



# Climate Services in India: An Overview

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INDIA METEOROLOGICAL DEPARTMENT

**Stakeholder Consultation Workshop on National Framework for Climate Services  
for India (NFCS-India), 5-6 October 2023**



सत्यमेव जयते  
Ministry of Earth Sciences  
Government of India



# Bottomline of Climate Change !!



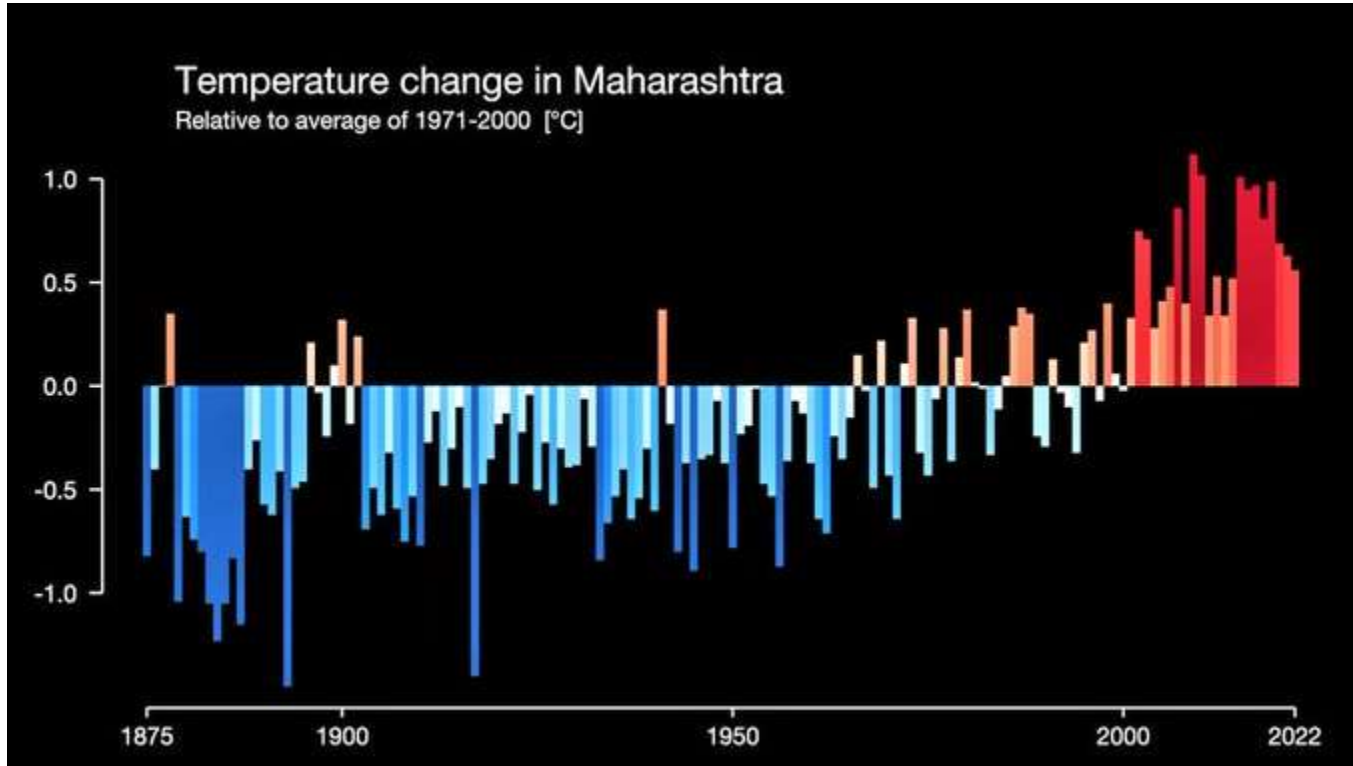
**“Owing to a lack of understanding, and data being unavailable, unusable or unsuitable, weather and climate information is currently underutilized in Sustainable Development Goal implementation. Improvements are essential in knowledge brokering, clarifying responsibilities, multi-institutional and multi stakeholder governance arrangements and research on systemic risks and decisions”**

Griggs, D. etal *Nat Rev Earth Environ* 2, 2–4 (2021).



*The Blue Marble*, taken by the [Apollo 17 crew](#) in 1972.

# Temperature changes in Maharashtra (1875-2022)



*A person who is engaged in killing creatures, polluting wells and ponds and tanks, and destroying gardens certainly goes to HELL.*

**The Padmapurana – Bhumi Khand**

# MULTI-HAZARDS DUE TO EXTREME RAINFALL



**Landslide**

Source: Deccan Herald



**Malin, Pune Mudslide 2014**

Source: [blogs.agu.org/landslideblog/](http://blogs.agu.org/landslideblog/)



**Erosion**

Source: [www.britannica.com](http://www.britannica.com)



**Flash Flood**

Source: The Weather Channel



**Crop Damage**

Source: Times of India

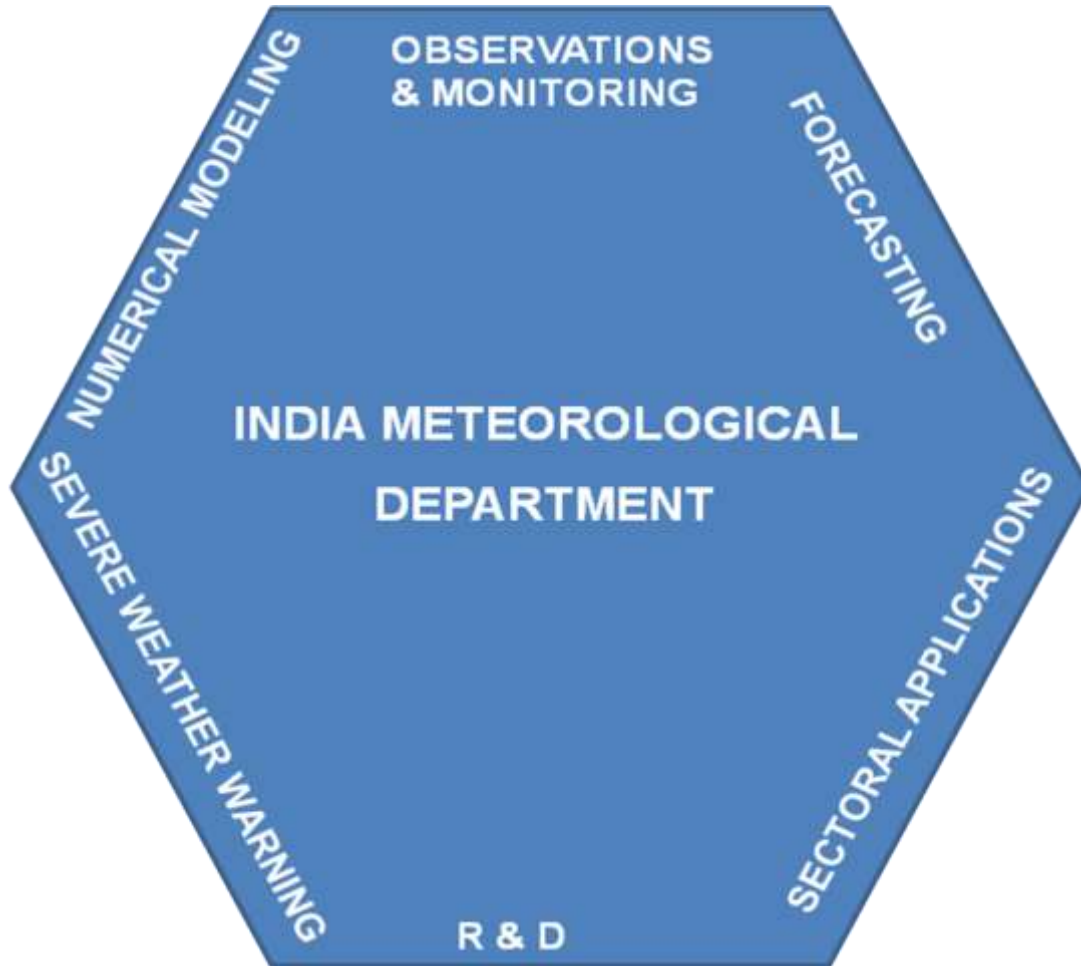


**Property Damage**

Source: India Today

# Weather and Climate Services for Self Reliant India

- **Pillars of SRI: Quantum jump in Economy through**



- **Meteorological observations & forecast for optimum operation of weather sensitive activities**
- **Hence to enable enhancement in Economy**

# Contribution to Economy through:

- **Prediction of land, atmospheric and Oceanic states at different scales to provide weather and climate forecast in different spatial and temporal range**
    - **Nowcasting (few hours)**
    - **Short range (1-2 days)**
    - **Medium range (few days – week)**
    - **Extended Range (Week-Month)**
    - **Seasonal (Few months, e.g. Jun-Sep Monsoon)**
    - **Climate Scales**
- Spatial range : Location, Block, District, Meteorological Sub-division, River catchment, State and Homogeneous regions**

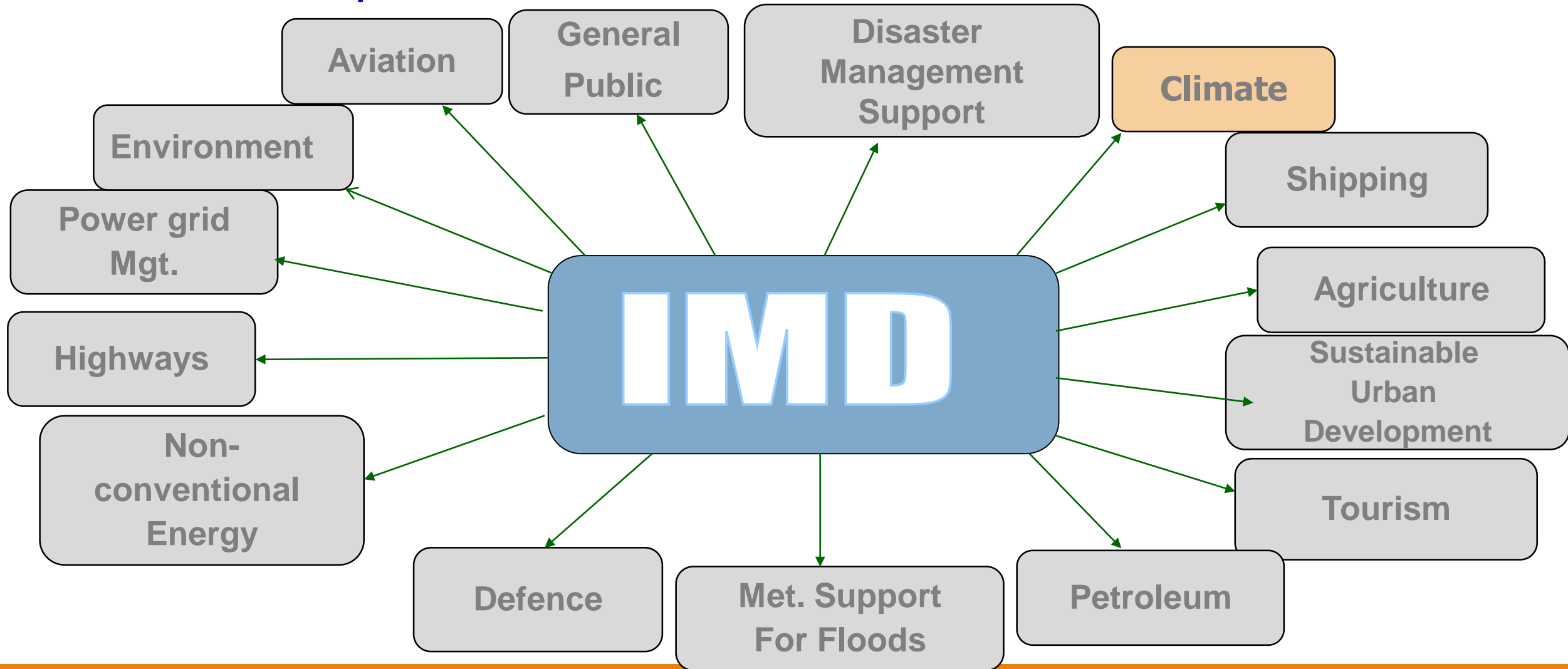
# Jump in Economy through improved weather and climate services:

Over the past few years, the quality of weather, climate, ocean services provided by the Ministry of Earth Sciences has improved due to systematic efforts in

- ✓ Augmenting atmospheric and ocean observations
- ✓ Developing adequate modelling strategy,
- ✓ Conducting cutting edge research and
- ✓ Investing in human resources development.

# Weather and Climate Services for Self Reliant India

- **Pillars of SRI: Improvement in Economy through Sectoral applications of weather and climate services as per Demand**





# System for weather and climate services:



## Three tier organization

At National level,  
Regional level and state  
and district level

A system that doesn't  
follow norms of previous  
century.

