Impact Based Forecasting of Severe Weather

India Meteorological Department

Ministry of Earth Sciences, India

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➢ **Brief to go about Impact Based Forecasting in stages**

➢ **Activities in IMD for the IBF of Severe Weather Events and associated hazards**

- ▪ **Heavy Rainfall episodes**

- **- Common strategy with various Approaches for the IBF of Heavy Rainfall**

- ▪ **Cyclones**

- ▪ **Dynamic IBF for coastal districts of India**

➢ **Way Ahead**

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Impact-Based Forecasting

A fundamental change in focus
From
What the weather will BE
To
What the weather will DO

Weather Extreme → Weather translate into Hazard → Impact Estimation → Response Scenario

Move from
(Information based forecast)

What the weather will *be*:
- -12 cm in 24 hours
- 34 knot winds

Observations + Forecast + Warning

Towards
(Impact based information and Risk based warning)

What the weather will *do*:
- Water logging in low lying areas
- Damage to vulnerable structure

Observations + Forecast + Expected Impacts + Risk based warning

Admirable Beginning of IBF for Heavy Rainfall during monsoon 2021

New Arena of Dynamical IBF is now open for Huge Challenges/Scopes

(iv) Damage expected over south Tamilnadu (Kanniyakumari, Tirunelveli, Thoothukudi and Ramanathapuram districts) and south Kerala (Thiruvananthapuram, Kollam, Pathanamthitta and Alappuzah districts)
- Damage to thatched huts.
- Minor damage to power and communication lines due to breaking of branches.
- Major damage to Kutcha and minor damage to Pucca roads.
- Some damage to paddy crops, banana, papaya trees and orchards.
- Sea water inundation in low lying areas after erosion of Kutcha embankments.

(v) Fishermen warning and Action suggested
- Total suspension of fishing operation during 3rd to 5th December over the areas as mentioned below.
- Fishermen are advised not to venture into southwest Bay of Bengal and along & off east Sri Lanka coast on 3rd December, Comorin Area, Gulf of Mannar and south Tamilnadu-Kerala and west Sri Lanka coasts from 3rd to 4th December, over Lakshadweep-Maldives area & adjoining southeast Arabian Sea from 3rd to 5th December.
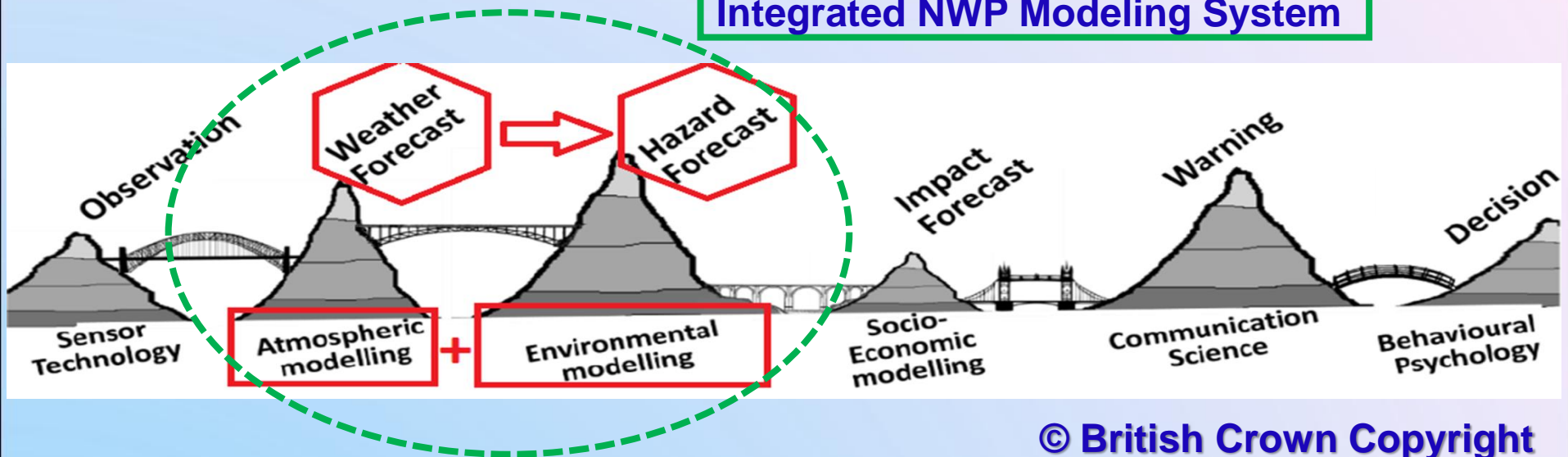
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Modelling in IBF and RBW

Economic concept of a value chain to explore the extended warning production chain

Integrated NWP Modeling System

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Peaks of expertise, valleys of death and bridges of communication between them, in a conceptual value chain for a weather-related hazard warning. Each peak adds value to the process, but value is lost in each valley and the value of warning lead time is lost at every stage of the process.

➤ **Modern NWP systems are combining both weather and hazard forecasts together with a increase of computing resources and advanced hybrid (dynamical, statistical or computational) technologies.**

➤ **Sometimes single system is capable of forecasting multi-hazards over a region with available rich datasets**

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Modeling of hydro-meteorological hazards

- ➤ **Directly from NWP models**
  - ➤ Rainfall – heavy rain episodes/long spell of moderate rain/cloud bursts
  - ➤ Wind – strong wind with gust/Gale, Gust front, CAT for aviation
- ➤ **Program module or application tool to post-process NWP model outputs**
  - ➤ Lightning – hazard for general public, power and aviation sector
  - ➤ Hail – hazard for life, property, transport and agriculture
  - ➤ Fog – hazard for power, transport and aviation hazard, power
  - ➤ Icing – aviation hazard
- ➤ **Hazard Models integrated to NWP models**
  - ➤ Hydrological Model - Flood hazard
  - ➤ Air-quality model - Pollution hazard
  - ➤ Dispersion and trajectory model - Explosion hazard
  - ➤ Wave model – Extreme Sea state condition
  - ➤ Storm surge model

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IBF System through Four Stages in IMD

❖ **Stage-I (Threshold Method)**

Elements are (a) Meteorological threshold, (b) Likelihood of occurrence and (c) Expected impact

❖ **Stage-II (Qualitative combination method)**

Elements are (a) Stage I and (b) Generalized impact based forecast based on ongoing practices.

❖ **Stage-III (Impact Model method)**

Elements are (a) Stage I and Stage II, (b) Climatological data of past impact based on different thresholds and (c) Climatological impact expected

❖ **Stage-IV (Climate Sensitivity Method)**

Real time dynamical impact based forecast and risk based warning using (a) Stage I, II & III, (b) Real time information on - Meteorological Hazard, Geophysical hazard, Geo reference Coordinate and Socio economic indicators in digital form and (c) Decision Support System

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IBF of Heavy Rainfall in IMD

- ➤ **Before 2020**
  - ➤ Change in forecast paradigm by the head (DGM) of NMHS (IMD)- from Weather Forecasting to Impact Based Forecasting
  - ➤ Formation of functional group on IBF of Heavy Rainfall: Operational all India implementation

- ➤ **During Monsoon-2020**
  - ➤ Within stringent data limitations, the experimental IBF started for 25 major cities and a few districts. (COVID-19 time)
  - ➤ First SOP (with 4 stages) for real-time IBF

- ➤ **During 2021 (Partially Dynamic IBF without expert systems or DSS)**
  - ➤ All districts (or clusters) throughout India are covered and continued improvement of ongoing real-time IBF - **modification of bulletin format and SOP**
  - ➤ **Data collection drive (climatology, geophysical, exposure, vulnerability maps and etc.)**

- ➤ **During 2022 - Journey towards Dynamic IBF and automation**
  - ➤ **GIS Integration of the data**
  - ➤ **Mapping/Layering/merging for easy decision making algorithms → Decision Support System (DSS) development**

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IBF of Heavy Rainfall Flow

Data Module

Scenarios & Extremes
Obs. cumulative 3 & 24 hrs/SAFFGS maps

Analysis	Point distribution	Cum. D1+D2, D1+D2+D3, … D1+D2+D3+D4+D5
Actual, Normal & Departure		

All Current Observations
Surface & Upper-Air

Satellite-QPE

Radar-QPE

Forecasts
NWP Models-DMO D1,D2,D3,D4,D5 D1+D2, D1+D2+D3, …, D1+D2+D3+D4+D5

Final Forecasts D1,D2,D3,D4,D5

+

IBF Module

Climatology of extremes

Hazard information (Past + Current)
Suitable combination of D1, D1+D2, D1+D2+D3, D1+D2+D3+D4, D1+D2+DD4+D5

Geo-physical	Socio-economic	Vulnerability

Production Module
Standardize SOP

Sector Specific Products
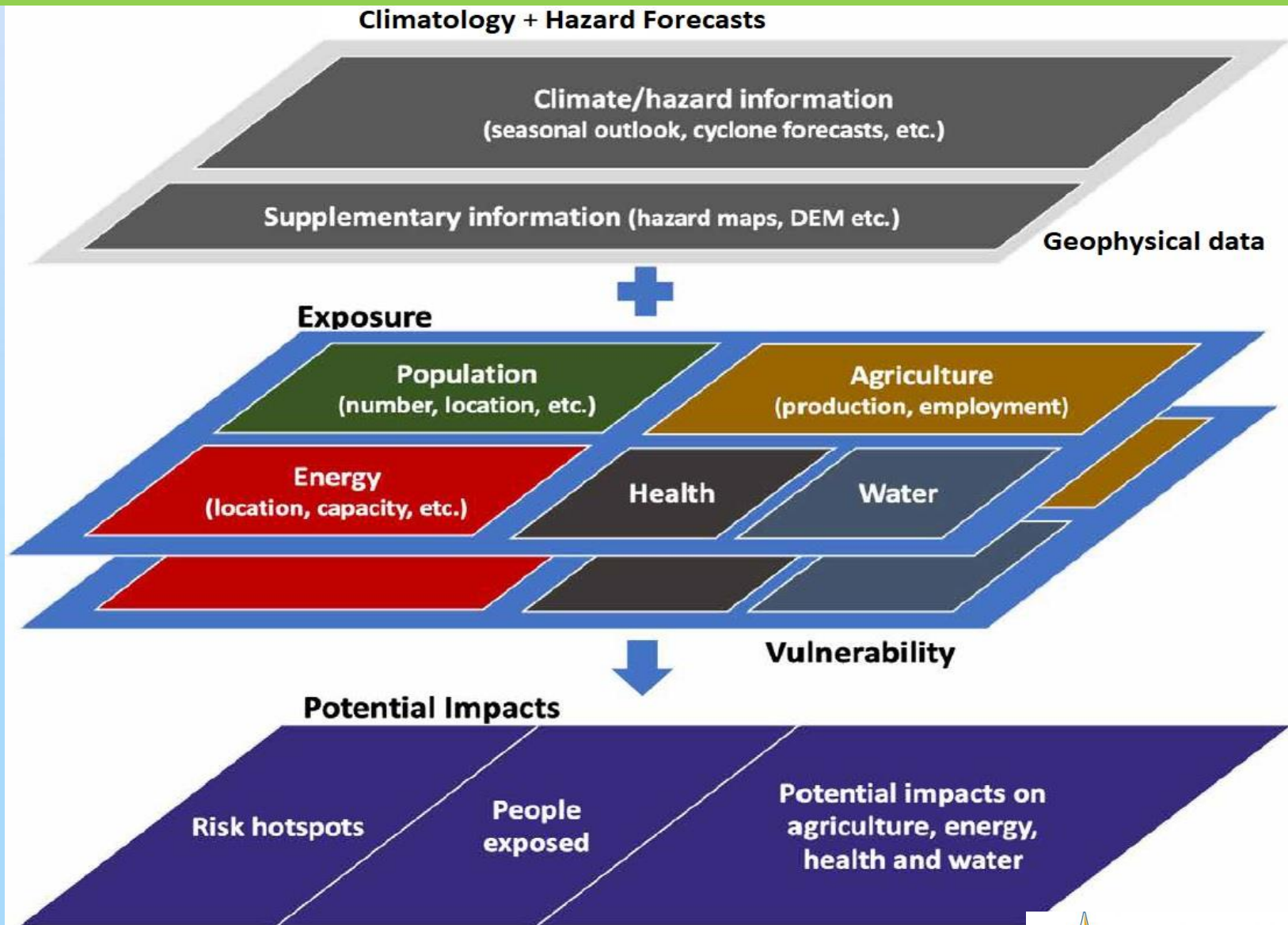
Customized Bulletins

