IMPACT & ACTION SUGGESTED:**

Yellow alert Areas: (1)Moderate temperature, Heat is tolerable for general public but moderate health concern for vulnerable people e.g. infants, elderly, people with chronic diseases.
(2) Avoid heat exposure, Wear lightweight, light coloured, loose, cotton clothes, Cover your head, Use a cloth, hat or umbrella.

Orange alert Areas: (1) High temperature, Increased likelihood of heat illness symptoms in people who are either exposed to sun for a prolonged period or doing heavy work. High health concern for vulnerable people e.g. infants, elderly, people with chronic diseases.
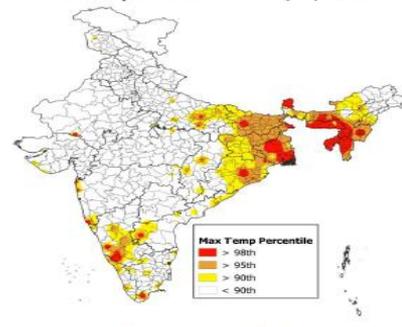
(2) Drink sufficient water- even if not thirsty, Use ORS, homemade drinks like lassi, torani (rice water), lemon water, buttermilk, etc. to keep yourself hydrated.

5 DAYS HEAT WAVE WARNING MAP

TODAY(20.04.2023)

TOMORROW(21.04.2023)   22.04.2023

23.04.2023   24.04.2023

NO WARNING   WATCH   ALERT   WARNING

For Districtwise heat wave warning visit:
https://mausam.imd.gov.in/responsive/districtWiseHeatwaveWarning.php

Maximum Temp Percentile Dated 19/04/2023   Minimum Temp Percentile Dated 20/04/2023

Max Temp Percentile
> 98th
> 95th
> 90th
< 90th

Min Temp Percentile
> 98th
> 95th
> 90th
< 90th
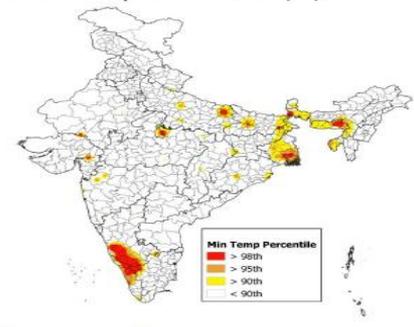
(The percentile analysis uses all the days on record for the current month.)

Annexure 4

Observed Temperature at 1430 hrs IST Dated 20/04/2023   24 hrs Temperature Change at 1430 hrs IST Dated 20/04/2023
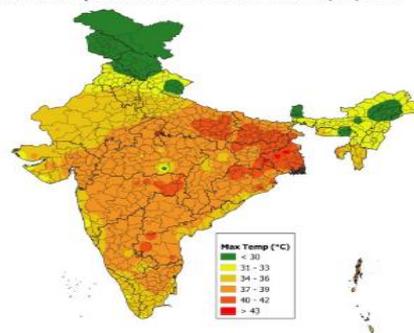
Max Temp (°C)
< 30
31 - 33
34 - 36
37 - 39
40 - 42
> 43

24 Hour Temp Change (°C)
> 4
1 - 3
No Significant Change
(-1) - (-3)
< -4
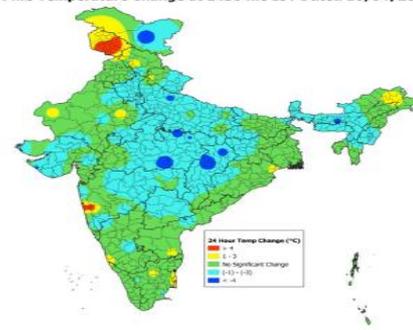
"Due to humid air and high temperature, hot and discomfort weather very likely over Kutch and Kerala today."