It should be able to fulfill  
21st century dreams and  
be technology driven

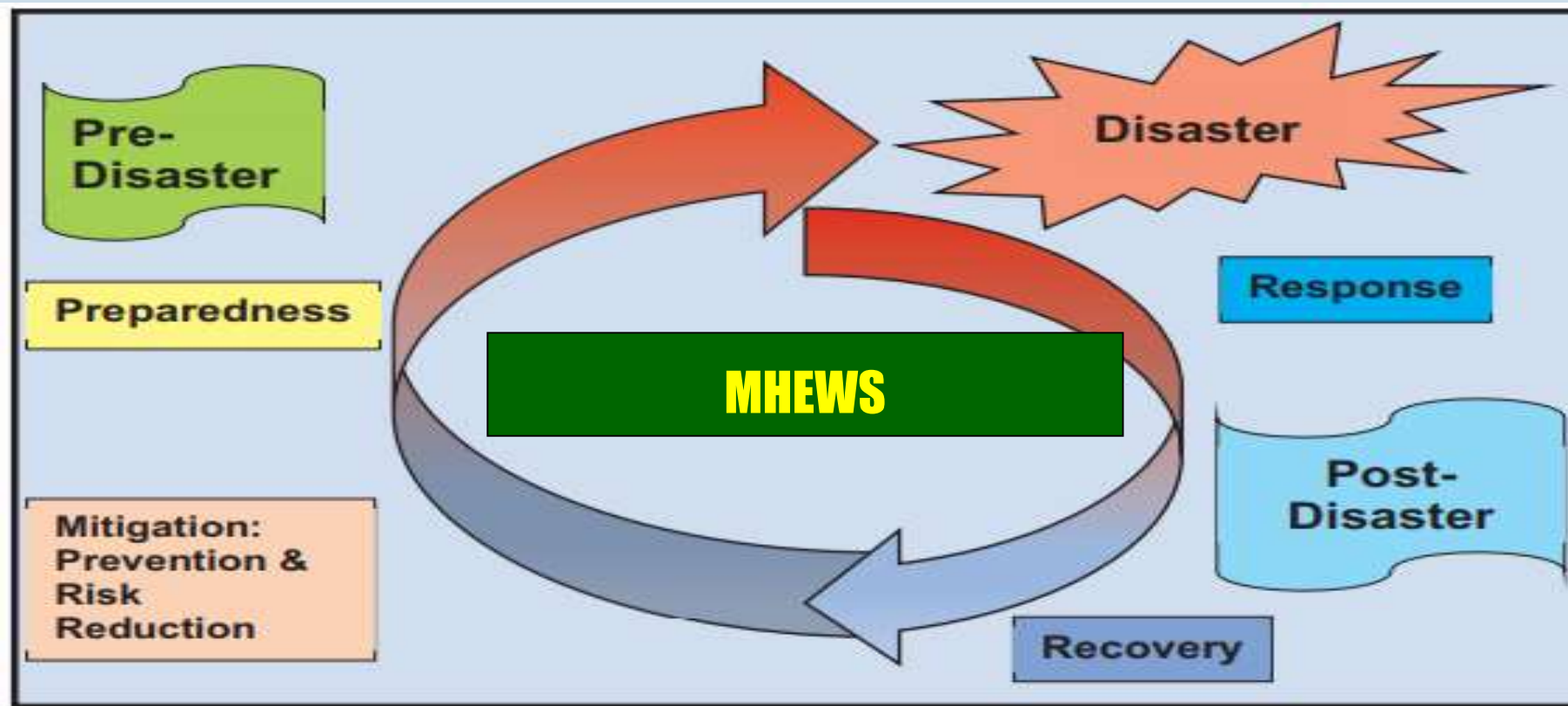
# Weather and Climate Services for Self Reliant India

- **Quantum jump in weather and climate services for disaster management**
- **Components of disaster management**

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  - ✓ Weather hazard should NOT go undetected and unpredicted
  - ✓ **Early warning** and mitigation.
  - ✓ Warning against any hazard should be accurate with reasonable lead time and trigger response from disaster managers and general public to save life and property.
  - ✓ **Technical support** in vulnerability analysis, risk assessment
  - ✓ **Technical support** in preparedness & planning,
  - ✓ **Technical support** in management of natural resources (Agriculture/Water resources, Energy Resources etc)

# MHEWS in India for Disaster Risk Reduction



- National Policy
- National DM Act
- National DM Plans
- National Guidelines
- Institutional Mechanism

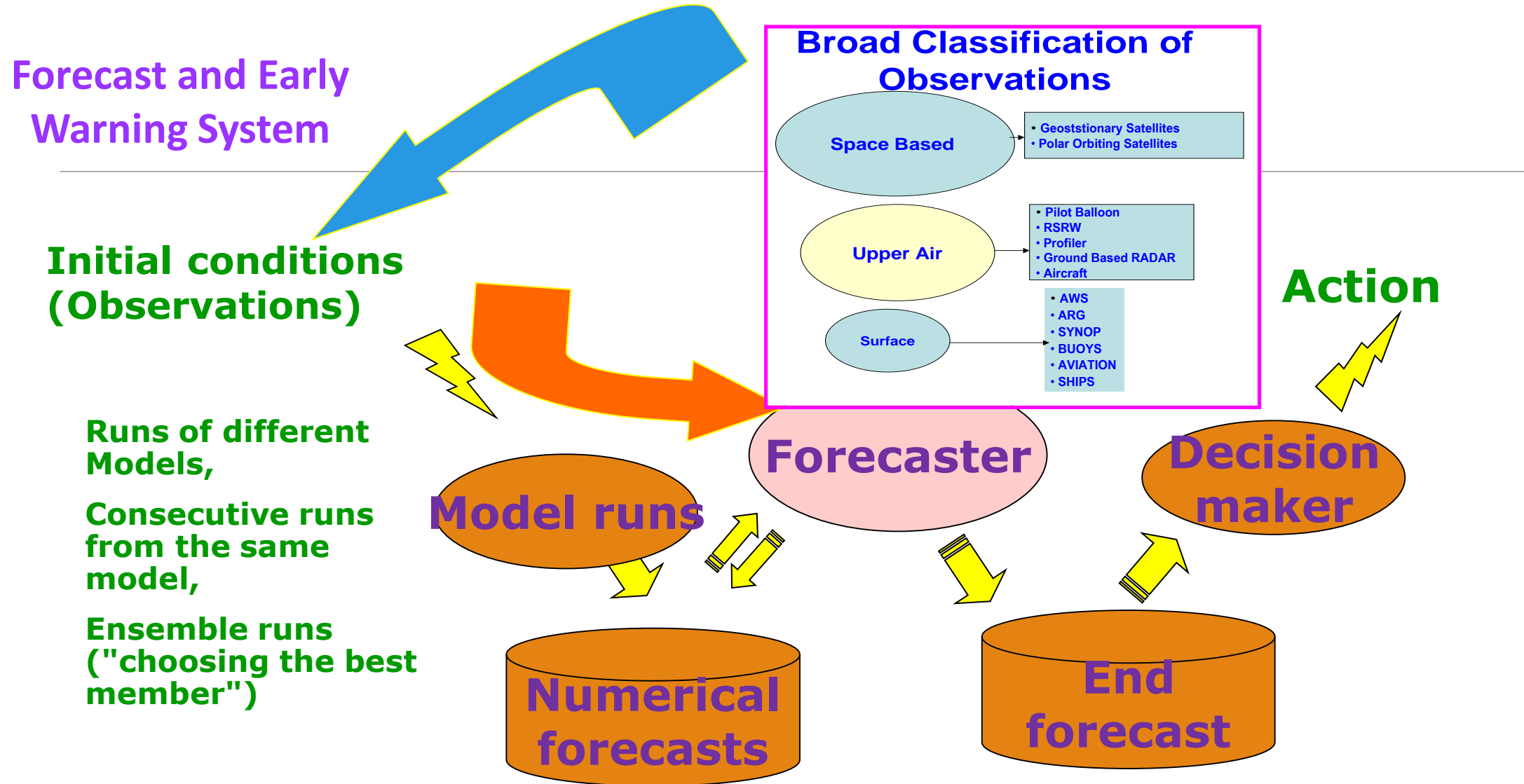
MHEWS plays a dominant role during, before and after the disasters in all phases of preparedness, prevention and risk reduction

India is self reliant with respect to weather and climate services in terms of contribution to economy, development of system and infrastructure, socio-economic applications and disaster risk reduction

In terms of forecast accuracy and service delivery, it is at par with leading global centres

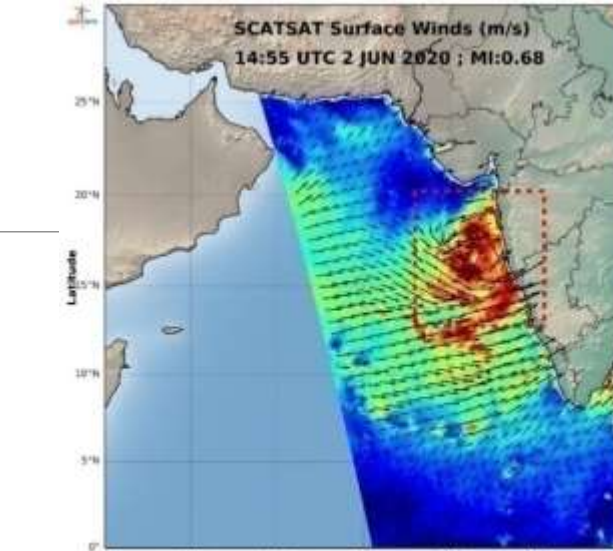
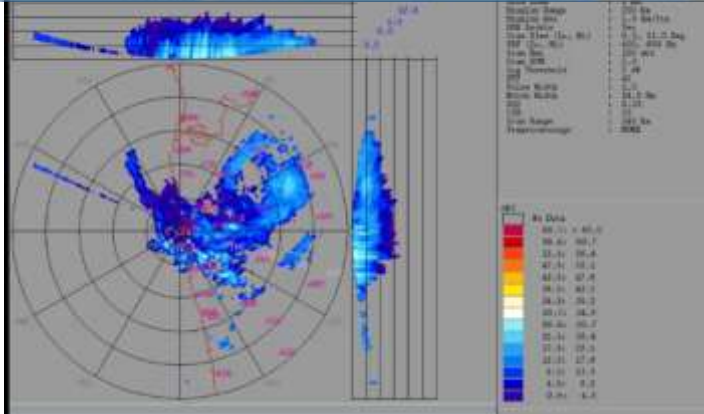
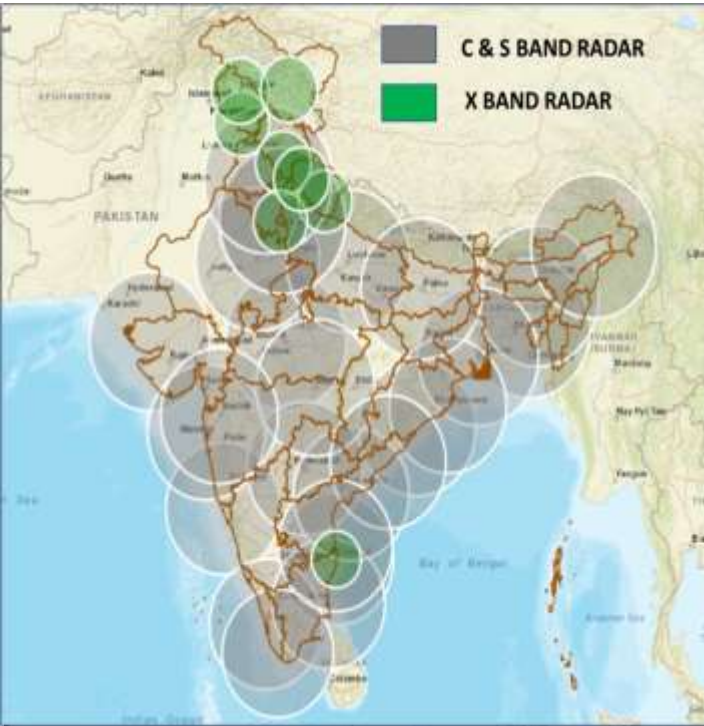
National Policy/plans/guidelines are in place to enable response actions so as to reduce risk

# End to End Early Warning System for disaster management

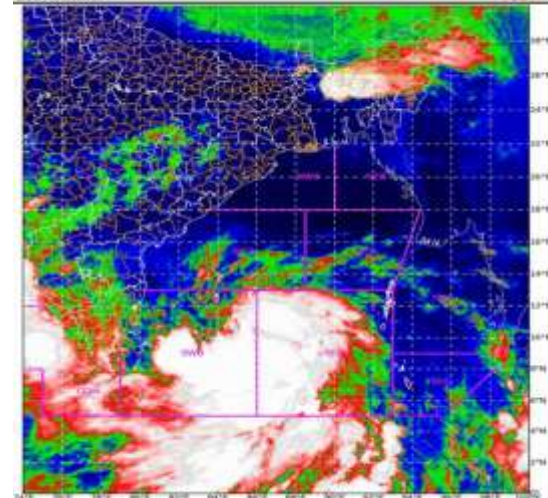


Improved Forecast and Early warning system with respect to all the above components