Dissemination/Communication Module

Capacity Building & Feedback Module

Archival & Verification Module
Documentation/Archival of data/records

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IBF Module

Data required

- ❖ **Administrative layers (State, district, city, ward boundary etc)**
- ❖ **Digital Elevation Model Data**
- ❖ **Land Use Land Cover Data**
- ❖ **Rainfall Data (Station and interpolated)**
- ❖ **Infrastructure layers (Rail, Road, Buildings, etc)**
- ❖ **Demographic Data (Population, etc)**
- ❖ **Major Point of Interest Data (POI)**

- School, college, hospital, Airport, bus stand, communication towers, Major industries, water resources structures, shelters, etc.

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Various Exposures: Presented in GIS layers
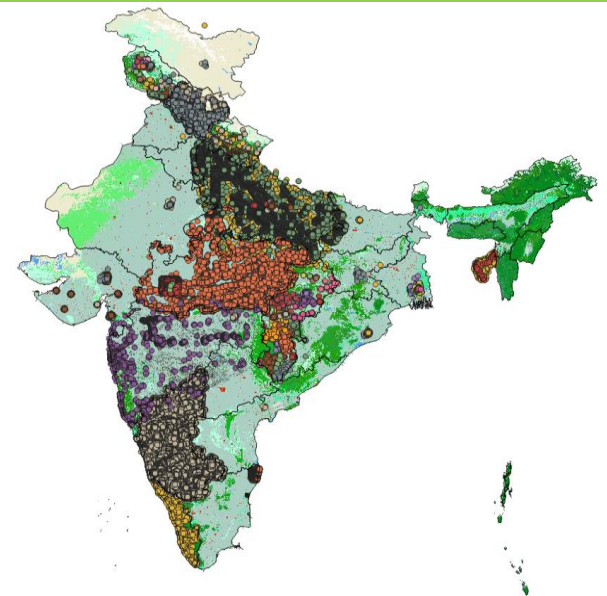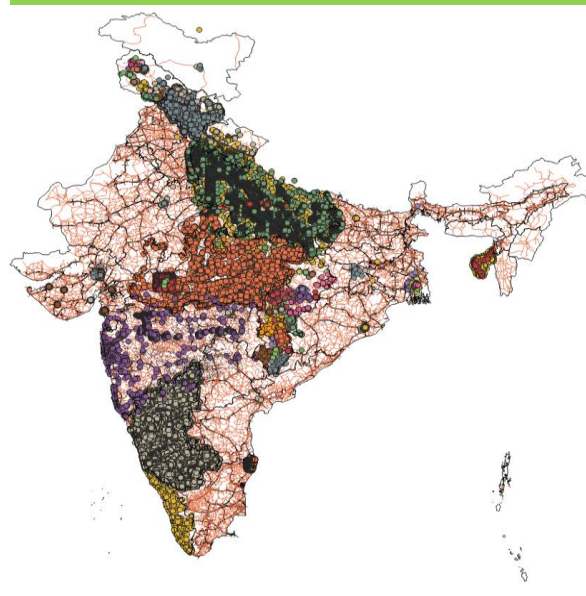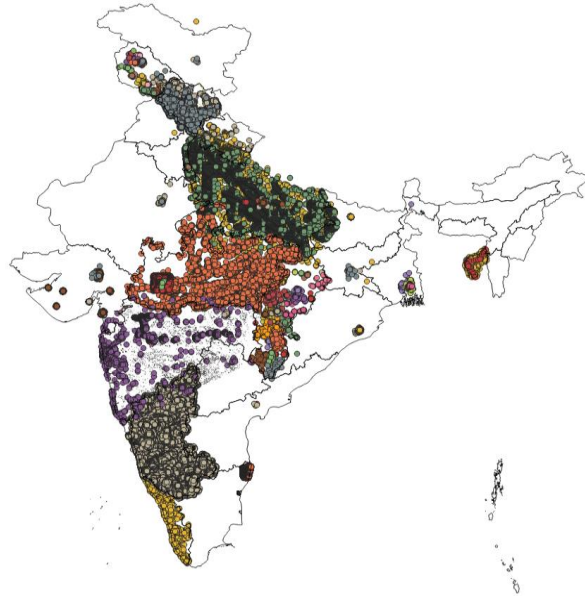
Legend (left maps):
- Tourism
- Sports
- School, University & College
- Railway
- Hospital
- Airport
- Hotel
- A_Water Body
- Road_Network
- Railway_line

Open Source Dataset - PAN India
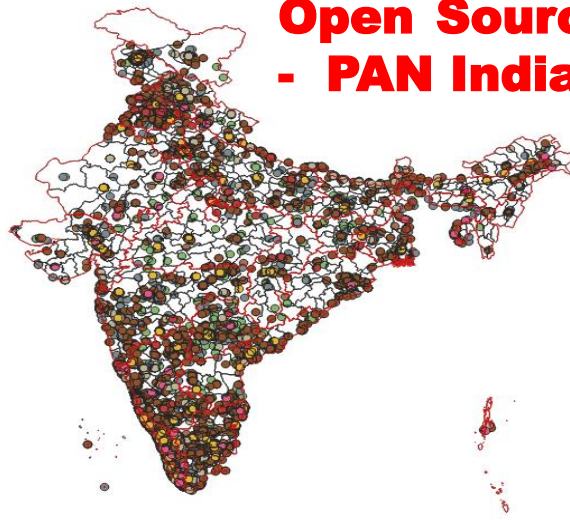
Legend (bottom map):
- Admin2
- 2011_Dist
- zoo_osm
- university_osm
- stadium_osm
- shelter_osm
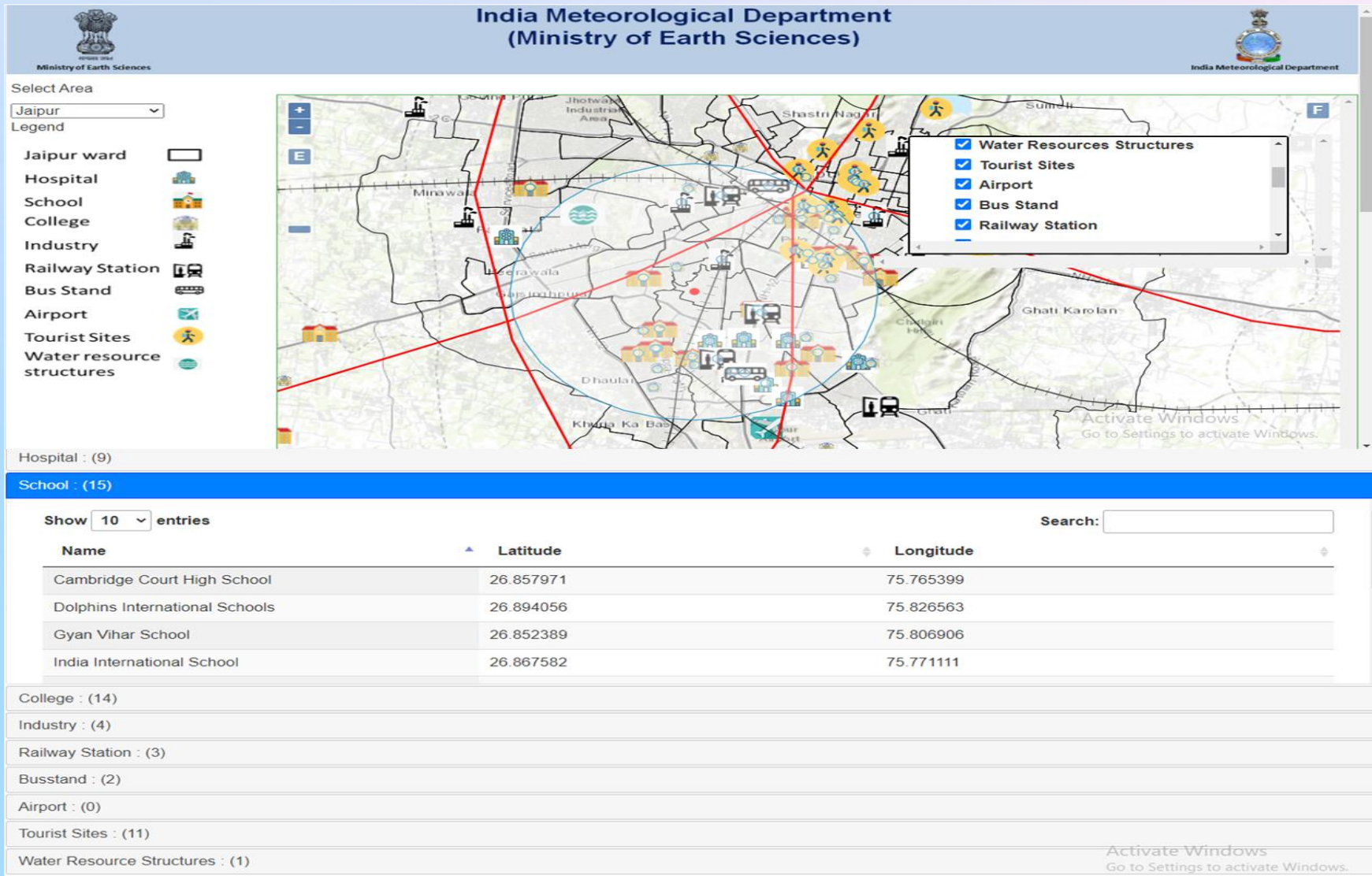- school1_osm
- hospital_osm
- comm_tower
- college_osm