Heat wave forecasting skills 2023

Heat Wave Warning Skill Scores (March to June) 2023 — bar chart with FAR, MR, CSI, POD values:
- Day 1: FAR 3, MR 5, CSI 68, POD 95
- Day 2: FAR 3, MR 19, CSI 59, POD 81
- Day 3: FAR 2, MR 42, CSI 46, POD 58
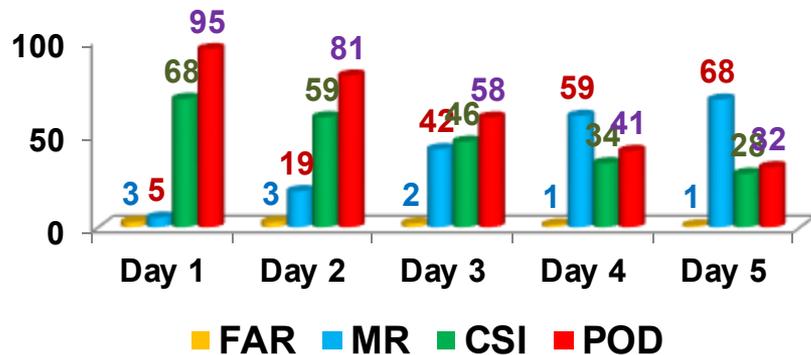- Day 4: FAR 1, MR 59, CSI 34, POD 41
- Day 5: FAR 1, MR 68, CSI 28, POD 32

POD Improvement — bar chart with 2015-2018, 2019-2023, % Improvement:
- Day 1: 83, 96, 16
- Day 2: 66, 81, 22
- Day 3: 41, 61, 49
- Day 4: 21, 47, 122
- Day 5: 15, 39, 159
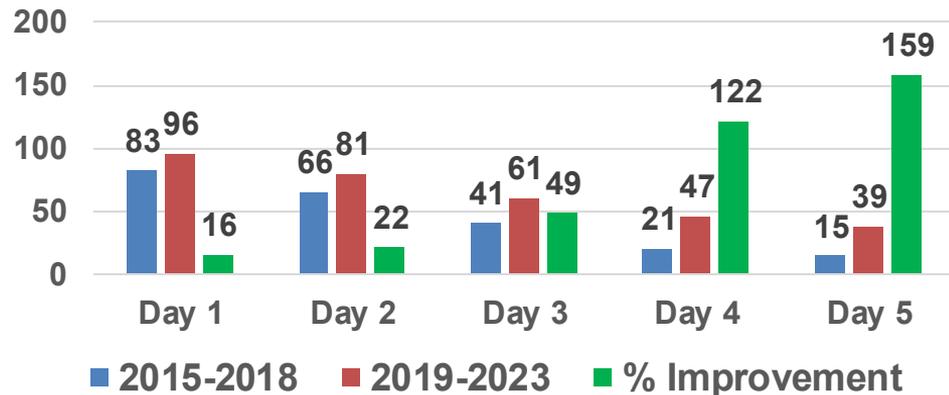
- **POD: Probability of Detection**

- **CSI: Critical Success Index**

- **There is significant improvement in recent five years compared to previous five years**

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Heat Wave impact on agriculture

- ❖ Average yield loss of **217 kg ha⁻¹ (~4.5 %)** in **heat-wave years**

- ❖ Milch animals, body-temperature increases of 0.5 to 3.5 °C during the heat wave.

- ❖ Milk yields declined by up to **~15 %** in some cases.

- ❖ Egg production dropped by ~10 % in the initial two days of the heat wave and then by ~4–7 %

- ❖ **In 2022:** Heat wave over Northwestern & Central India Overlapped with critical crop growth stages during Rabi harvest. Severely effect the agriculture production declines the **wheat yield by 4.5%**

- ❖ **Terminal heat stress** of wheat leads to Shriveled grain Grain-filling duration **reduced by 7–10 days**.

- ❖ High evapotranspiration leads to soil moisture stress

- ❖ 40-50% vegetable production reported in few states

- ❖ Less fruit setting in horticultural crops such as Kinnow, Pomegranate, Mango and Lemon.

Future products: Heat Stress forecast for Livestock

❖ India, the world's largest milk producer (241.5 Mt in 2023-24), supports over >70 million rural households reliant on dairying.

❖ Heat stress is a major environmental stressor reducing dairy productivity, milk yield, and fertility in India.

❖ Rising temperature (average 25-35 °C, often exceeding 40 °C during summer) and high humidity (60-85%) intensify livestock thermal load.

❖ Temperature-Humidity Index (THI) effectively quantifies climate-induced thermal stress on dairy systems.

❖ The major milk producing states are often coincides with the heat wave prevailed areas.