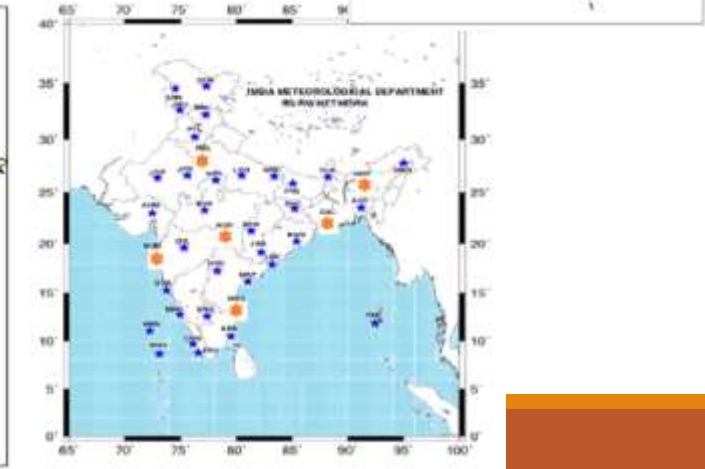
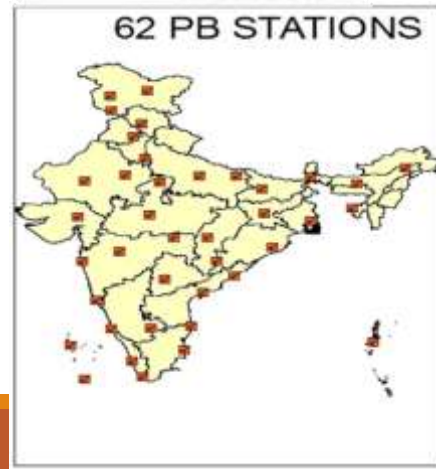
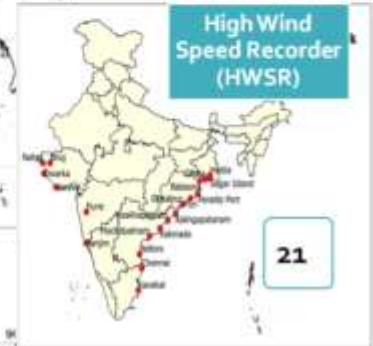
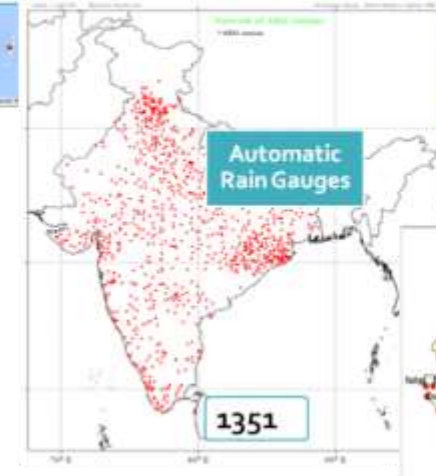
# Observational techniques : Current status



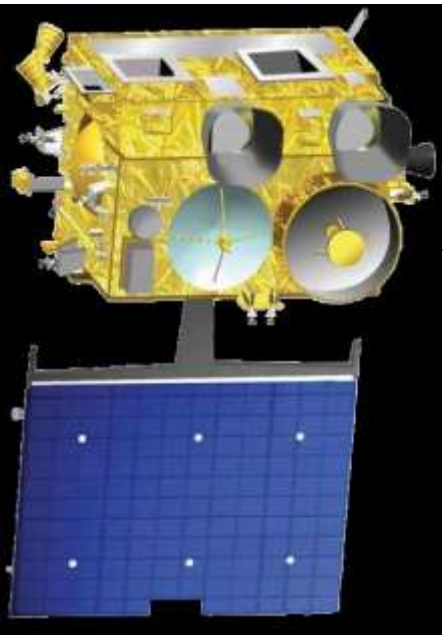
SAT: INSAT-3D IMG 16-05-2020(0000 to 0027) GMT  
IMG\_TIRE\_TEMP 10R km 16-05-2020(0330 to 0357) IST  
LIC Meteorology



Colorbar: IMD, DELHI



# Satellite Data: Current Status



**INSAT-3D/3DR**

| Spectral Band | Wave length ( $\mu\text{m}$ ) | Ground Resolution |
|---------------|-------------------------------|-------------------|
| Visible       | 0.55-0.75                     | 1 km              |
| SWIR          | 1.55-1.70                     | 1 km              |
| MIR           | 3.80-4.00                     | 4km               |
| WV            | 6.50-7.10                     | 8km               |
| TIR1          | 10.2-11.3                     | 4km               |
| TIR2          | 11.5-12.5                     | 4km               |

## Multi-Mission Meteorological Data Receiving and Processing System

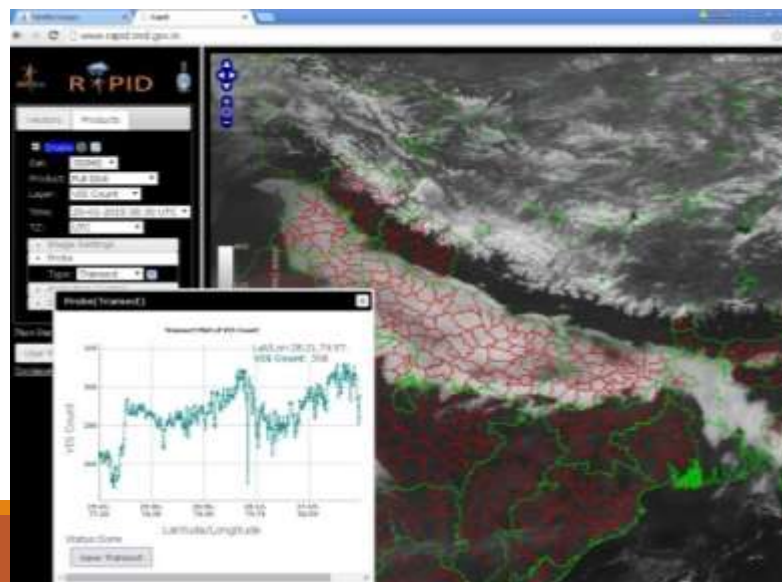


**INSAT-3D launched on 26<sup>th</sup> July, 2013**

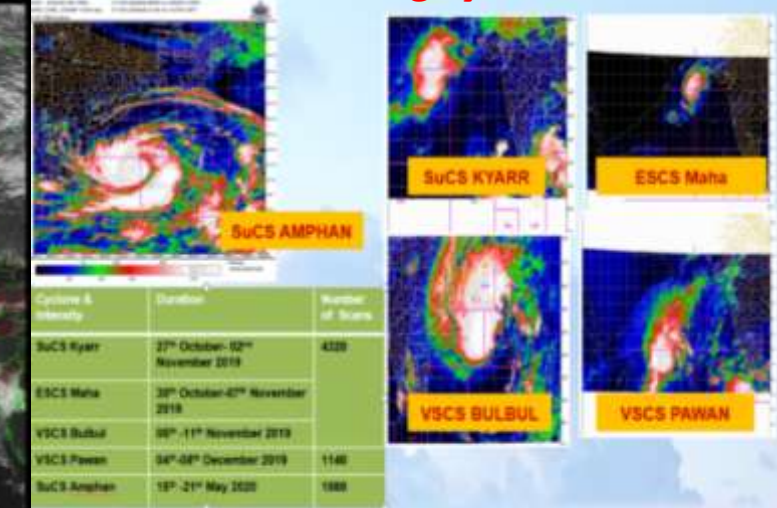
**Pay loads in INSAT 3 D (R)**

- ❖ Six Channel Imager
- ❖ 19 Channel Sounder
- ❖ Data Relay Transponder
- ❖ Satellite Aided Search and Rescue (SAS & R) Transponder.

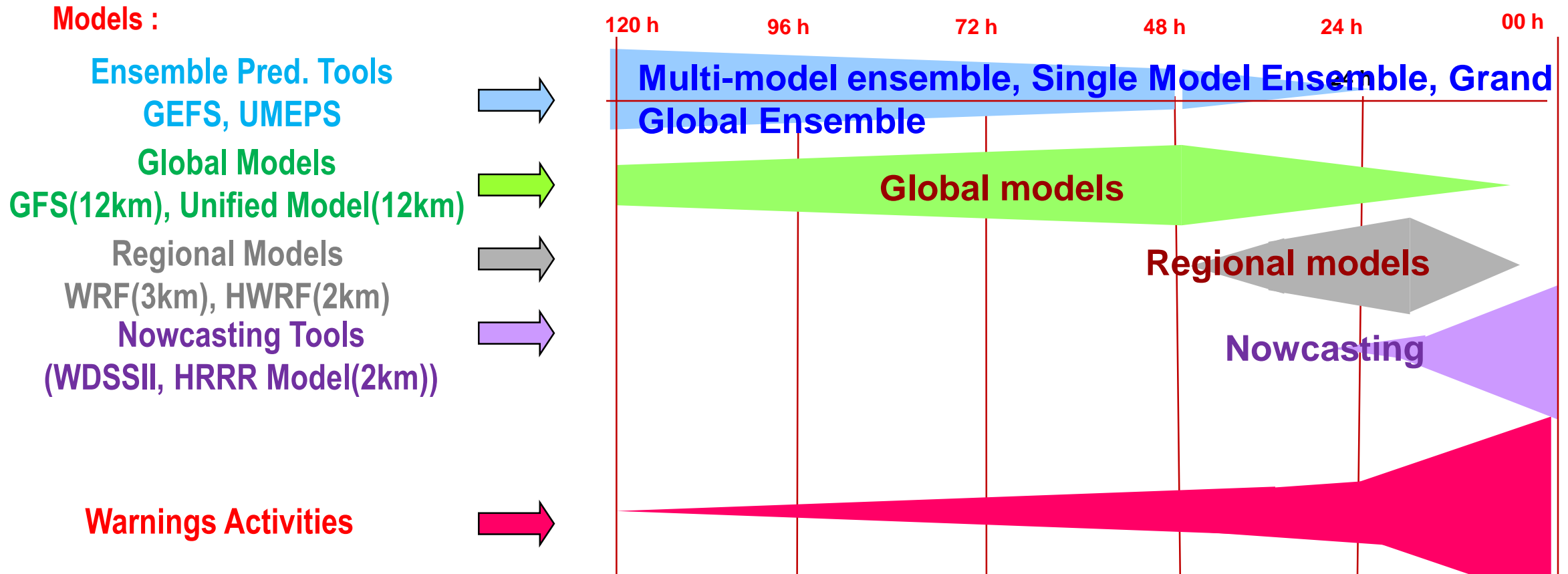
**RAPID: Web-based analysis tool:**



**RAPID SCAN during cyclone events**



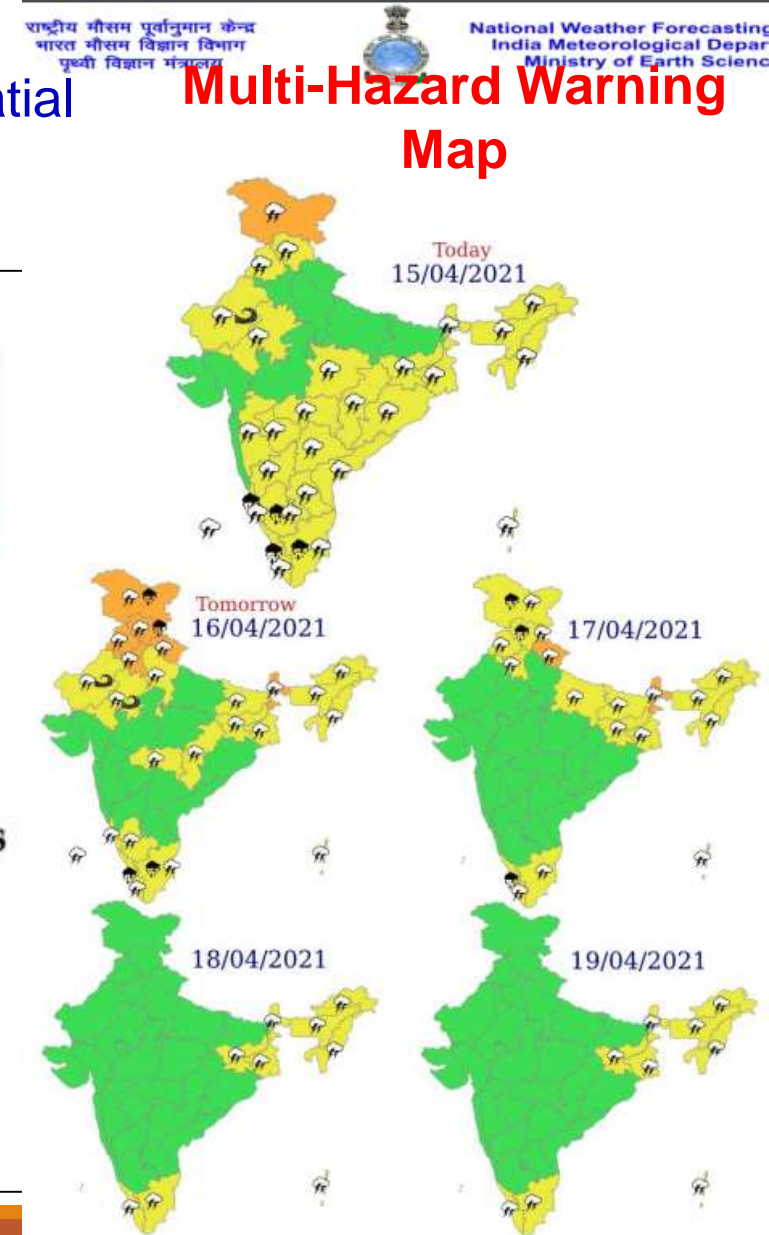
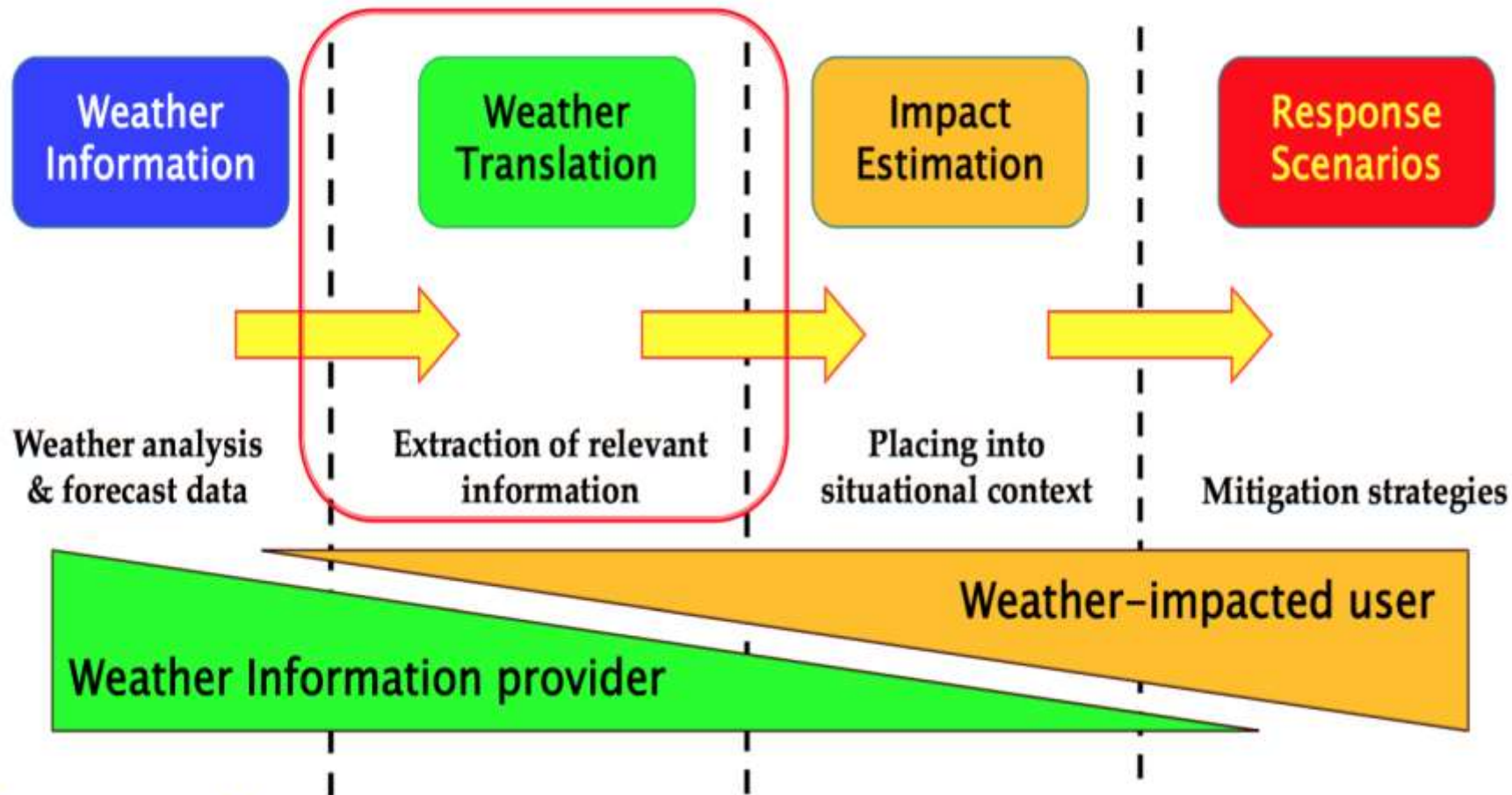
# Way Forward : Numerical Weather Prediction (NWP) Modeling Backbone for Forecasting and Warning Services