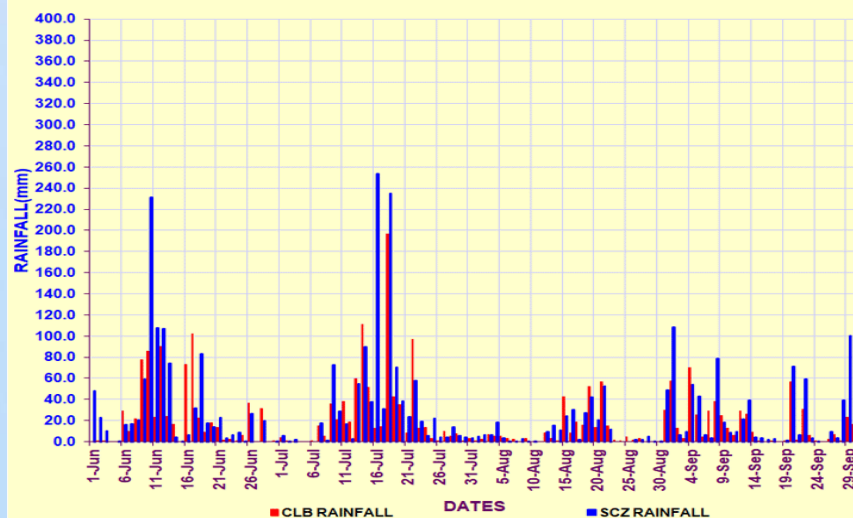# Web-GIS based portal for Impact base forecasting: A prototype

Integrated FLood Warning System (IFLOWS)-MUMBAI

❑ **Developed by:** Ministry of Earth Sciences (MoES), in coordination with the Municipal Corporation of Greater Mumbai (MCGM).

❑ **Working:** Comprises of 7 modules
- **Data assimilation**
- **Flood & inundation**
- **Vulnerability**
- **Risk**
- **Dissemination**
- **Decision Support System (DSS)**

❑ Weather forecasts from **NCMRWF & IMD** and field data from the rain gauge network stations.

Benefits: This will boost the city's resilience by providing early warning for flooding specially during high rainfall events and cyclones.

❑ **GIS based DSS**
- Land topography, land use, infrastructure, population, lakes, creeks
- River **bathymetry** of all rivers (Mithi, Dahisar, Oshiwara, Poisar & Ulhas.

❑ The system has provisions to capture the city drainage data and predict the areas of flooding.

DAILY RAINFALL OVER MUMBAI FROM JUNE 2021
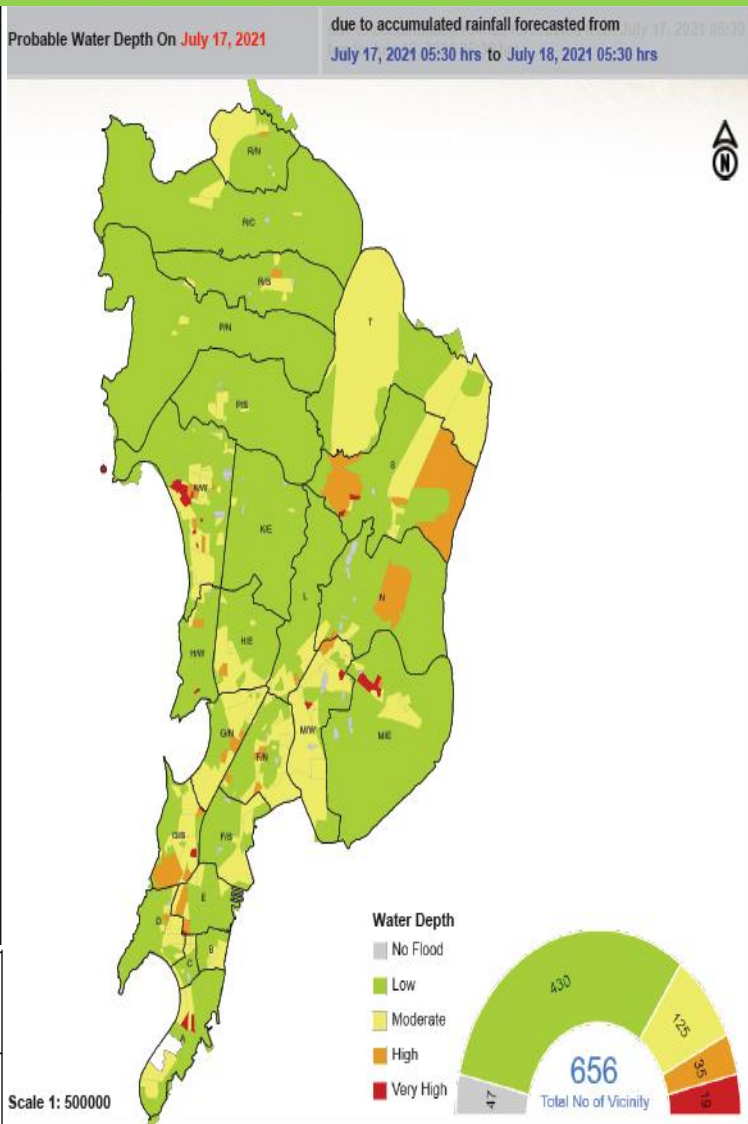
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Integrated FLood Warning System (IFLOWS)-MUMBAI

Rainfall Realised at 0300 hrs IST of 18 July 2021 (from 0830 hrs IST of 17 July 2021)	Mumbai city and suburbs experienced intense to very intense spell of rainfall during past 3 hrs. Colaba (AWS) –174.5 mm, Santacruz -213 mm, Juhu Airport- 197.5mm, Bandra -197.5 mm, Bhayander -164.5mm, Ram Mandir -171.5mm , Mahalaxmi – 154.5mm
Forecast for next 3-4 hrs	As per latest observations, Mumbai city and suburbs are very likely to experience intense to very intense spells of rainfall (greater intensity towards northern parts of suburbs) during next 3-4 hours. Possibility of thunder/lightning and gusty winds in some areas.
Warning for 24 hours (from 0830 hrs of the day to 0830 hrs of next day)	Heavy to very heavy rainfall at a few places with extremely heavy rainfall at isolated places Possibility of thunder/lightning and gusty winds.
Impact Expected	• Water logging/inundation in most parts of low lying areas and river banks • Disruption to road, rail, air and ferry transport. Major roads and local trains affected. • Possibility of flash floods coinciding with high tide. • Local disruption of municipal services (Water, electricity etc.) • Flow of water over low-lying roads and bridges. • Possibility of danger to very old buildings and unmaintained structures • Occasional gusty winds with speed reaching 45-55 gusting to 60 kmph along and off the coast resulting in possibilities of damage to vulnerable /temporary structures. • Landslide/Mudslides and rock falls in vulnerable areas.
	• Rough Sea conditions along the coast. • Possibility of cloud to ground lightning.
Action Suggested	• Traffic may be regulated effectively • People staying in vulnerable places may take caution.

Probable Water Depth On July 17, 2021

due to accumulated rainfall forecasted from July 17, 2021 05:30 hrs to July 18, 2021 05:30 hrs

Water Depth
- No Flood
- Low
- Moderate
- High
- Very High

Scale 1: 500000

430 / 125 / 35 / 19 / 47
656 Total No of Vicinity

S.No	Ward Name	Vicinity Name	First Respondent Number	Vulnerability
1	S	Lake Side Area	1234567890	VERY HIGH
2	S	Mhada Clny 19	1234567890	VERY HIGH
3	R/N	K/W	1234567890	VERY HIGH
4	M/W	Subhas Nagar (Chembur)	1234567890	VERY HIGH
5	M/W	Lav Kush Society	1234567890	VERY HIGH
6	M/E	Four Bunglows	1234567890	VERY HIGH
7	M/E	Municipal Colony	1234567890	VERY HIGH
8	K/W	Four Bunglows	1234567890	VERY HIGH
9	K/W	Four Bunglows	1234567890	VERY HIGH
10	K/W	Gulmohar Colony	1234567890	VERY HIGH
11	K/W	Ashok Nagar (Juhu)	1234567890	VERY HIGH
12	K/W	Vithal Nagar (Juhu)	1234567890	VERY HIGH
13	H/W	Vaidya Nagar (Bandra West)	1234567890	VERY HIGH
14	G/S	Dighe Nagar (Parel)	1234567890	VERY HIGH
15	G/S	BDD Chawl Lower Parel	1234567890	VERY HIGH
16	E	Siddharth Nagar	1234567890	VERY HIGH
17	A	Mantralaya	1234567890	VERY HIGH
18	A	Church Gate	1234567890	VERY HIGH
19	A	Church Gate	1234567890	VERY HIGH
20	S & M/W	Tilak Nagar, Kurla East	1234567890	HIGH
21	S	Vikhroli East	1234567890	HIGH
22	R/S	Samata Nagar	1234567890	HIGH
23	R/N	CS Complex	1234567890	HIGH
24	N	Vikhroli East	1234567890	HIGH

S.No	Ward Name	Vicinity Name	First Respondent Number	Vulnerability
53	D	Talmakidi, Tardeo	1234567890	HIGH
54	D	Talmakidi, Tardeo	1234567890	HIGH
55	T	Mulund East	1234567890	MODERATE
56	S	Panchkutir Ganesh Nagar	1234567890	MODERATE
57	S	MHADA Colony Tagore Nagar (Vikhroli East)	1234567890	MODERATE
58	S	Bhandup East	1234567890	MODERATE
59	S	Hariyali	1234567890	MODERATE
60	S	Ashok Nagar (Vikhroli East)	1234567890	MODERATE
61	R/S	Alika Nagar	1234567890	MODERATE
62	R/S	Mahindra & Mahindra	1234567890	MODERATE