State wise milk production for the year 2023-2024
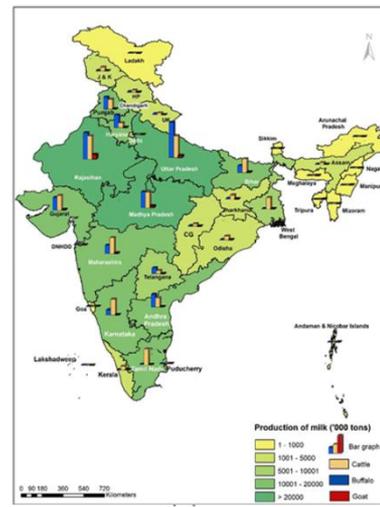
No. of heat wave days during May 2024
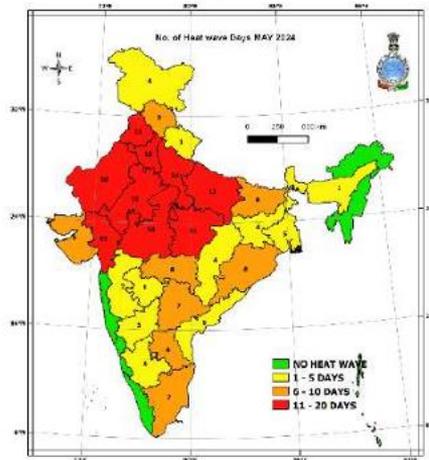
*Sources: AHS (Basic Animal Husbandry Statistics), 2024, and IMD, 2024*

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Temperature-Humidity Index (THI)

THI Computation by Kelly and Bond, (1971) equation:

THI	Category	Stress Level
≤74	Normal	No stress
75-78	Mild	Low stress
79-83	Moderate	Moderate stress
≥84	Severe	High stress

- Comfortable
- Moderate heat stress
- Severe heat stress
- Mortality

Daily Forecast of heat stress based on THI Matrix

THI Heatmap with Stress Thresholds

Relative Humidity (%)
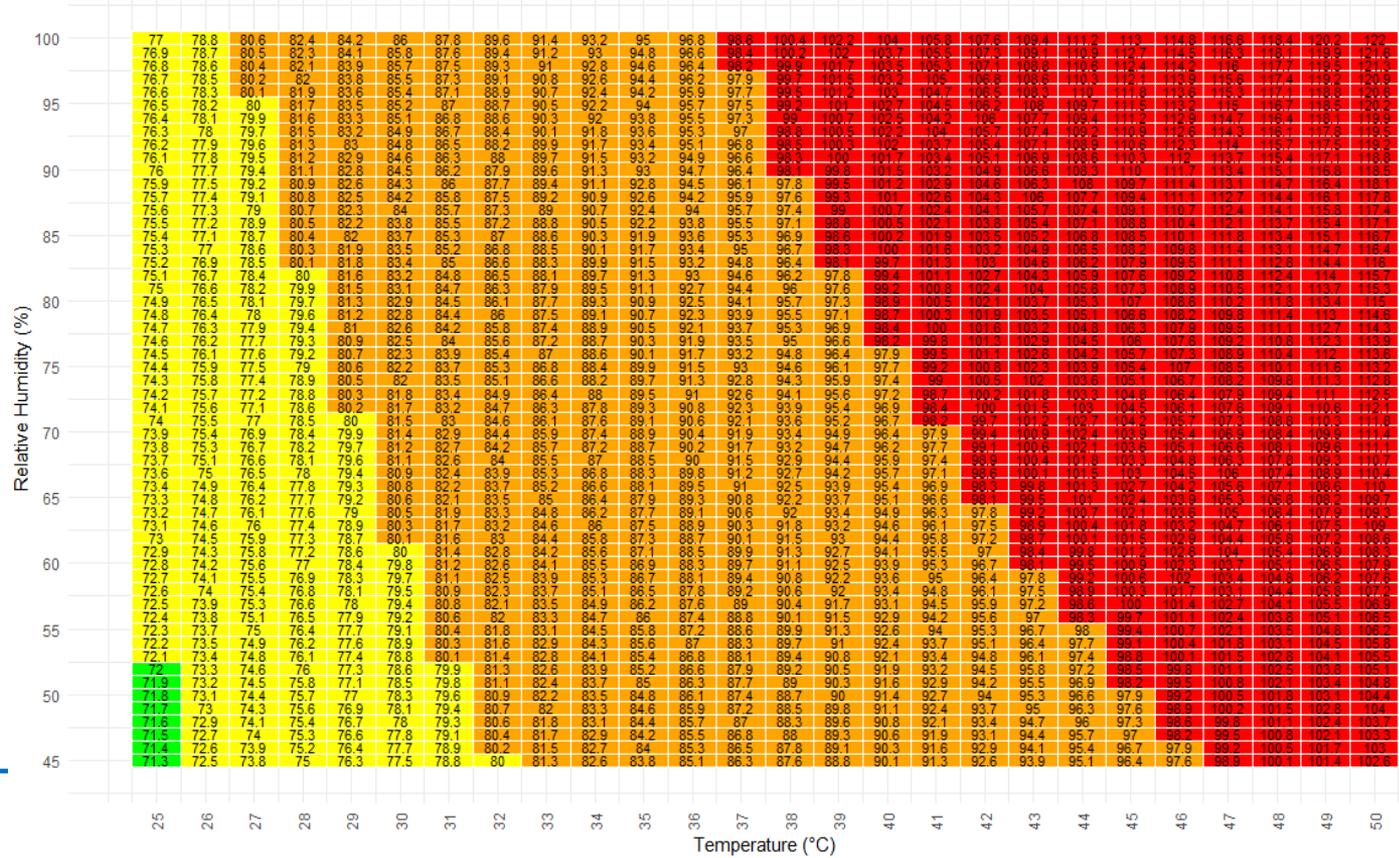
Temperature (°C)