**By 2023 :** 12 km Global Model Ensemble prediction system, 1-3 km Regional multi-model prediction system, ocean-atmosphere coupled severe weather pred. systems, Parametric models and Expert systems – severe weather Warning up to 5 days, Forecast outlook up to 10-15 days

# Impact-based Forecasting for all

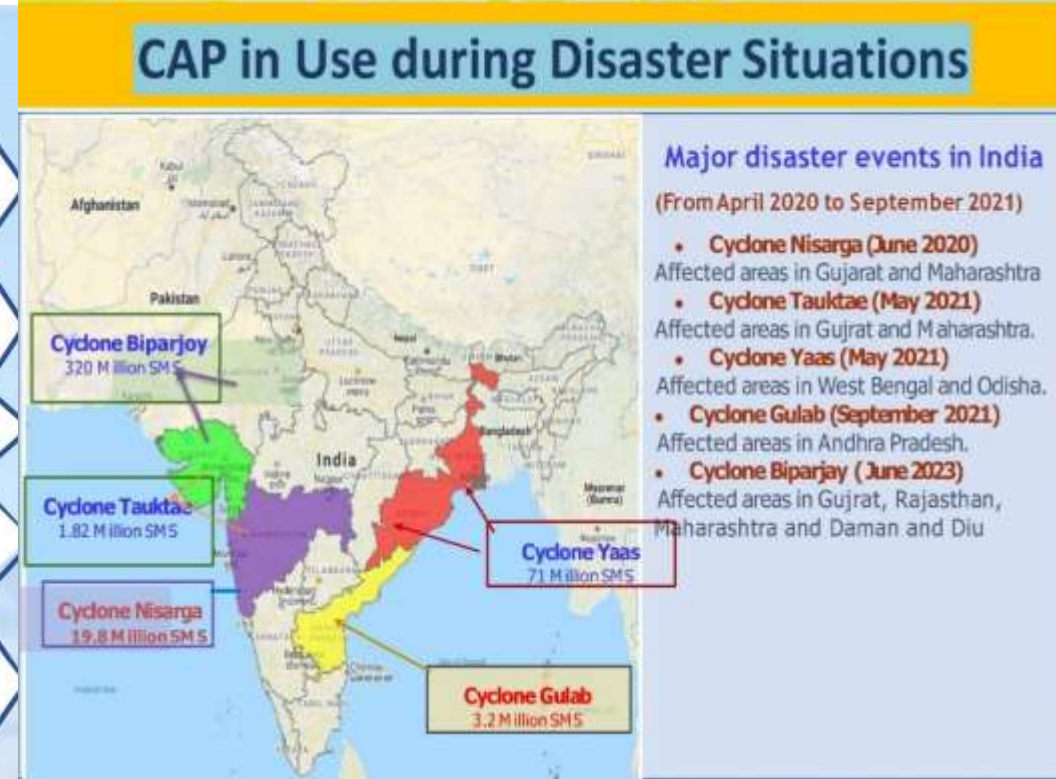
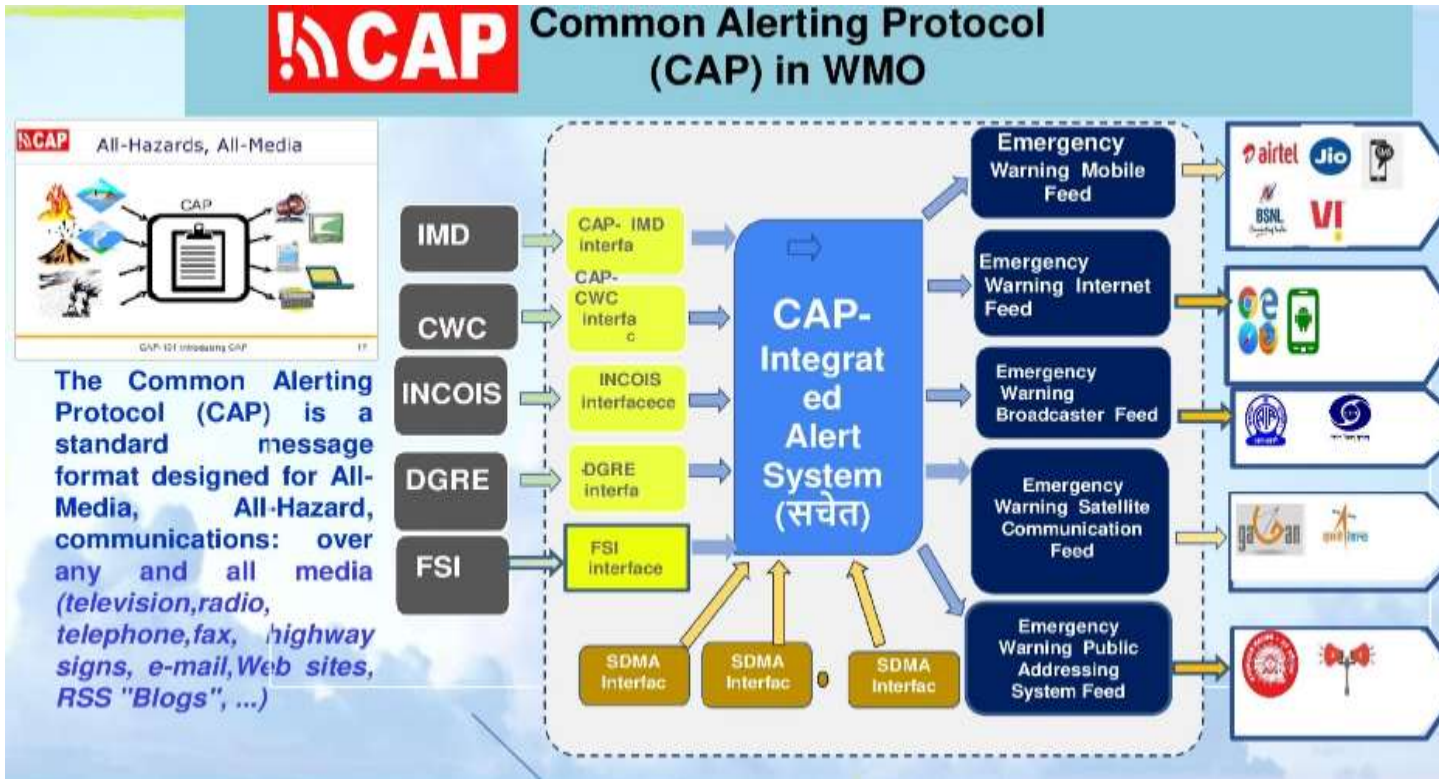
- **Role of technology**
- Creation of data (on meteorological hazards, secondary hazards, geospatial database and socioeconomic database)
- Hazard, Vulnerability and Risk modeling



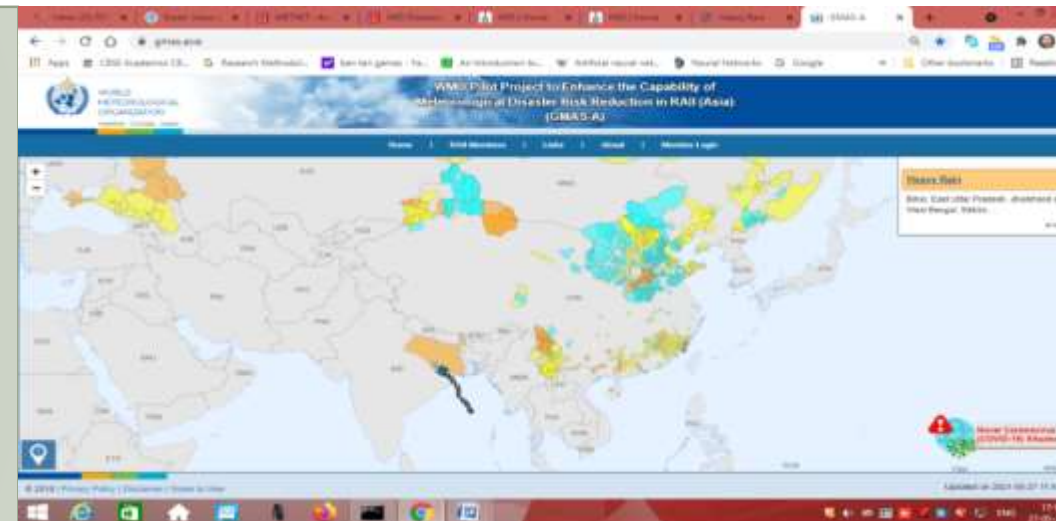
Source: Baode Chen and Xu Tang (2014) Translating weather forecasts into impact-relevant information



# Common Alerting Protocol (CAP):



- IMD's CAP feeds are now **operational** and it is automatically aggregated to the WMO Alert Hub.
- These alerts are also disseminated to Global Multi-Hazard Alert System (GMAS) portal (<https://gmas.asia/>), Google, AccuWeather, the Weather Company
- IMD's CAP feeds are also being disseminated by NDMA CAP SACHET Platform.