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Integrated FLood Warning System (IFLOWS)-CHENNAI
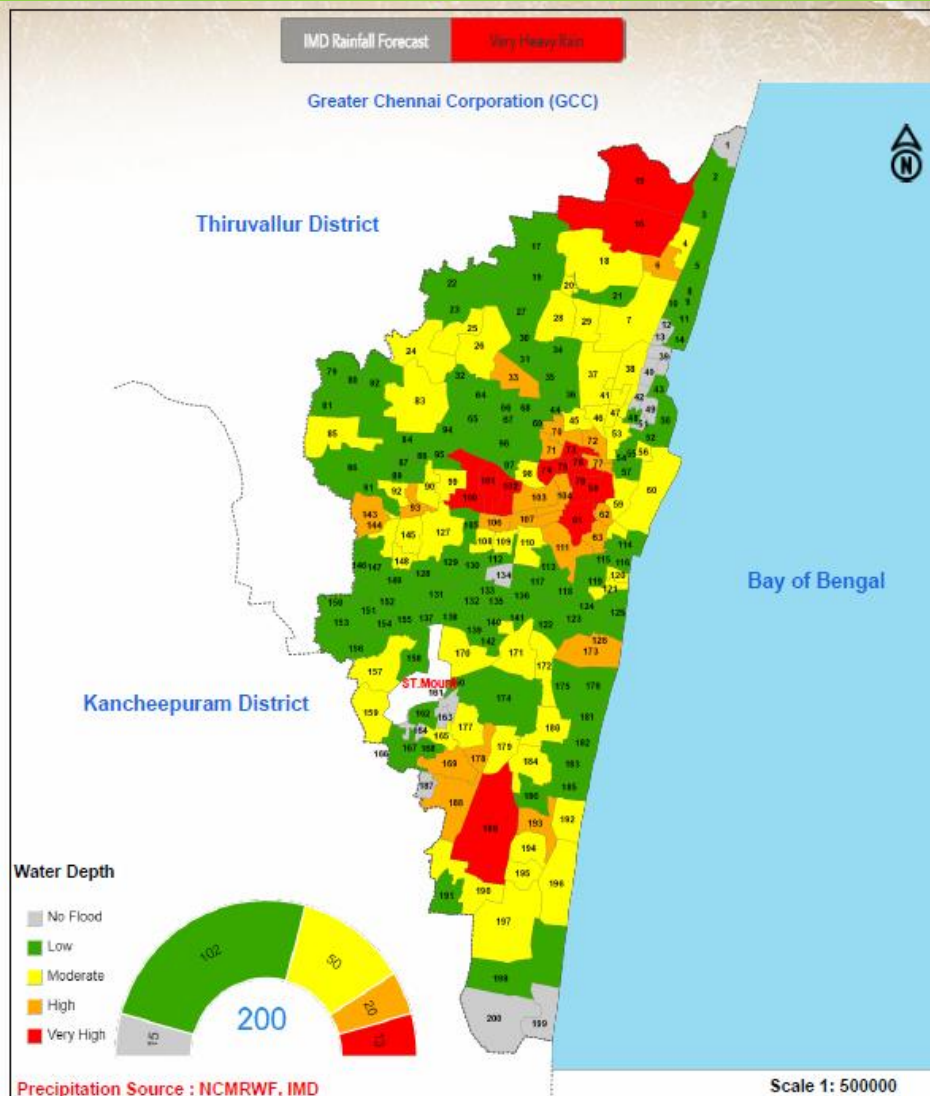
S.No	Ward Number	Zone Name	First Respondent Number	Vulnerability
1	189	PERUNGUDI	9445467189	VERY HIGH
2	102	ANNANAGAR	9445467102	VERY HIGH
3	101	ANNANAGAR	9445467101	VERY HIGH
4	100	ANNANAGAR	9445467100	VERY HIGH
5	78	THIRU-VI-KA-NAGAR	9445467078	VERY HIGH
6	76	THIRU-VI-KA-NAGAR	9445467076	VERY HIGH
7	75	THIRU-VI-KA-NAGAR	9445467075	VERY HIGH
8	74	THIRU-VI-KA-NAGAR	9445467074	VERY HIGH
9	73	THIRU-VI-KA-NAGAR	9445467073	VERY HIGH
10	61	ROYAPURAM	9445467061	VERY HIGH
11	58	ROYAPURAM	9445467058	VERY HIGH
12	16	MANALI	9445467016	VERY HIGH
13	15	MANALI	9445467015	VERY HIGH
14	193	SOZHINGANALLUR	9445467193	HIGH
15	188	PERUNGUDI	9445467188	HIGH
16	178	ADYAR	9445467178	HIGH
17	173	ADYAR	9445467173	HIGH
18	169	PERUNGUDI	9445467169	HIGH

S.No	Ward Number	Zone Name	First Respondent Number	Vulnerability
27	72	THIRU-VI-KA-NAGAR	9445467072	HIGH
28	71	THIRU-VI-KA-NAGAR	9445467071	HIGH
29	70	THIRU-VI-KA-NAGAR	9445467070	HIGH
30	63	ROYAPURAM	9445467063	HIGH
31	62	ROYAPURAM	9445467062	HIGH
32	33	MADHAVARAM	9445467033	HIGH
33	6	THIRUVOTTIYUR	9445467006	HIGH
34	197	SOZHINGANALLUR	9445467197	MODERATE
35	196	SOZHINGANALLUR	9445467196	MODERATE
36	195	SOZHINGANALLUR	9445467195	MODERATE
37	194	SOZHINGANALLUR	9445467194	MODERATE

Layer Name	Total	Moderate	Heavy	Extremely Heavy
ATM	12	9	1	2
Bank	27	14	10	3
College	5	3	0	2
Fuel	35	21	12	2
Hall	1	1	0	0
Health_Care	45	20	14	11
Police_Station	18	10	5	3
Power_Station	0	0	0	0
Railway_Station	82	53	15	14
School	28	22	3	3
University	1	1	0	0
Workship	83	54	20	9

Description of Flash Flood Guidance System Products

Flash Flood Guidance Model runs every six hours and product updates available at 00,06,12 and 18 UTC.

Diagnostic Products

MWGHE – NOAA/NESDIS Microwave-adjusted Global Hydro Estimator Satellite-based CMORPH Precipitation Estimates (Every Hourly);

GHE – NOAA/NESDIS Global Hydro Estimator Satellite Cloud Top Brightness Temperature (Infrared (IR) based) Precipitation Estimates (Every Hourly);

GMAP - Gauge Mean Areal Precipitation (Every 3 Hourly);

Merged MAP - Merged Mean Areal Precipitation (Every Hourly);

ASM – Average Soil Moisture (Every 6 Hourly) (SAC-SMA model)

FFG Products

FFG – Flash Flood Guidance Value (Every Hourly)

IFFT - Imminent Flash Flood Threat (Every Hourly)

PFFT - Persistence Flash Flood Threat (Every Hourly)
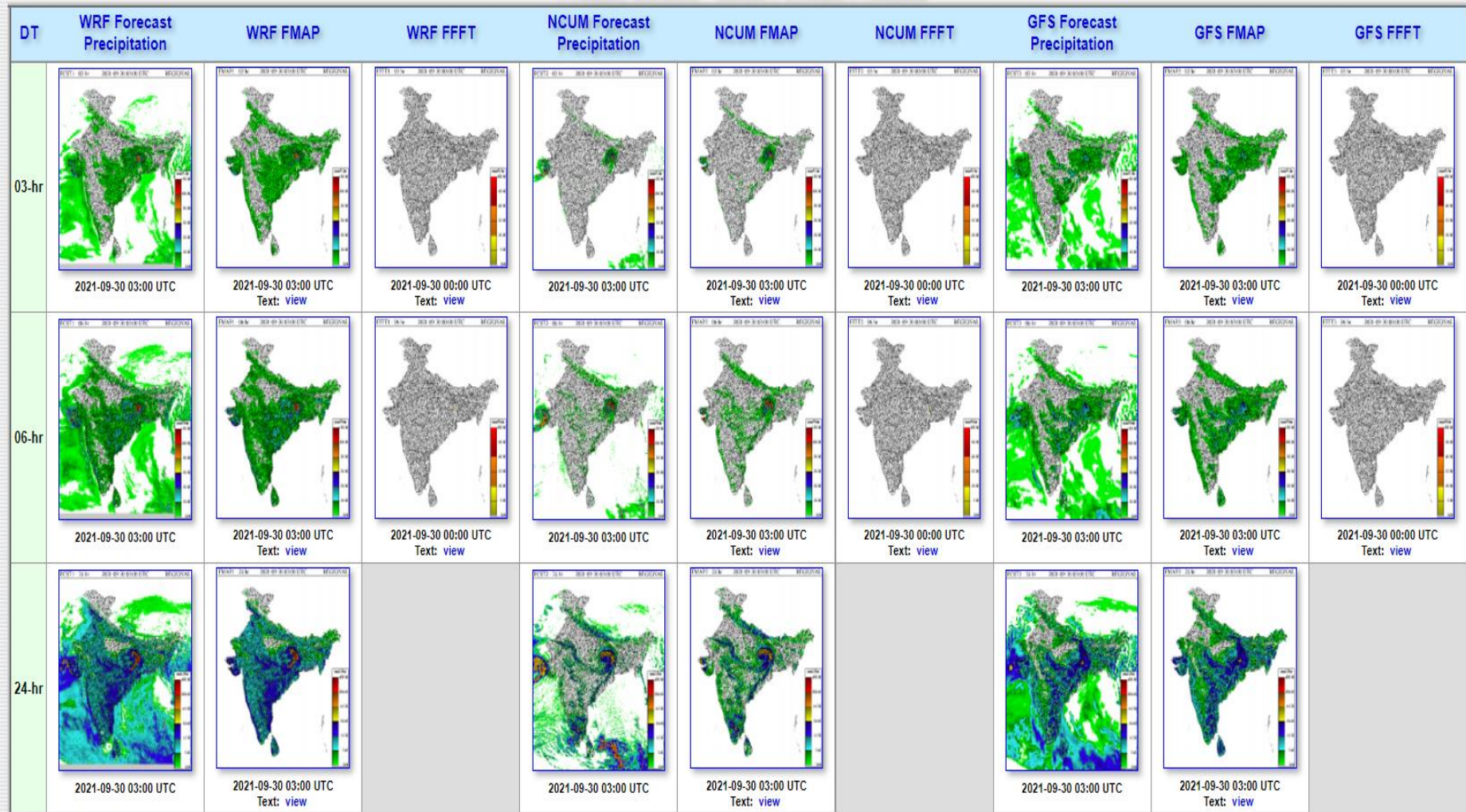
*Validity is for next 6 hours

Forecast Products
(WRF, NCUM, GFS)

Forecast - Model Precipitation Forecast (Every 3 Hourly)

FMAP - Forecast Mean Areal Precipitation (Every 3 Hourly)

FFFT - Forecast Flash Flood Threat (Every 6 Hourly)

FFR - Flash Flood Risk (12, 24 and 36 hours product)