Temperature Threshold based Impact and Action for Agricultural crops


Crop Weather Calendar

❖ Crop weather calendar for major crops for almost all agriculturally important districts are developed

❖ Thresholds retrieved from these Crop Weather Calendars utilized for forecast generation

❖ Impact and action collected from knowledge pool i.e ICAR, State agriculture universities and well-established research
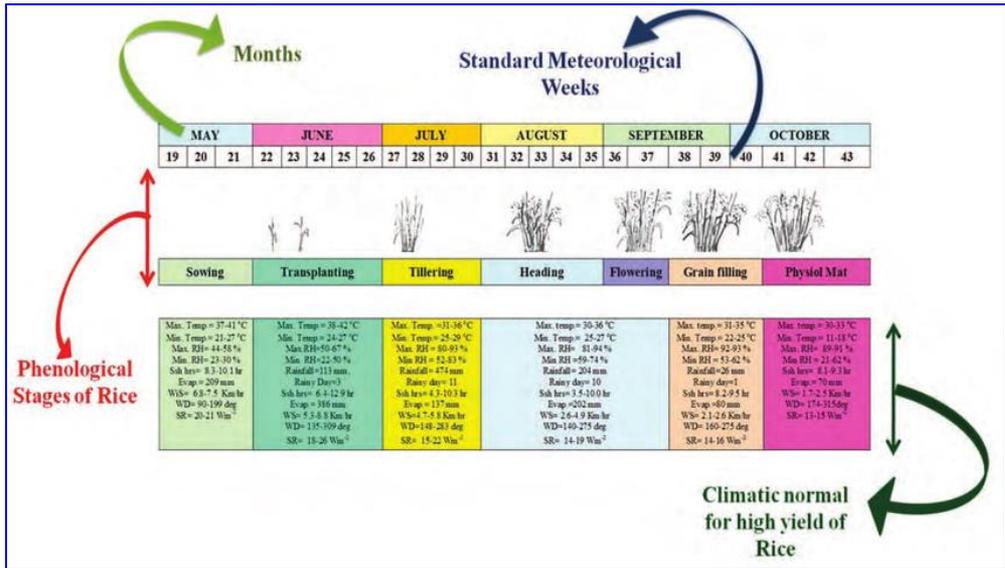
Flow Diagram of Issuance of Impact Based Forecast for Agriculture and its verification