# Advances in Warning Dissemination Mechanism

- ❖ Telephone, Tele-fax, Mobile Phones (SMS) through IMD severe weather network, Agromet Network, INCOIS network.
- ❖ VHF/HFRT/Police Wireless, Aeronautical Fixed Terminal Network, GMDSS
- ❖ Global telecommunication system (GTS) :
- ❖ NAVTEX , Internet (e-mail), ftp
- ❖ Mass Media: : Radio/TV, News Paper network (AM, FM, Community Radio, Private TV) : Prasar Bharati and private broadcasters, Websites, Dedicated websites and web pages, Social media, Weekly and daily Weather Video
- ❖ GAMES and NAVIK



Public Website ([mausam.imd.gov.in](http://mausam.imd.gov.in))

IMD Apps: Mausam/ Meghdoot/DAMIN/RAIN ALARM, UMANG

Social Media: Facebook, Twitter, Instagram, BLOG

Twitter: <https://twitter.com/Indiametdept>

Facebook::

<https://www.facebook.com/India.Meteorological.Department/>

Blog: <https://imdweather1875.wordpress.com/>

Instagram:[https://www.instagram.com/mausam\\_nwfc](https://www.instagram.com/mausam_nwfc)

Youtube:[https://www.youtube.com/channel/UC\\_qxTReoq07UVARm87CuyQw](https://www.youtube.com/channel/UC_qxTReoq07UVARm87CuyQw)

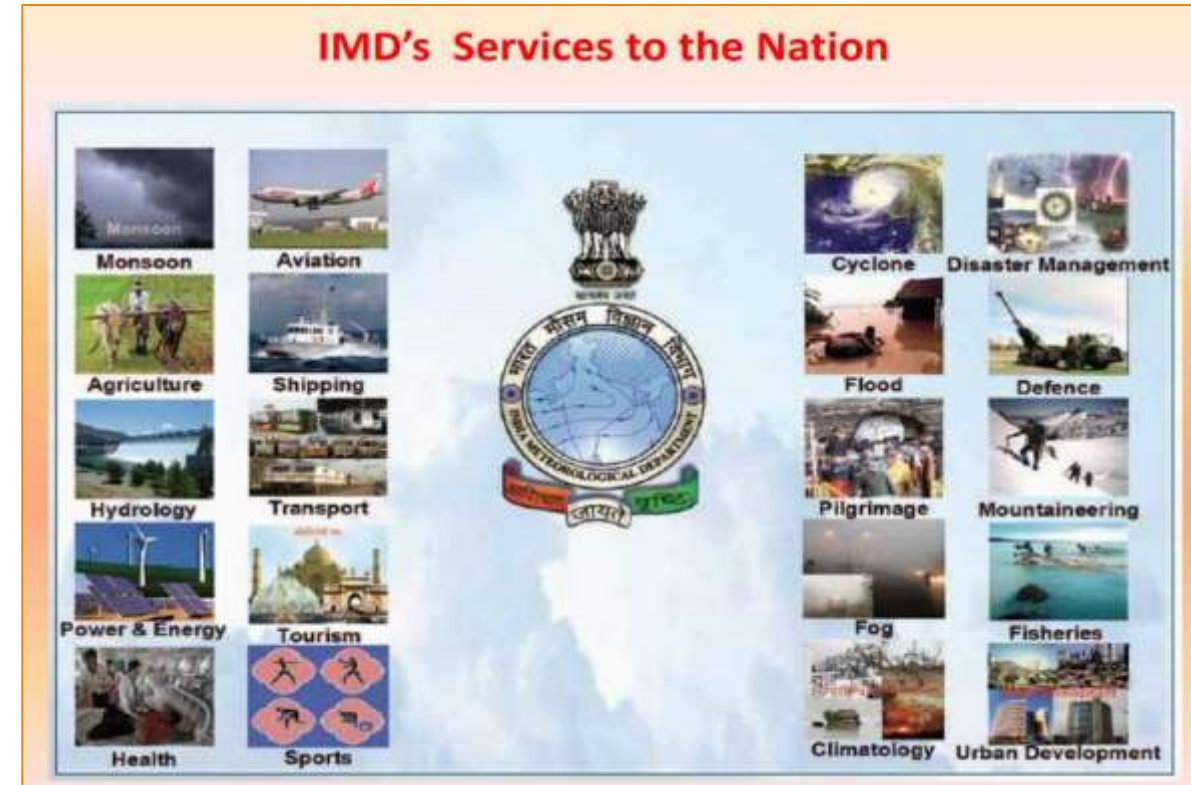
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# Information beyond weather scale: Towards an efficient Climate Forecast and DSS

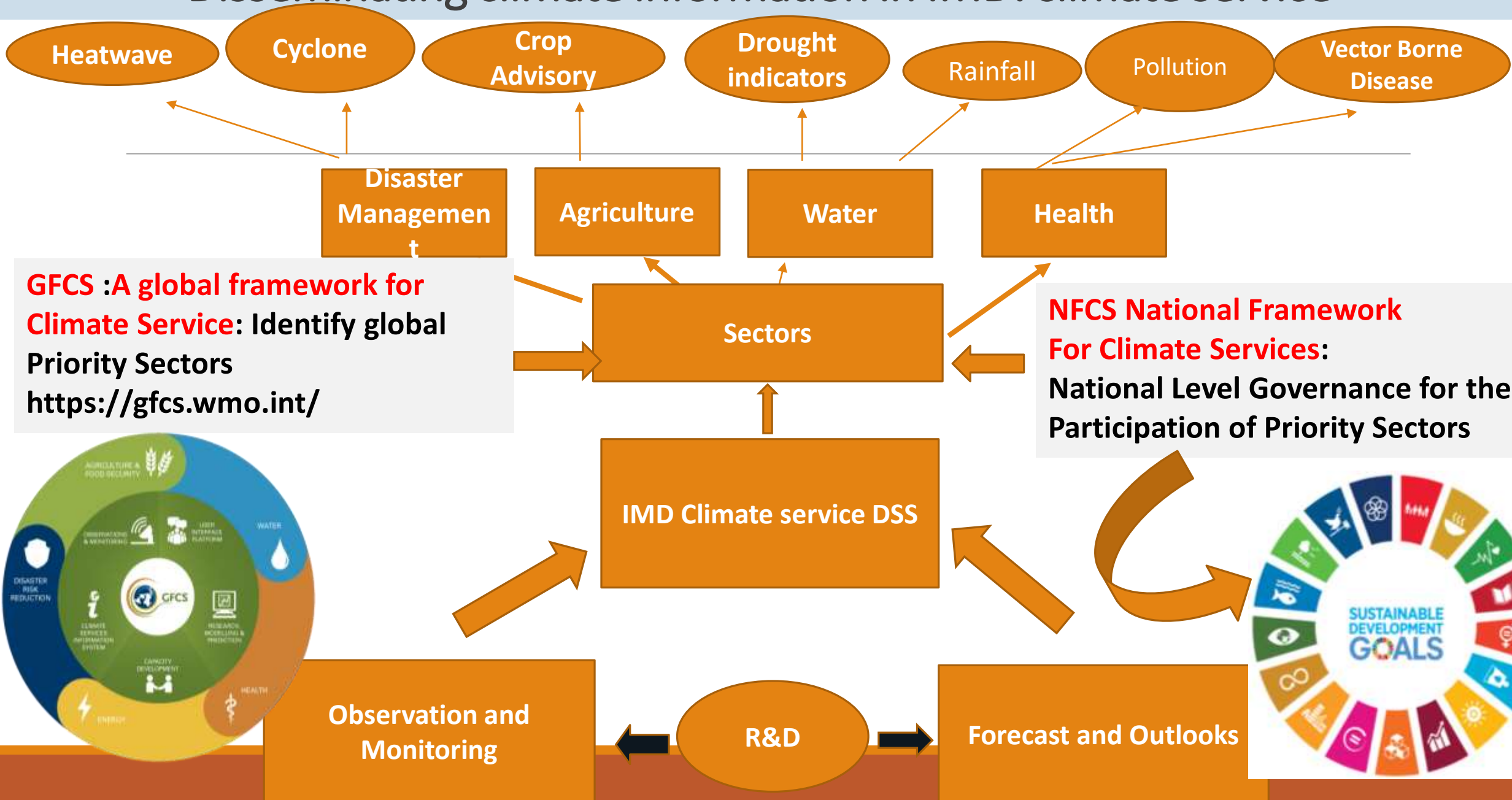
# Climate information and decision-making

Climate information is increasingly critical for a wide range of users:

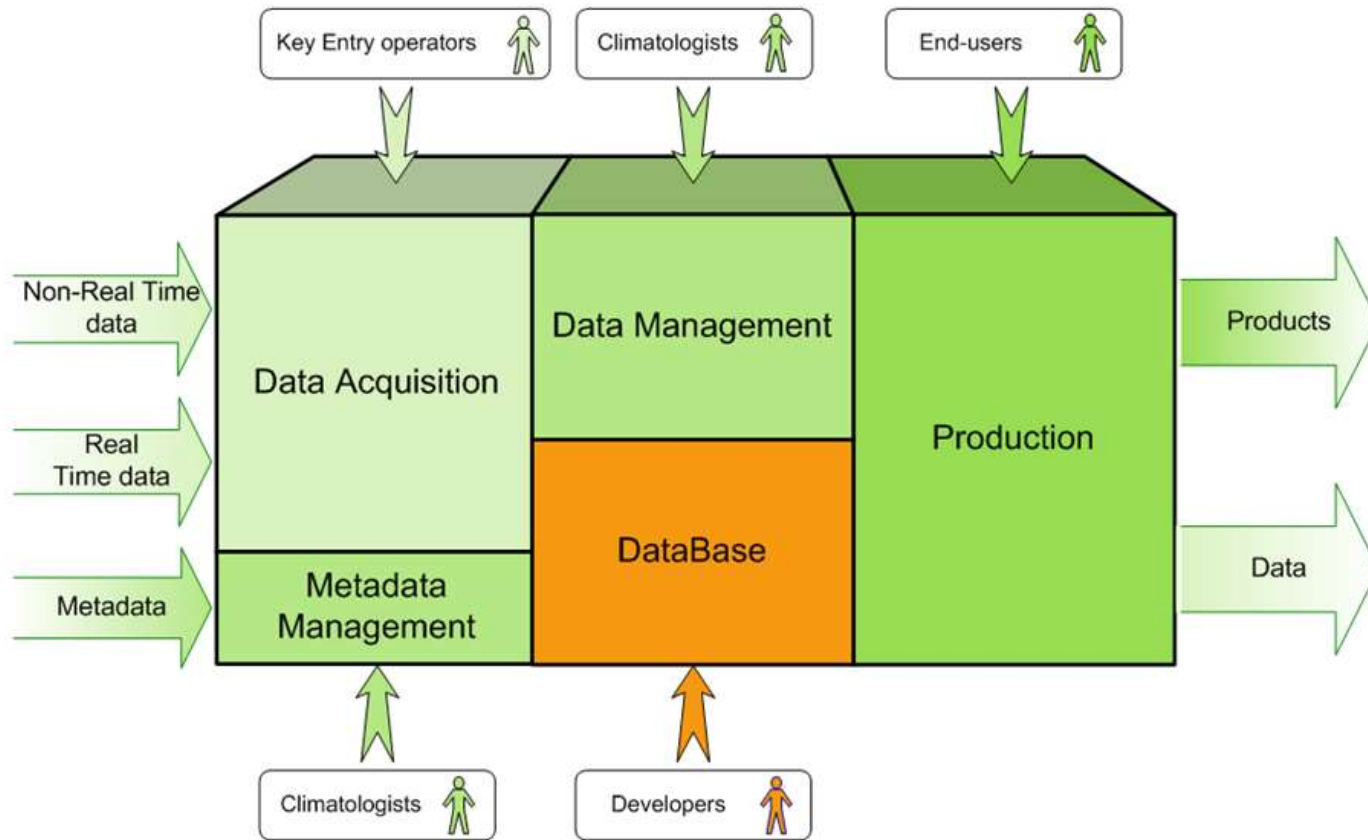
- Agriculture and food security
- Disaster risk reduction
- Energy production
- transport and usage
- Finance and insurance
- Water quality/resources management
- Health Trade and commerce
- Transport & Tourism
- Urban development/management
- Recreation and sports...and many more...



# Disseminating climate information in IMD: climate service



# Functional Architecture - Five subsystems



## Legend



- **Database (Metadata, Data & others)**
- **Data Acquisition (real time and non real time)**
- **Metadata Management (station, instruments ..)**
- **Data Management (Ingestion, monitoring, quality control, generation- normal/ extremes .., modification/ update, catalogue)**
- **Production (data, summaries, tables, graphs, reports and analysis) in text, graphics, GIS**

# Components of Climate system

- Data collection
- Data monitoring
- Data quality Control as per WMO standards
- Meta data Management
- Data base Management
- Archival / Retrieval
- Data generation (Basic data, derived products generation)
- Data Visualization
- Bulletin & report generation
- Data Supply

## Climate Applications Products (Five Important Sectors)

- ❖ Agriculture & Food Security *(Active/Break cycle, Temperature; forecast at met-subdivision level for Agro-advisory)*
- ❖ Water *(Heavy rainfall forecasting, forecast at river basin scales for reservoir operation etc)*
- ❖ Energy *(Tmax/Tmin, Heat wave/Cold wave)*
- ❖ Disaster Risk Reduction *(Prediction of Severe Weather like Cyclogenesis)*
- ❖ Human Health *(Vector borne diseases) Experimentally it is being prepared*



❖ Seasonal and Extended range forecast provides useful skill for applications in Agriculture, Hydrology, Energy, Health and Disaster Management.



Demand-supply chain is our power, we should use it to its full potential.