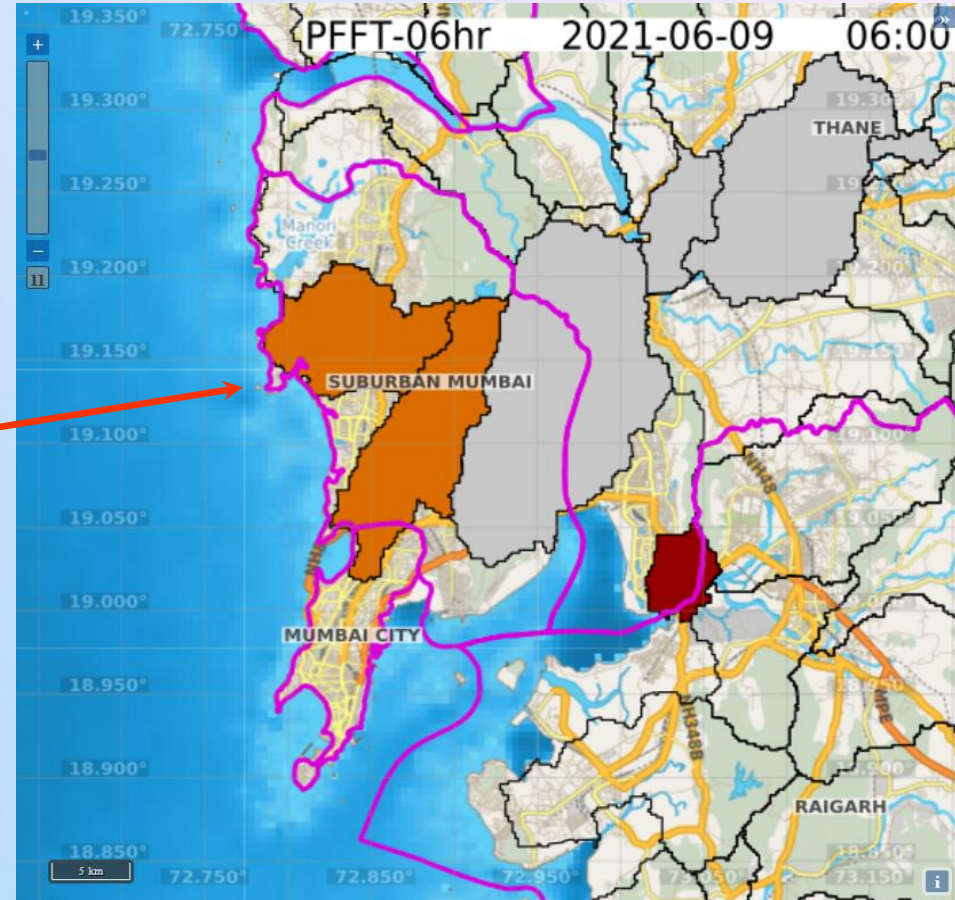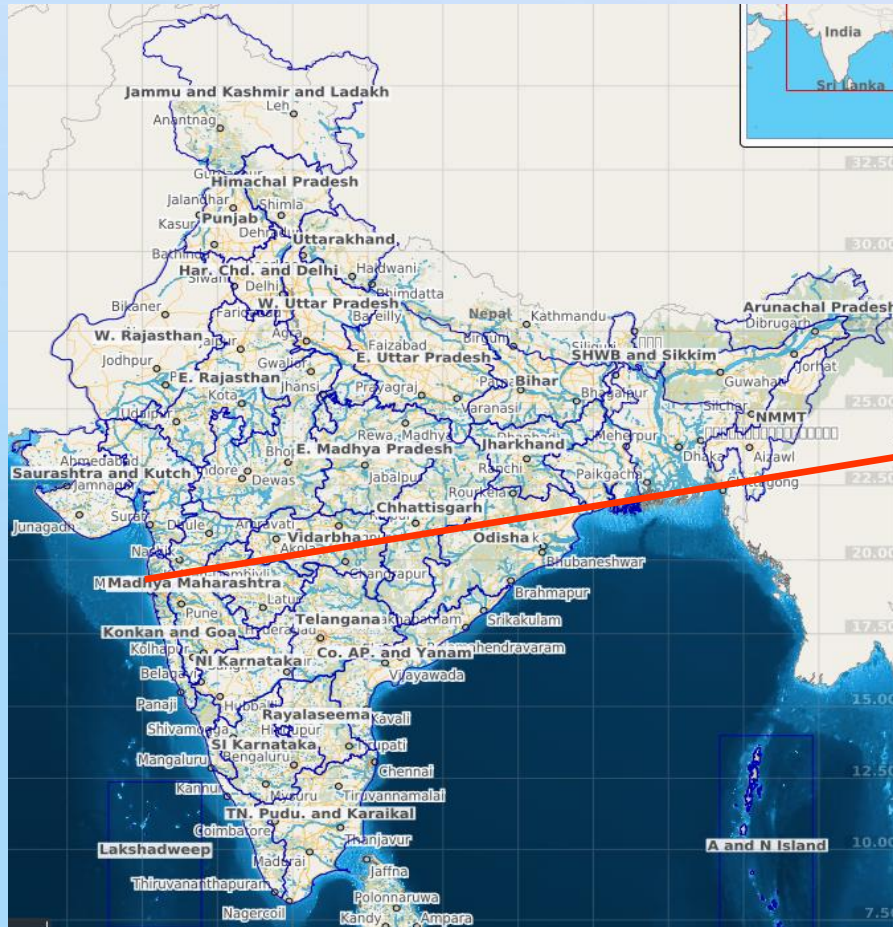***CMORPH is based on microwave scattering from hydrometeors**

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South Asia Flash Flood Guidance System Products

RSMC New Delhi Training Programme on Tropical Cyclone Monitoring and Forecasting (ONLINE, 04th to 14th April, 2022)

South Asia Flash Flood Guidance System Products

South Asia Flash Flood Guidance System Products

Mumbai & Neighborhoods Event Dt 09.06.21 : Hydro meteorological Trigger

Soil is fully saturated up to 99 % based on past 06 hours observations

Persistent Heavy Rainfall up to 11 cm observed from IMD RG stations in 24 hours
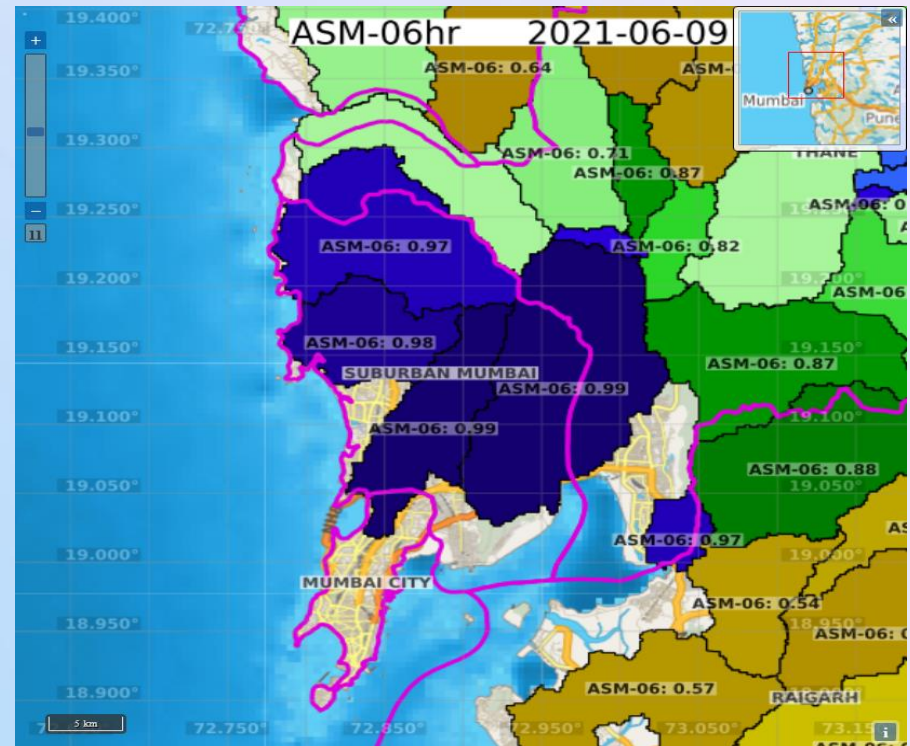
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South Asia Flash Flood Guidance System Products

Mumbai & Neighborhoods Event Dt 09.06.21 : Hydro meteorological Trigger

Moderate to High threat alert prevails over watersheds & neighbourhoods

FFG is minimum and lowest up to 24.76 mm/1hr indicates surface runoff at any moment with persistent rainfall

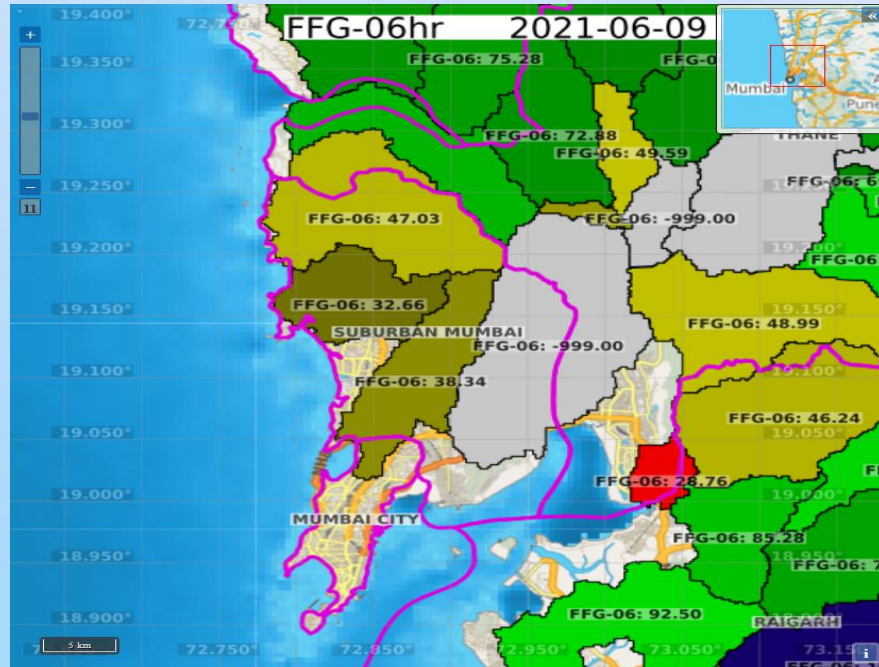*RSMC New Delhi Training Programme on Tropical Cyclone Monitoring and Forecasting (ONLINE, 04th to 14th April, 2022)*
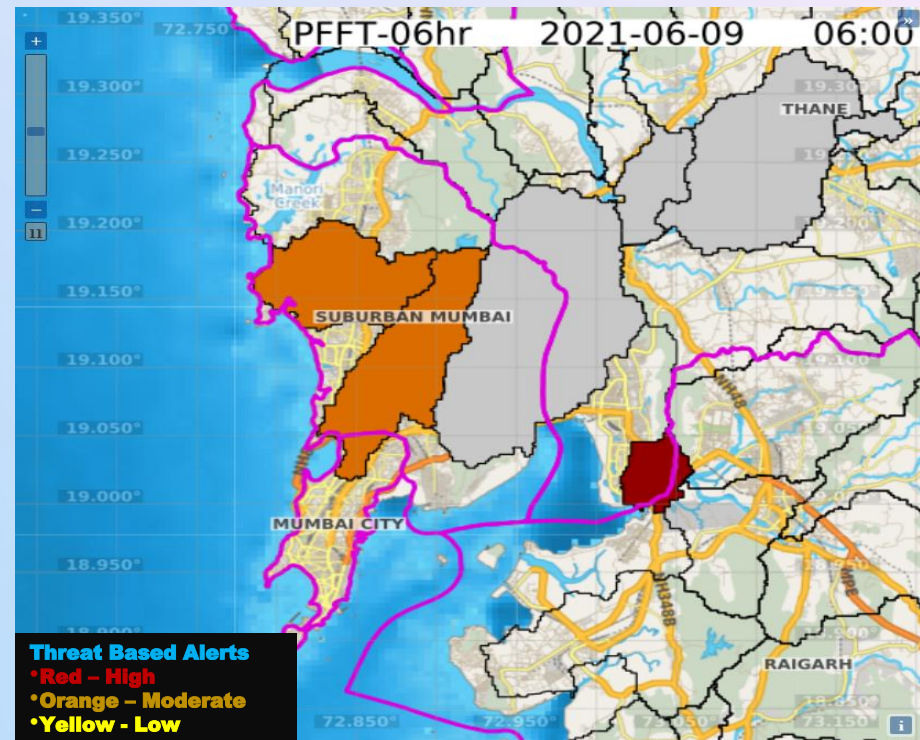
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Issued Bulletin

GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT
HYDROMET DIVISION
FLASH FLOOD GUIDANCE CELL

Persistent Flash Flood Threat (PFFT)
Till 1730 IST of 09.06.2021:

Moderate to High flash flood threat over Some watersheds and neighborhoods of Suburban Mumbai, Thane and Raigarh districts of Konkan and Goa Subdivision.