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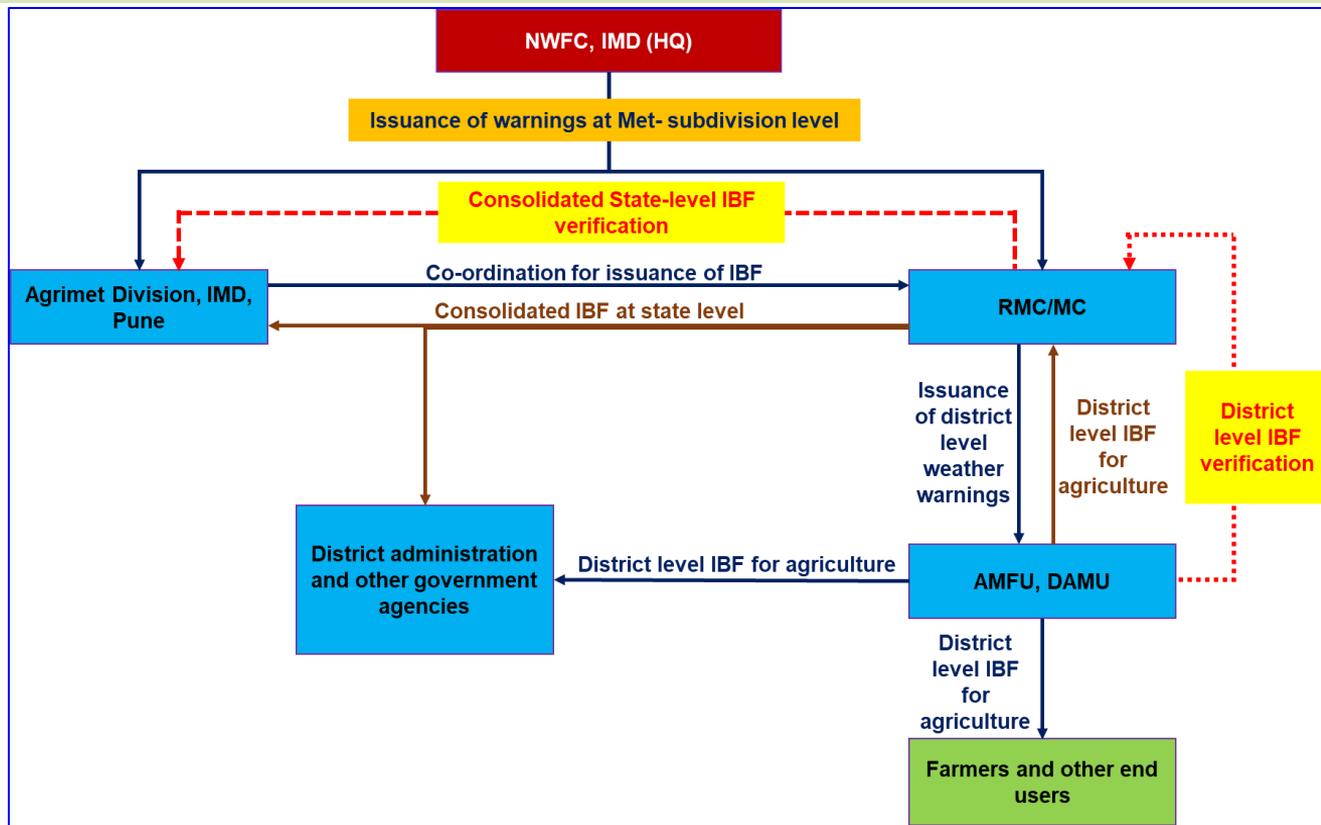
IMD's requirement for Impact based Forecasting (IBF) of Heat Waves:-

- **Multistakeholder team having experts from academia/research as well as operational setup from specific sector.**
- **Easy accessibility of data from the sectors.**
- **The aim of the team would be to devise methods and threshold for targeted region wise sector specific impact based forecasting services.**

Coordination by NDMA and depending on priority following tentative sector could be considered.

Heat Wave + Health.
Heat Wave + Agriculture.
Heat Wave + Forest Fire.
Heat Wave + Transport.
Heat Wave + Energy.
Heat Wave + ...

IBF requires domain expertise from the specific sector in addition to meteorological expertise. These teams could be tapping this multisectoral expertise in generating targeted forecast and warning services.

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THANK YOU

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