## Gramin Krishi Mausam Sewa (GKMS)



Increase in dissemination of Agromet advisories for millions of farmer from 2012 to 2019

43.0\* (2019)

39.0 (2018)

22.71 (2016)

5.06 (2014)

3.40

\* Millions till Date

One in three family connected in the country

\* Advisories till Date

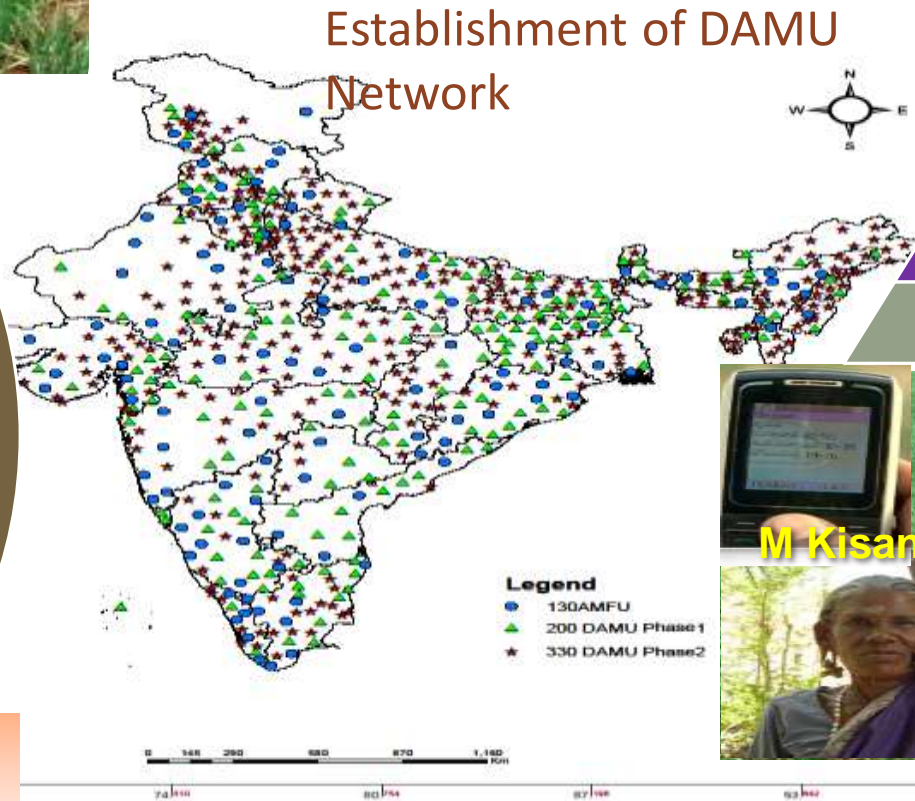
696\*  
(2019)

658 (2018)

622 (2016)

600 (2014)

593 (2012)



M Kisan



Mass & Social Media, Whats app, etc



Panchayati Raj



External Agencies



Digital India

# IMD's Operational Extended Range Forecast (ERF) System

## Operational module

Atmospheric ICs  
NCMRWF

Current week **Forecast run** for 32 days  
based on Wednesday day ICs  
Total 16 ensemble members  
(1 control + 3 perturbed) each  
CFSv2\_T126 (4 mem)  
CFSv2\_T382 (4 mem)  
GFSv2bc\_T126 (4 mem)  
GFSv2bc\_T382 (4 mem)  
(Based on Wednesday ICs)

Ocean ICs - INCOIS

## Hindcast module

Atmospheric ICs  
NCMRWF

13 years **Hindcast run** for 32 days  
(2003 to 2015) based on same date ICs  
Total 16 ensemble members  
(1 control + 3 perturbed) each  
CFSv2\_T126 (4 mem)  
CFSv2\_T382 (4 mem)  
GFSv2bc\_T126 (4 mem)  
GFSv2bc\_T382 (4 mem)  
(Based on Corresponding Date ICs)

Ocean ICs - INCOIS

## Bias Corrected Forecasts for 4 weeks

(Wind, Rainfall, Tmax and Tmin)  
**and its anomaly  
Friday to Thursday**

Week 1 : (Days 03-09)  
Week 2 : (Days 10-16)  
Week 3 : (Days 17-23)  
Week 4 : (Days 24-30)

14:38 5G

← Post

**MoES GoI** @moesgoi

🌤️ Reaching unprecedented heights: 9 Years of Unparalleled Efforts in Weather Forecasting!

📈 The India Meteorological Department (@Indiametdept), under @moesgoi, has been consistently working on enhancing its weather observation & forecasts.

9 Years of Global Sustainability!

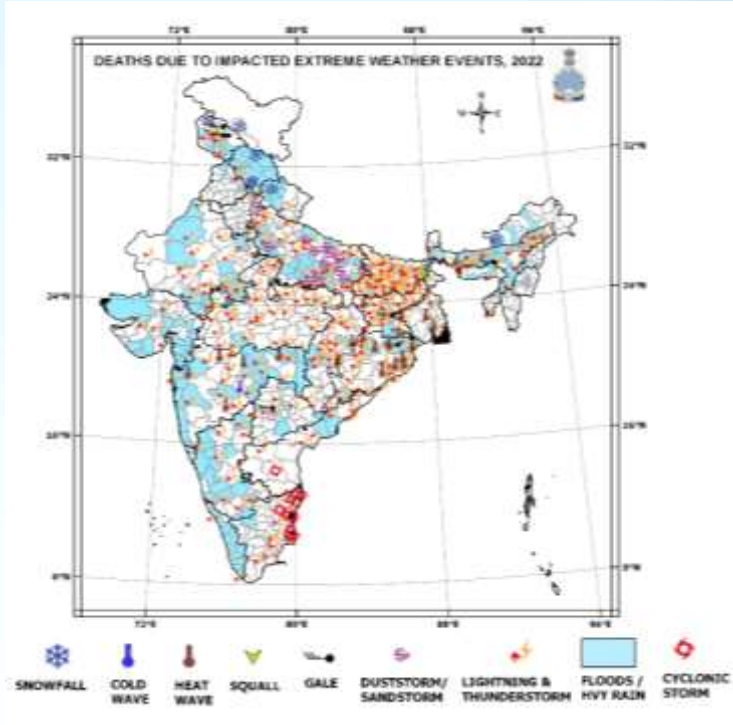
**IMD's Stellar Feat: Extended Range Forecast up to 4 weeks**

- IMD has empowered the nation with Extended Range Forecasts (ERF) of 4 weeks in advance significantly improving over the last 9 years.
- ERF benefits a range of sectors from agriculture, livestock, coastal community, disaster management, institutions, policy makers, etc. with information-backed decision making.
- Effective and better forecasting has led to value addition in service to public, nation's wealth, and resources.

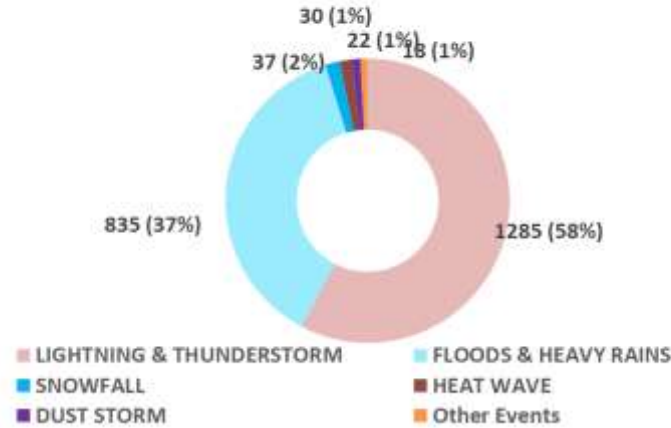
Post your reply

# Climate Monitoring

## Major Extreme Weather Events Occurred during 2022 & associated loss of life

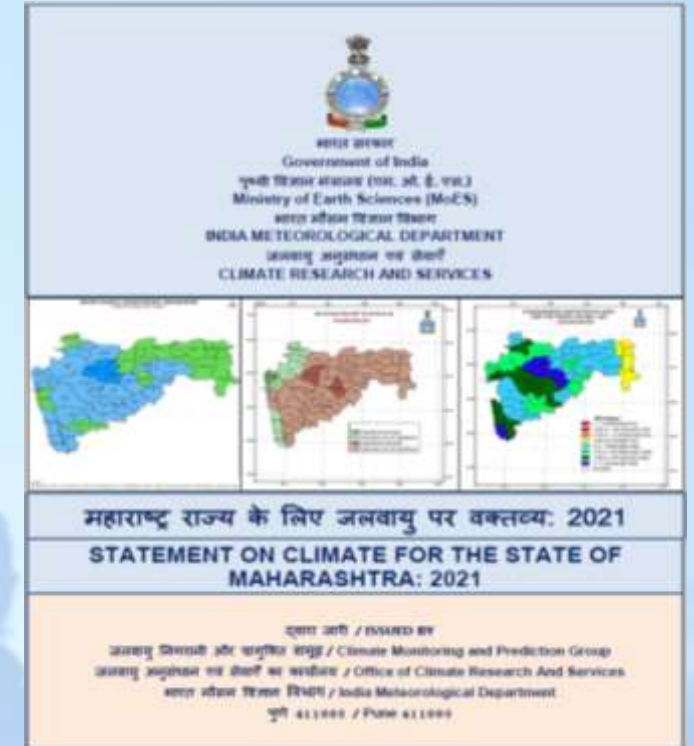


Distribution of Number of Deaths & it's percentage during 2022 for Impacted Extreme Weather Events



**Thunderstorms and lightning reportedly claimed more than 1285 lives from different parts of the country.**

## State-wise annual climate statement



- Monthly Climate Summary and Annual Climate Summary for India
- Gridded Climate Data products (Rainfall and Temperature)
- Climate Diagnostic Bulletin of India (Monthly and Seasonal)
- Annual Report on Disaster Weather Events (DWEs)



# Climate Applications & User Interfaces (CAUI)



## Hydro Meteorology

Started in 1946 to coordinate rainfall registration of State Government, collection of data and to execute statistical studies

- Collection, scrutiny, processing & archival of Daily rainfall/snowfall from 9500 rain gauge stations
- Daily, monthly, seasonal and annual rainfall series for districts, subdivisions, states, four homogeneous regions, whole country
- Preparation of Daily, monthly, seasonal, and annual rainfall *normal* for stations, districts, subdivisions, states, homogeneous regions, whole country and **updated every decade**.



## Drought Research

Started in the year , 1967 by recommendations of Planning commission after drought in 1965 and 1966

- Drought monitoring using Aridity Anomaly Index(AAI), Standardized Precipitation Index(SPI) and Standardized Precipitation Evaporation Index(SPEI) in weekly, biweekly, monthly and seasonal scales.
- **Weekly SPI maps** and values according to Drought manual of the Ministry of Ag.
- Generation of SPI and AAI outlook upto four weeks (**weekly once**)
- Weekly monitoring and prediction based on ERF for 101 river sub-basins of India. (**weekly once**).



## Sectorial Applications (Health, Energy & other Sectors)

Started during 2013-14

- **Weekly Bulletin for Climate Outlook for Health** (vector borne diseases Malaria and Dengue) for Week 1 & 2
- **Joint collaboration with State Health Department and the NGO Malaria No More for development of predictive models**
- Research on Threshold Criteria for Seasonal Amplification and Outbreaks of Mosquito-Borne Disease (MBD) Cases.



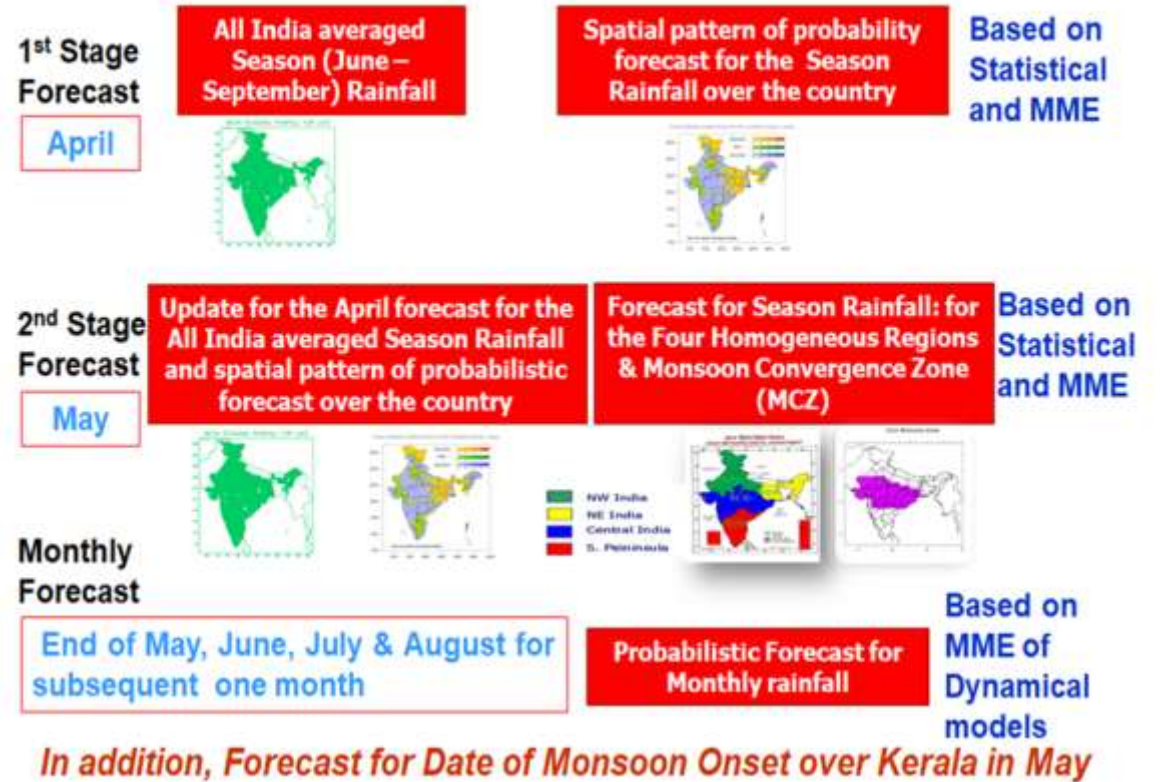
# Climate Forecasting

| Sr. No. | Forecast Outlook for  | Issued in        | Method/ Model    |
|---------|---|------------------|------------------|
| 1       | Rainfall during the Winter Season (Jan-March)                         | December         | Statistical, MME |
| 2       | Temperatures during Hot Weather Seasons (March to May) & (April-June) | February & March | Dynamical / MME  |
| 3       | Rainfall during the SW Monsoon Season (June to September)             | April            | Statistical, MME |
| 4       | Rainfall During the NE Monsoon Season (October to December) Rainfall  | September        | Statistical, MME |
| 5       | Temperatures during the Cold Weather Season (Dec- Feb) Temperature    | November         | Dynamical/ MME   |
| 6       | Monthly Outlook for Rainfall & Temperature                            | Every Month      | Dynamical/ MME   |

- ENSO and IOD Bulletin (issue monthly)
- Monthly and Seasonal Climate Outlook for South Asia
- Website Anomaly and Probability Forecast Products
- Conduct Seasonal South Asia Seasonal Climate Outlook Forum (SASCOF) (including Capacity Building training)