24 hours Outlook for Flash Flood Risk
Till 1130 IST of 10.06.2021:

Moderate Flash Flood Risk over Some watersheds and neighborhoods of northern part of Konkan and Goa subdivision.

Note: Next Bulletin will be issued based on 1730 IST of 09.06.2021.

Stationwise Rainfall Distribution (mm)
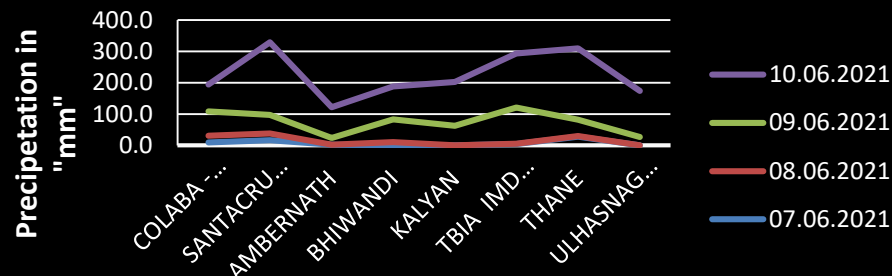
Realised situation

Paresh M Kanade @PareshKanade96 · Jun 9, 2021
#MumbaiRains #Monsoon2021
Waterlogged in low lying areas due to Heavy Rainfall in Mumbai.
Photo by Paresh Kanade.
@Hosalikar_KS @SanjayJog7 @bbcnewsmarathi @IndiaWeatherMan @mumbaimatterz @RoadsOfMumbai @richapintoi @ss_suryawanshi @rajtoday

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Dynamic Impact Based Forecasting of Cyclone

Scenario: Cyclone Amphan, Run 1, (2030 hrs IST, 17 May 2020) Odisha

Analysis Level	State
State Name	Odisha
Hazard Type	Wind
Model/Scenario	Historical / Amphan
Study Area	Upto 10 Meter Elevation
Exposures Analysed	Residential Buidings, Commercial Buidings, Industrial Buidings, Fire Stations, Hospitals, Police Stations, Cyclone Shelters, Schools, Airports, Bridges, Railway Stations, Railway Lines, Roads, Seaports, Communication Channels, Electric Lines, Potable Water, Waste Water, Power Plants, Oil And Gases

Scenario

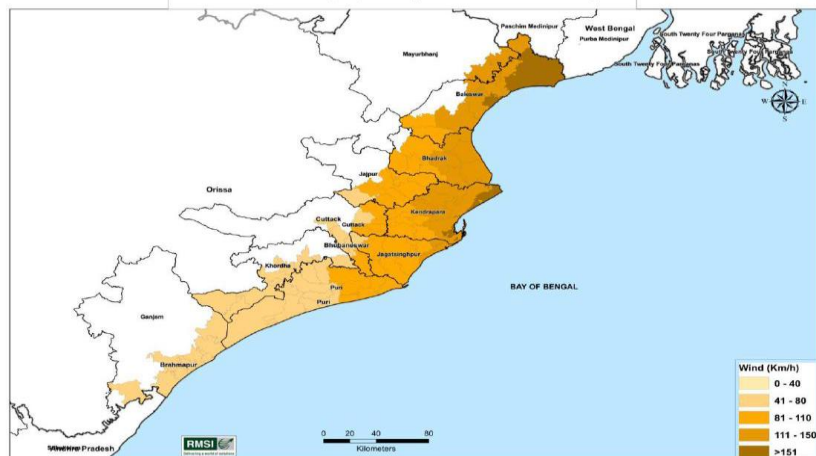|	
Analysis Level	State
State Name	West Bengal
Hazard Type	Flood
Model/Scenario	Amphan
Study Area	Upto 10 Meter Elevation
Exposures Analysed	Residential Buidings, Commercial Buidings, Industrial Buidings, Fire Stations, Police Stations, Cyclone Shelters, Airports, Bridges, Railway Stations, Railway Lines, Roads, Seaports, Communication Channels, Electric Lines, Potable Water, Waste Water, Power Plants, Oil And Gases

Web Based Dynamic Composite Risk Atlas & Decision Support System – WebDCRA & DSS

(a)Based on 17/0600 UTC (84 hrs prior to landfall)

D: DEPRESSION, DD: DEEP DEPRESSION, CS: CYCLONIC STORM, SCS: SEVERE CS, VSCS: VERY SEVERE CS, ESCS: EXTREMELY SEVERE CS, SUCS: SUPER CS
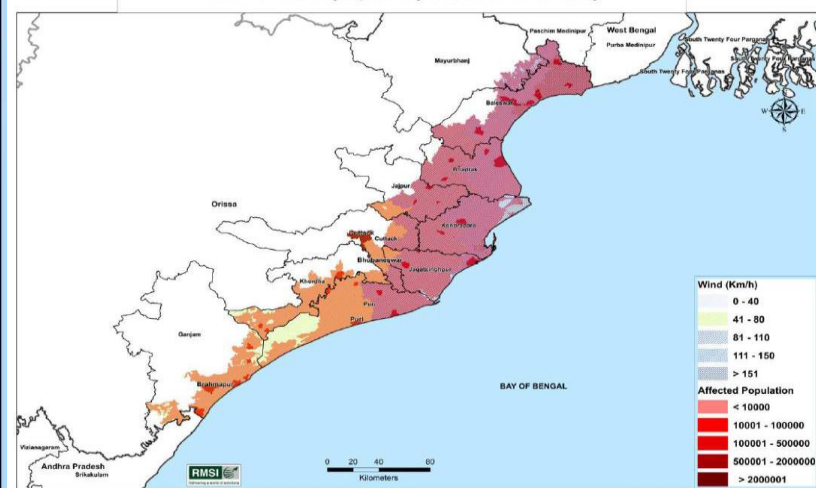
OBSERVED TRACK
FORECAST TRACK
CONE OF UNCERTAINTY

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A few Example from WebDCRA – Cyclone Amphan

Different wind speed zones from Amphan Cyclone at IST 20:30 May17, 2020 (Based on IMD Bulletin)

Affected population in different wind speed zones from Amphan Cyclone at IST 20:30 May17, 2020 (Based on IMD Bulletin)

Total Exposures vs Affected Count

Exposures	Total Count/Length	Affected Count/Length
Residential	3202878	51634
Commercial	917798	10448
Industrial	40050	589
Fire Stations	67	58
Hospitals	1306	124
Police Stations	285	148
Cyclone Shelters	733	324
Schools	6095	2068
Airports	2	1
Seaports	2	1
Railway Station	76	73
Railway Lines	540.67 km	0 km
Electric Lines	11235.48 km	0 km
Bridge	3800	1044
Road	22153.41 km	0 km
Oil and Gas	198.01 km	0 km
Power Plant	0	0

Loss By Category

Exposure Type	Exposure (INR Lakhs)	Loss (INR Lakhs)	Loss %
Building	14,039,880.59	51,709.65	0.37
Essential Facilities	1,027,373.52	891.97	0.09
Transportation	8,215,891.90	825.08	0.01
Utilities	916,394		

RSMC New Delhi Training Programme on Tropical Cyclone Monitoring and Forecasting (ONLINE, 04th to 14th April, 2022)

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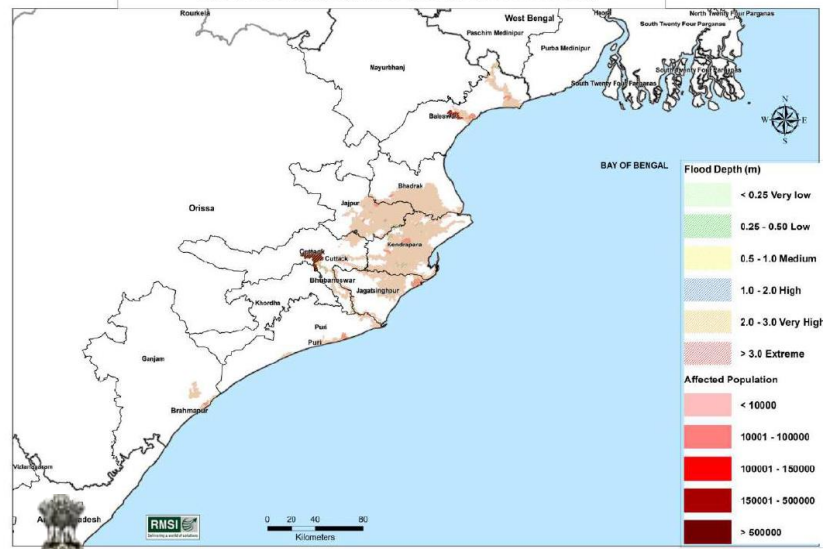
Different flood zones from Amphan Cyclone of May17, 2020
(Based on IMD Bulletin)
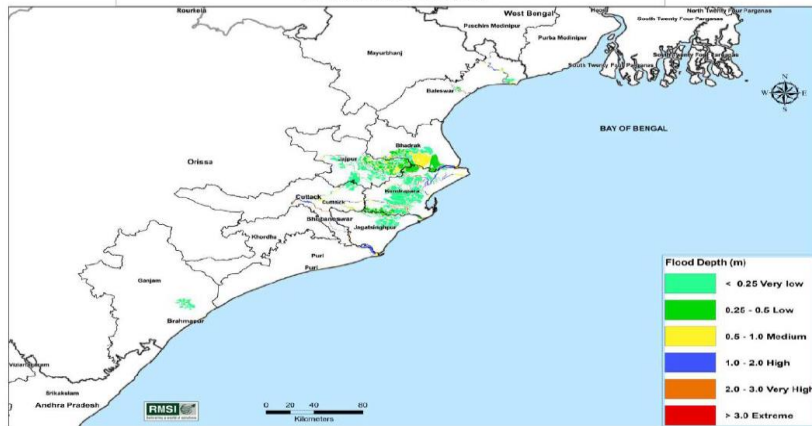
Affected population in different flood zones from Amphan Cyclone
at IST 20:30 May17, 2020 (Based on IMD Bulletin)