## New Seasonal Forecasting System Based on the Multi Model Ensemble (MME): 2021

### New Strategy for Long Range Forecast



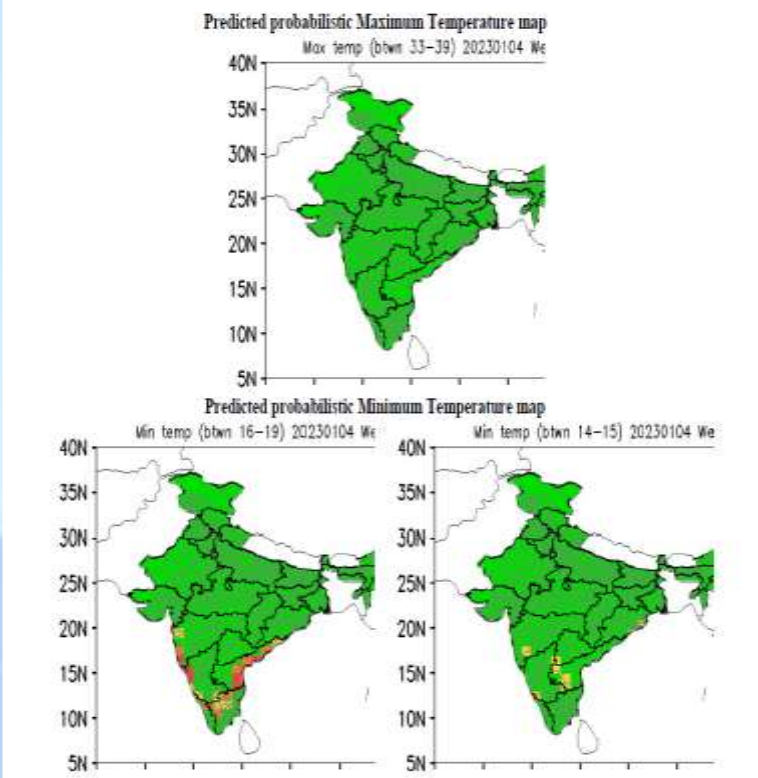
# Climate Publication Section

## Example Products: Drought Monitoring & Prediction Products:

## Example Products: Health Bulletin

Weekly to fortnightly probabilistic outlook for prevalence of transmission window for vector borne diseases

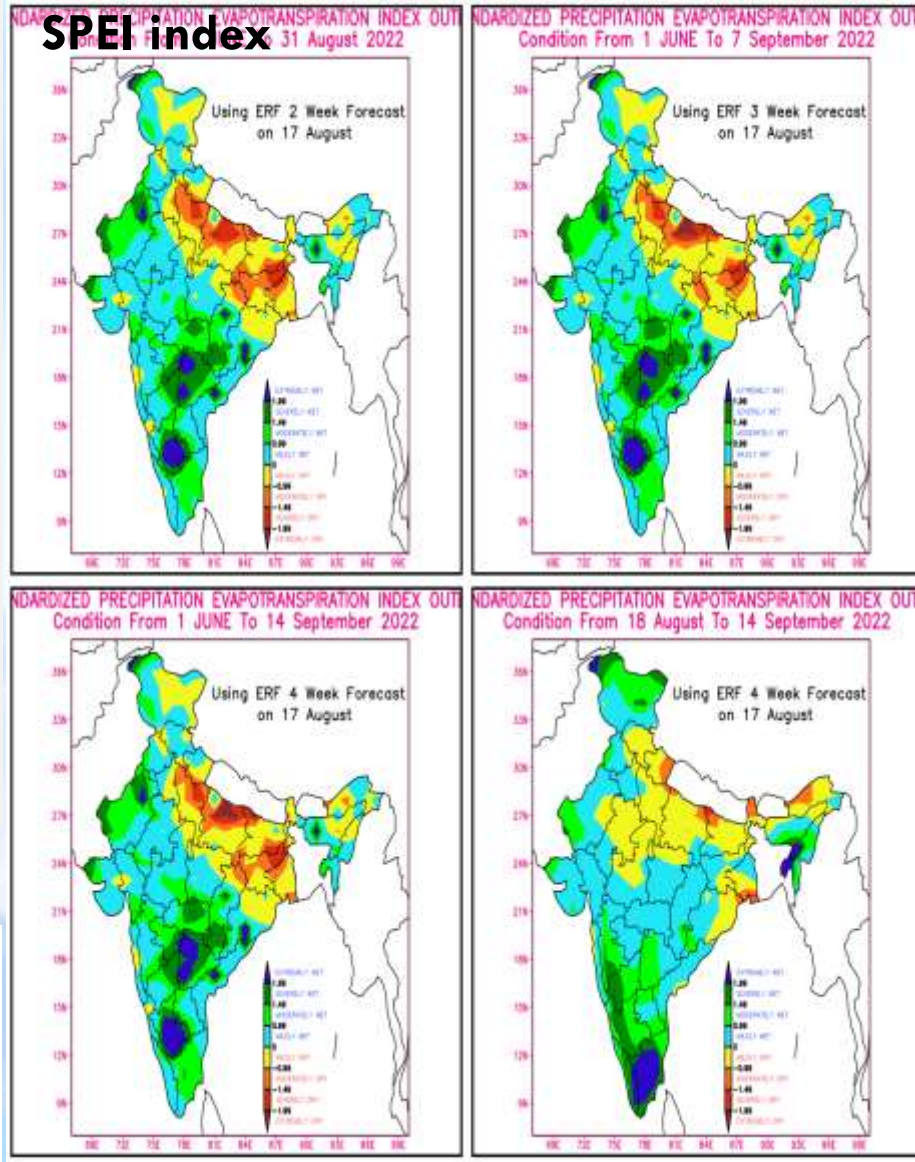
Weekly probabilistic outlook for prevalence of transmission window for Malaria



Probabilistic weekly evolution of transmission window for Malaria (*Plasmodium falciparum*).

Second week (13<sup>th</sup> to 19<sup>th</sup> Jan 2023):

|   |                                |   |
|---|--------------------------------|---|
| 1 | 75 probability level           | Major districts of Goa, some districts of Andhra Pradesh, few districts of Maharashtra, Karnataka and Tamil Nadu. |
| 2 | 55-75 probability level        | Some districts of Andhra Pradesh, Tamil Nadu, few districts of Maharashtra, Karnataka and Kerala.                 |
| 3 | 35-55 probability level        | Some districts of Karnataka, Tamil Nadu, few districts of Maharashtra, Goa, Andhra Pradesh and Kerala.            |
| 4 | Less than 35 probability level | Major districts in rest of states.  |



- Preparation of all district climatological summaries and supply state gazetteer units to publish in respective district gazette.
- Preparation of district summaries as and when requested by state gazetteer units
- Aerodrome climate summary
- Agroclimate summary
- Annual Climate statement
- Climate change report
- Climate of extreme weather events
- Hazard and vulnerability Atlas



# Climate Data

- ❖ Meteorological data from the entire country are received at the National Data Centre (NDC), IMD, Pune.
- ❖ After standard quality check process, these data are archived permanently at NDC.
- ❖ Climatological Normals and other climate products are prepared with the help of these data.
- ❖ The data are also made available to different users including general public through online portal.

## Climate Data Service Portal (CDSP)

- ❖ A portal developed in-house for- Visualisation of weather data recorded by IMD Observatories on real-time.
- ❖ Visualisation of seasonal variation plots of different meteorological parameters.
- ❖ Sharing data of Climatological Tables, Extremes and Normals in tabular and graphical format
- ❖ Information on Monsoon Rainfall, Seasonal Temperature and extreme weather.

<https://cdsp.imdpune.gov.in>

## Data Supply Portal (DSP)

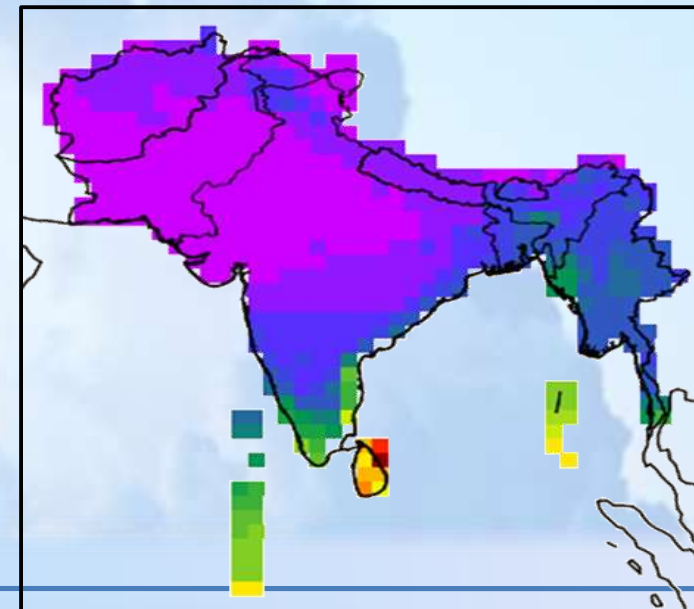
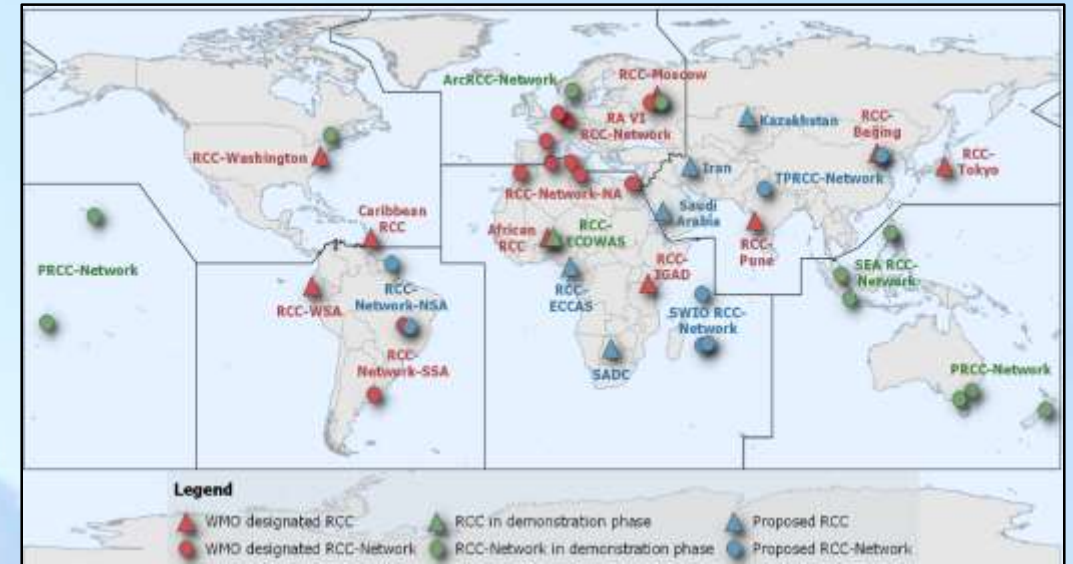
- ❖ IMD's Data Supply Services has been made online from 2019.
- ❖ This portal was developed in-house for online management of all activities related to supply of meteorological data
  - To enhance the efficiency & transparency and
  - To reduce the data delivery time.
- ❖ Four fold increase in number of data requests after the services have been made online.
- ❖ The data delivery time has reduced from days to a few minutes.

<https://dsp.imdpune.gov.in>



# Regional Climate Center (RCC) - Pune

- World Meteorological Organization (WMO) RCCs are centres of excellence that strengthen the capacity of WMO Members in each region to deliver the **best climate services to national users**.
- RCCs perform the following mandatory functions
  - Operational Activities for **Long-range Forecasting**
  - Operational Activities for **Climate Monitoring**
  - Operational **Data Services**, to support operational LRF and climate monitoring
  - **Training** in the use of operational RCC products and services
- RCCs supports **National Meteorological and Hydrological Services (NMHSs)** to generate and deliver up-to-date climate information and products for climate services.



- Afghanistan
- Bangladesh
- Bhutan
- India
- Maldives
- Myanmar
- Nepal
- Pakistan
- Sri Lanka





# Developing an efficient Climate Service in India



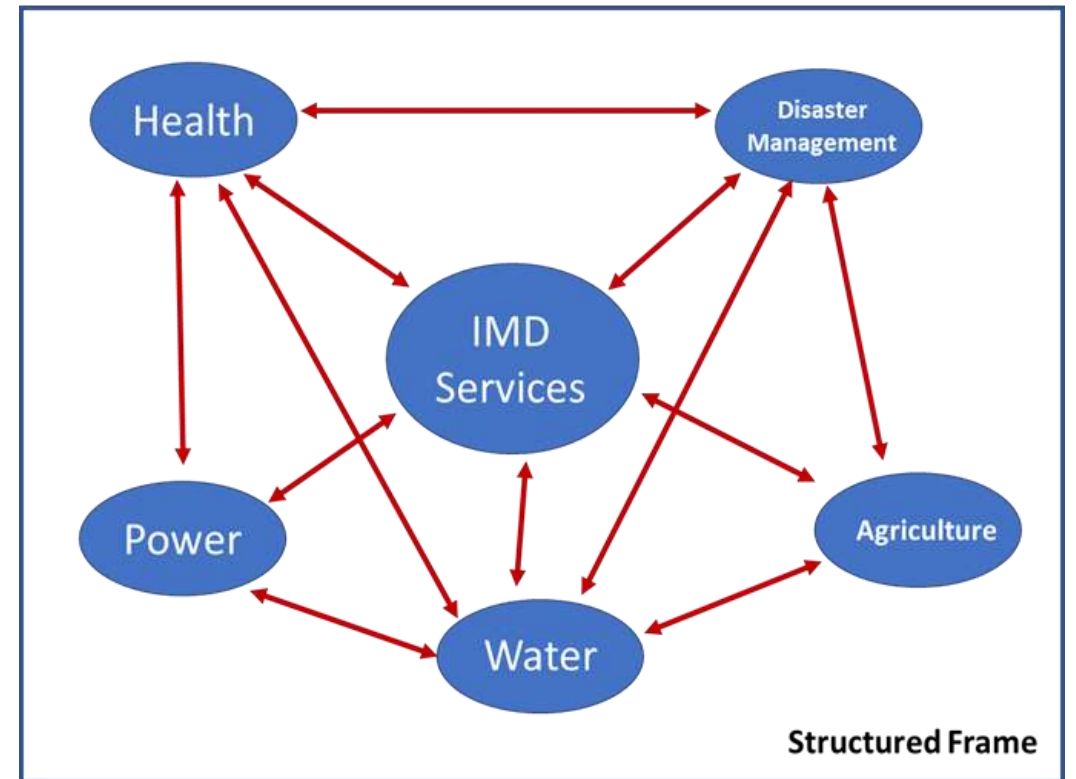
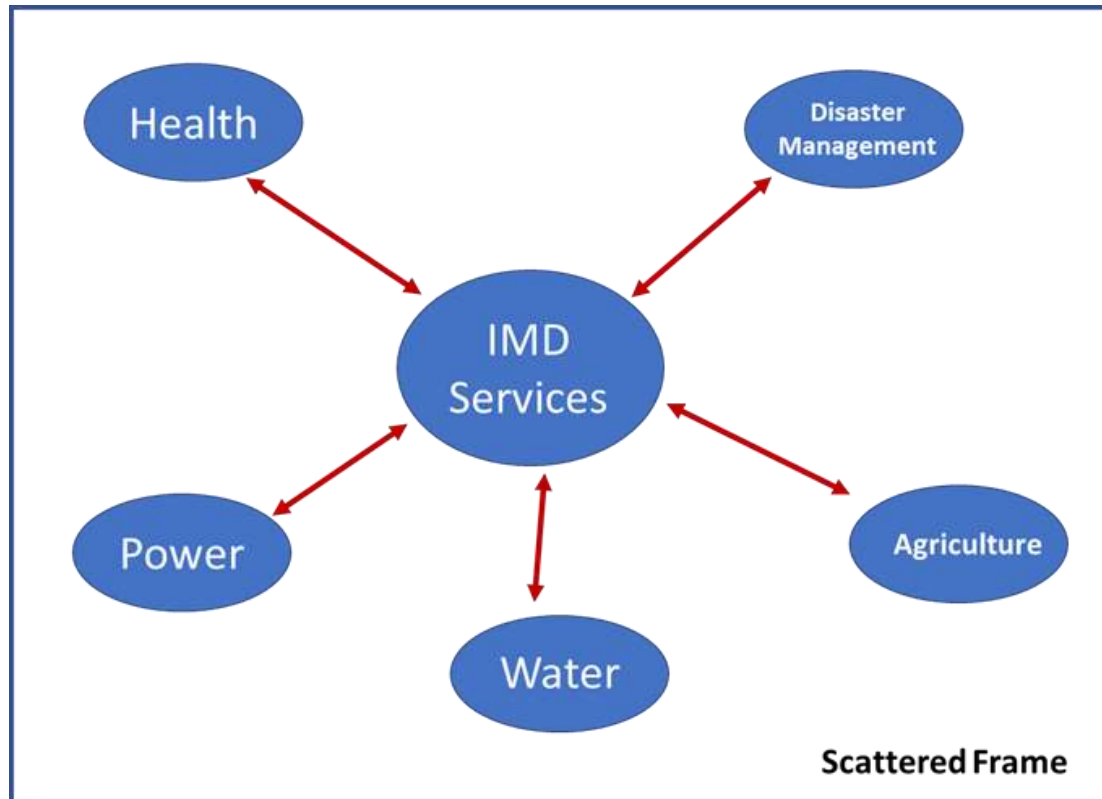
## Few Examples of institutional Success in operational services:

- a. Cyclone Forecast
- b. Severe weather forecast (Heat & cold wave, heavy rain, thunderstorm, lightning)
- c. Impact Based Forecast and warning
- d. Observational Network
- e. The development of multi-hazard early warning systems
- f. NWP, Extended Range and seasonal Forecast

# Towards a Shared and Efficient Future: NFCS India

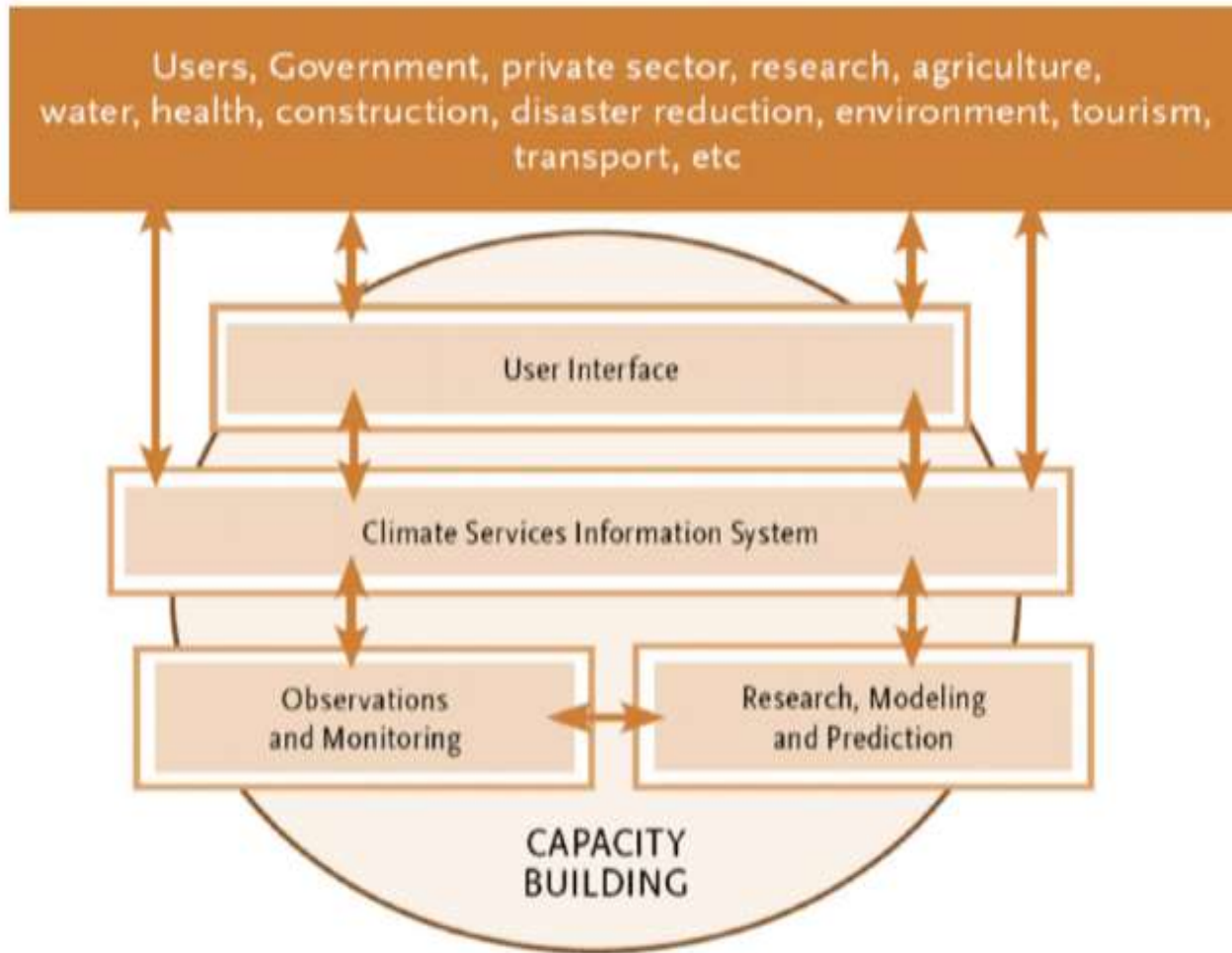
**From**

**To**



# Guideline to formulate NFCS: GFCS

## GFCS Framework



## NFCS Governance cum implementation Framework

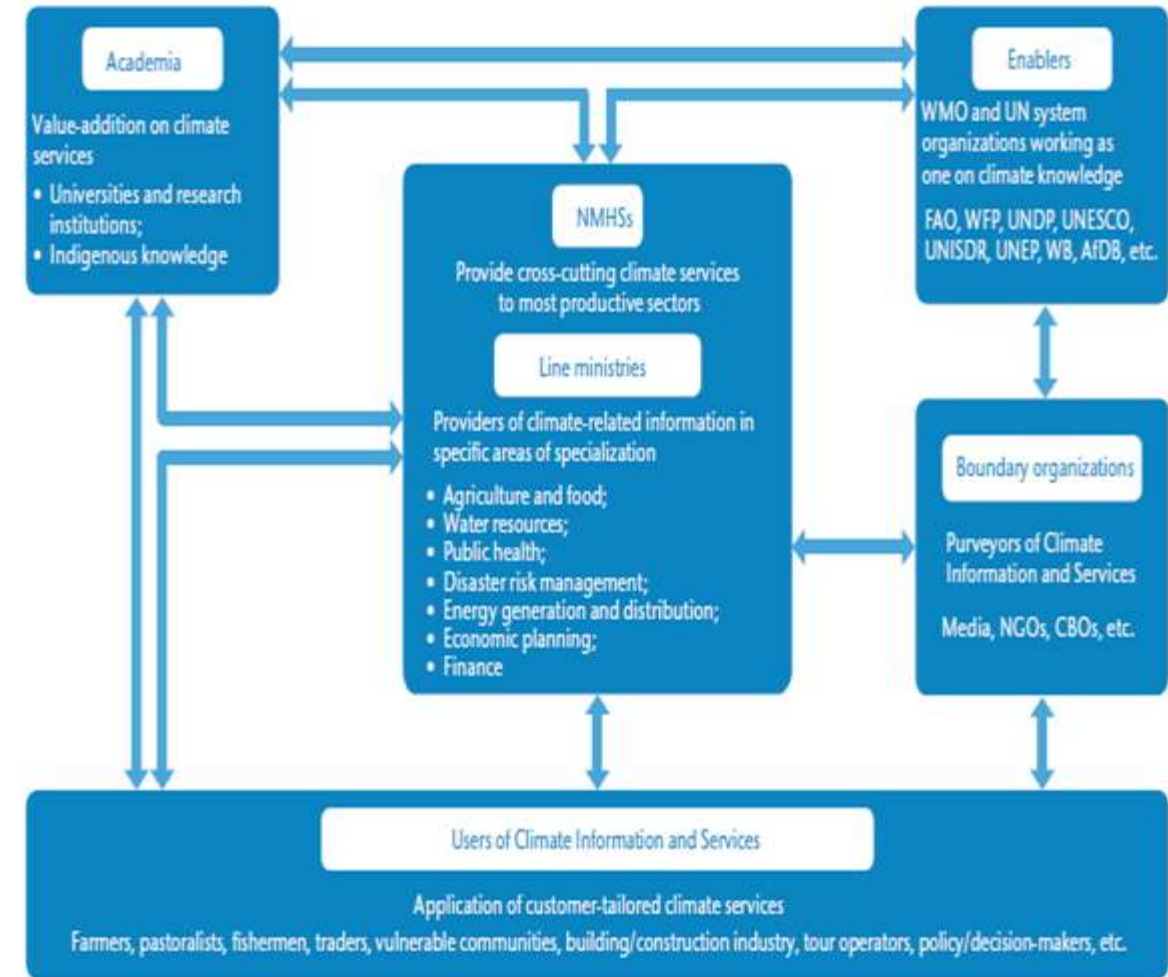


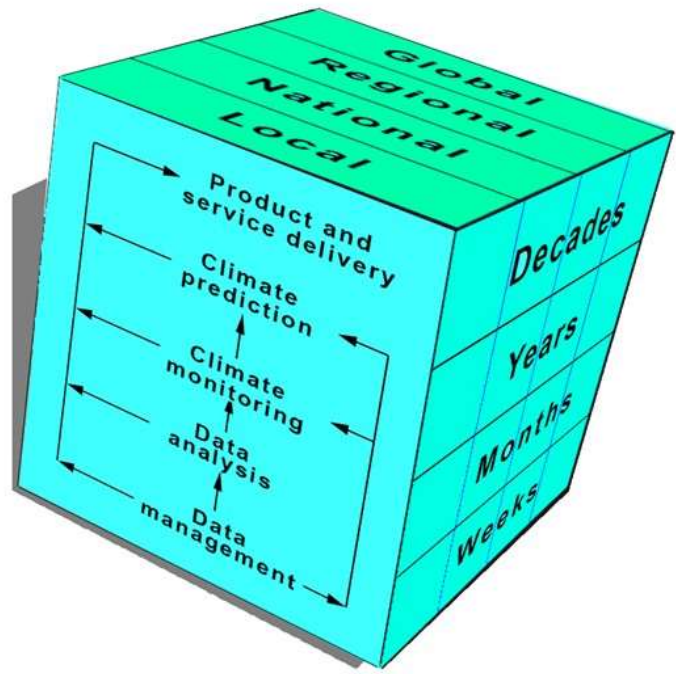
Figure 2: Functional components (pillars) of GFCS (Source: <https://gfcs.wmo.int/>)

# Goals of NFCS India:

1. Reducing the vulnerability of society to climate-related hazards through better provision of climate information and services
2. Advancing the key global development goals through better provision of climate information and services
3. Mainstreaming the use of climate information and services in decision-making
4. Strengthening the engagement of providers and users of climate services
5. Maximizing the utility of existing climate service infrastructure

It's just not technology that needs to evolve, but along with the technology, multi institutional/agencies approach and importantly the governing policies in place by then for well coordinated efforts in ground

**A multi Agency Operational & Easy accessible information-sharing Framework**



Let's join hands