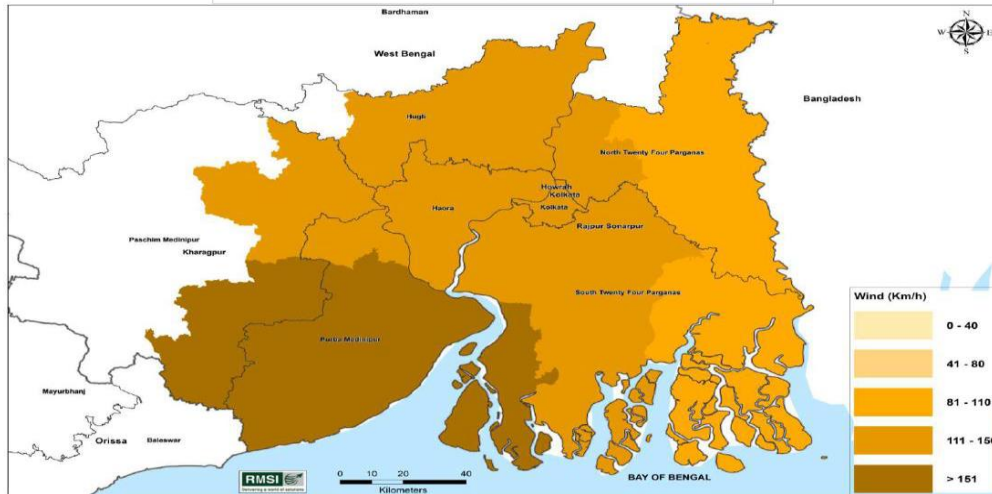## Total Exposures vs Affected Count

Exposures	Total Count	Affected Count
Residential	3202878	10990
Commercial	917798	777
Industrial	40050	70
Fire Stations	67	3
Hospitals	1306	3
Police Stations	285	3
Cyclone Shelters	733	0
Schools	6095	4
Airports	2	0
Seaports	2	1
Railway Station	76	4
Power Plant	0	0

Loss By Category

Exposure Type	Exposure (INR Lakhs)	Loss (INR Lakhs)	Loss %
Building	14,039,880.59	2,373.43	0.02
Essential Facilities	1,027,373.52	31,546.75	3.07
Transportation	8,215,891.90	1,035.33	0.01
Utilities	916,394.99	0.00	0.00

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A few Example from WebDCRA –Cyclone Amphan

Different wind speed zones from Amphan Cyclone at IST 20:30 May17, 2020 (Based on IMD Bulletin)

Wind (Km/h)
- 0 - 40
- 41 - 80
- 81 - 110
- 111 - 150
- > 151

Affected population in different wind speed zones from Amphan Cyclone at IST 20:30 May17, 2020 (Based on IMD Bulletin)

Wind (Km/h)
- 0 - 40
- 41 - 80
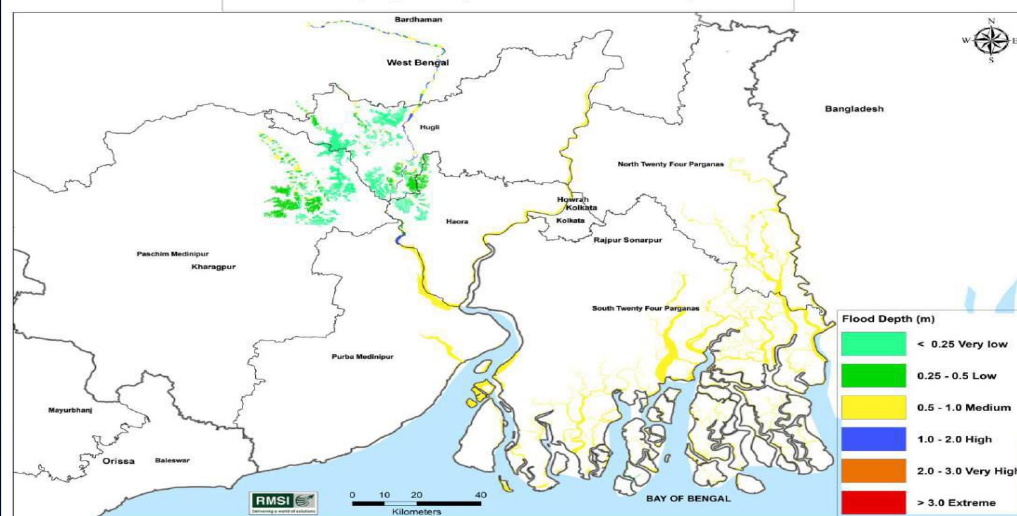- 81 - 110
- 111 - 150
- >151

Affected Population
- < 10000
- 10001 - 100000
- 100001 - 500000
- 500001 - 2000000
- > 2000001
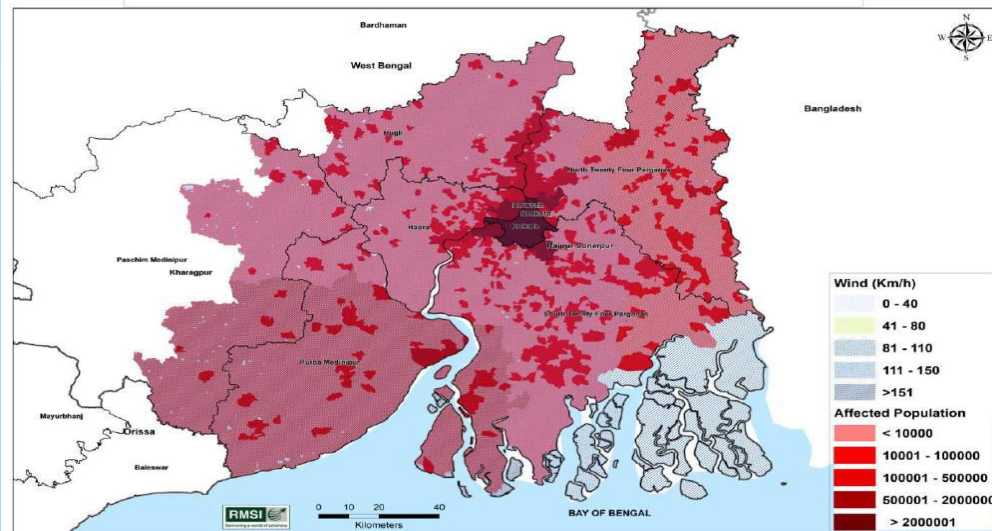
Total Exposures vs Affected Count

Exposures	Total Count/Length	Affected Count/Length
Residential	10646545	151634
Commercial	2073635	15918
Industrial	127766	746
Fire Stations	109	49
Hospitals	8108	1051
Police Stations	647	1
Cyclone Shelters	493	136
Schools	10123	904
Airports	6	3
Seaports	2	2
Power Plants	5	5
Railway Stations	280	213
Bridges	875	431
Electric Lines	10082.72 km	0 km
Roads	40253.56 km	0 km
Oil and Gas	404.20 km	0 km

Loss By Category

Exposure Type	Exposure (INR Lakhs)	Loss (INR Lakhs)	Loss %
Building	67,428,691.78	518,536.23	0.77
Essential Facilities	2,686,776.16	8,829.94	0.33
Transportation	10,524,200.23	6,171.77	0.06
Utilities	3,141,562.72	26,637.55	0.85

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Different flood depth zones from Amphan cyclone of May17, 2020 (Based on IMD Bulletin)

Flood Depth (m)
- < 0.25 Very low
- 0.25 - 0.5 Low
- 0.5 - 1.0 Medium
- 1.0 - 2.0 High
- 2.0 - 3.0 Very High
- > 3.0 Extreme

Affected population in different flood zones from Amphan Cyclone at IST 20:30 May17, 2020 (Based on IMD Bulletin)

Flood Depth (m)
- < 0.25 Very low
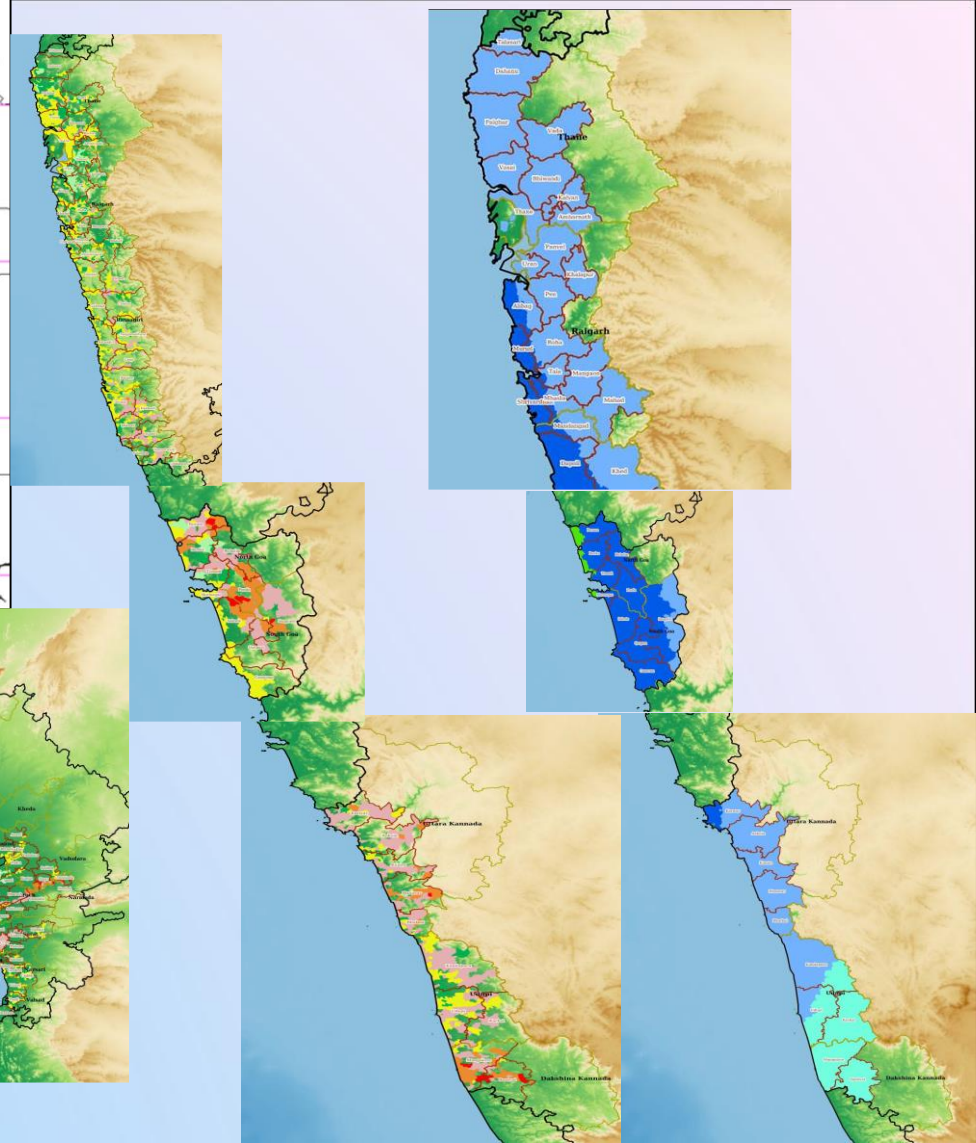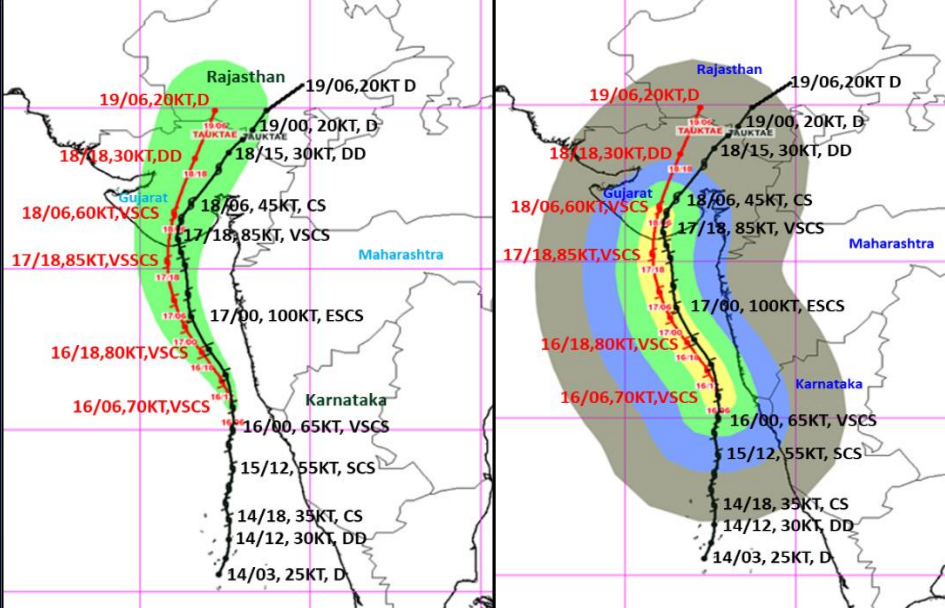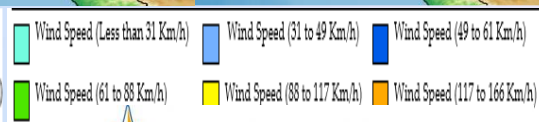- 0.25 - 0.50 Low
- 0.5 - 1.0 Medium
- 1.0 - 2.0 High
- 2.0 - 3.0 Very High
- > 3.0 Extreme

Affected Population
- < 10000
- 10001 - 100000
- 100001 - 150000
- 150001 - 500000
- > 500000
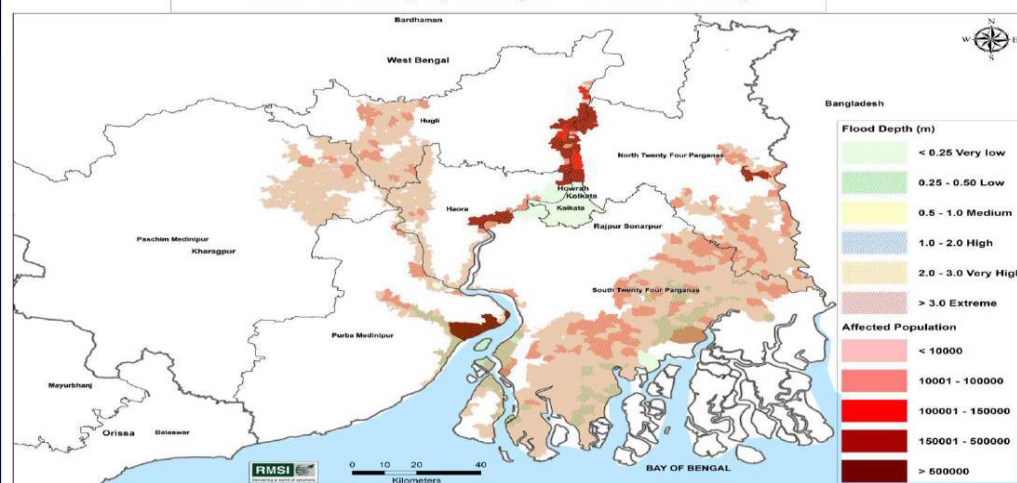
Total Exposures vs Affected Count

Exposures	Total Count	Affected Count
Residential	10646545	8990
Commercial	2073635	780
Industrial	127766	16
Fire Stations	109	2
Hospitals	8108	0
Police Stations	647	0
Cyclone Shelters	493	0
Schools	10123	0
Airports	6	1
Seaports	2	2
Power Plants	5	4
Railway Station	280	3

Loss By Category

| Exposure Type	Exposure (INR Lakhs)	Loss (INR Lakhs)	Loss %
Building	67,428,691.78	0.00	0.00
Essential Facilities	111,271.26	4,756.36	4.27
Transportation	10,524,200.23	9,704.78	0.09
Utilities	3,141,562.72	275,625.00	8.77

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Cyclone TAUKTAE: IBF based on 0300 UTC of 16th May 2021
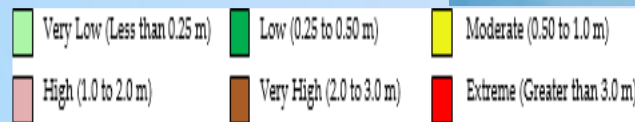
Very Low (Less than 0.25 m)
Low (0.25 to 0.50 m)
Moderate (0.50 to 1.0 m)
High (1.0 to 2.0 m)
Very High (2.0 to 3.0 m)
Extreme (Greater than 3.0 m)

Wind Speed (Less than 31 Km/h)
Wind Speed (31 to 49 Km/h)
Wind Speed (49 to 61 Km/h)
Wind Speed (61 to 88 Km/h)
Wind Speed (88 to 117 Km/h)
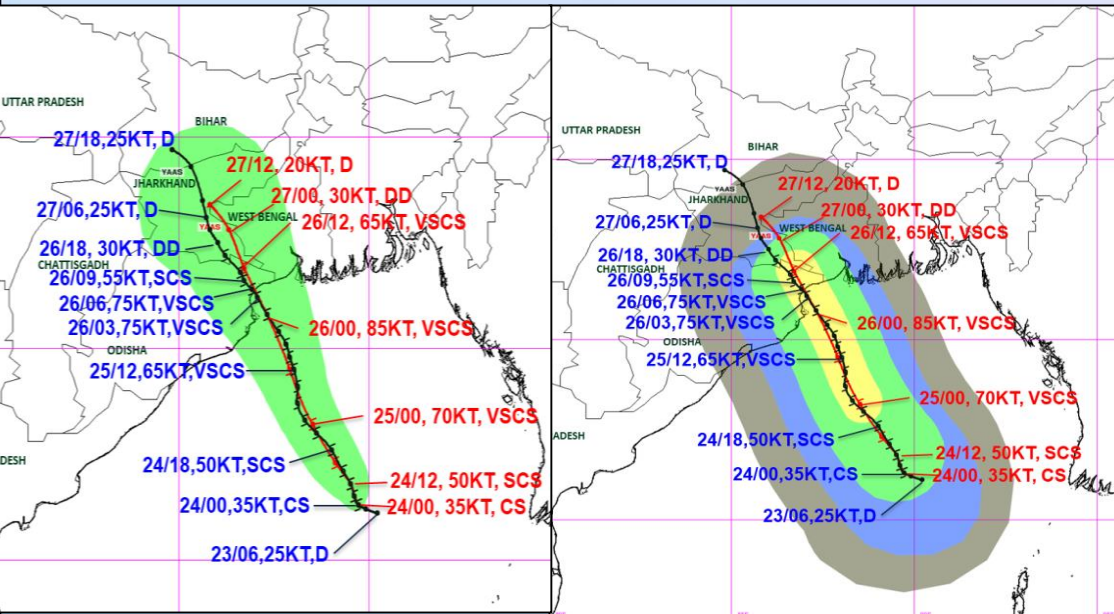Wind Speed (117 to 166 Km/h)
Win

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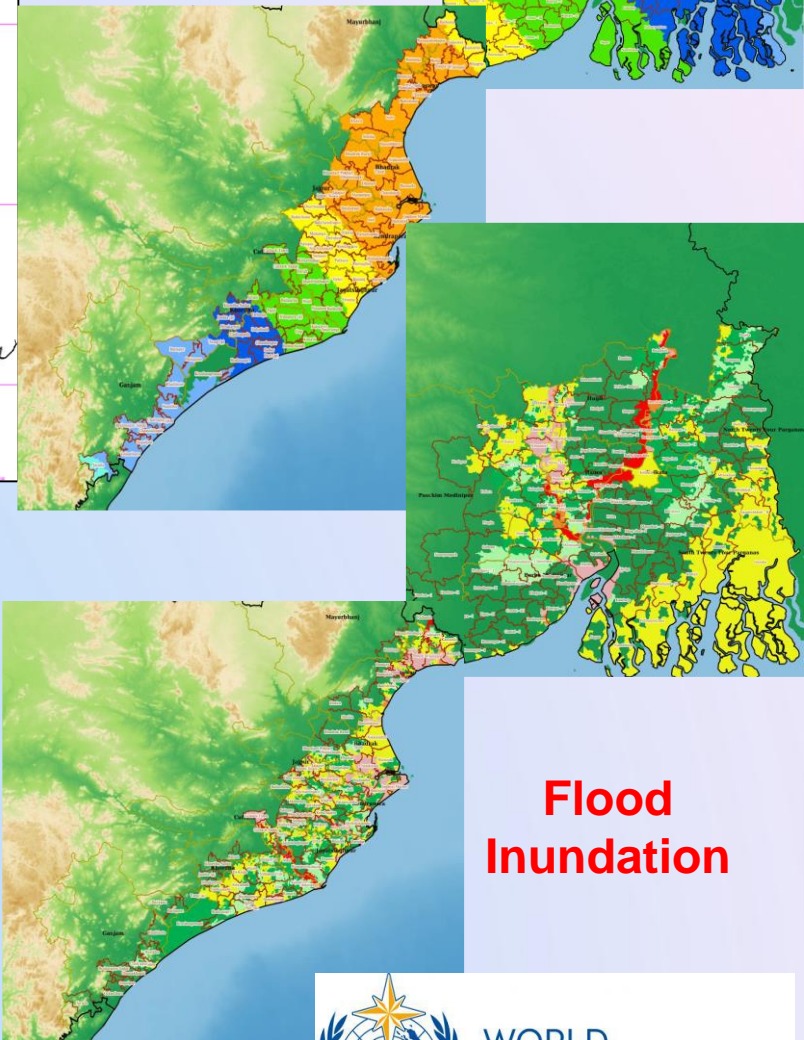
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Cyclone YAASH: IBF based on 0600 UTC of 25th May 2021
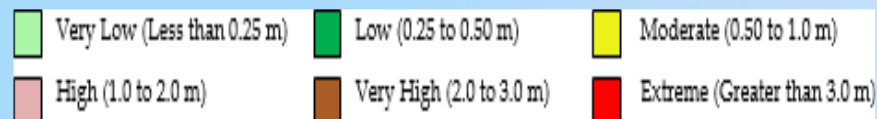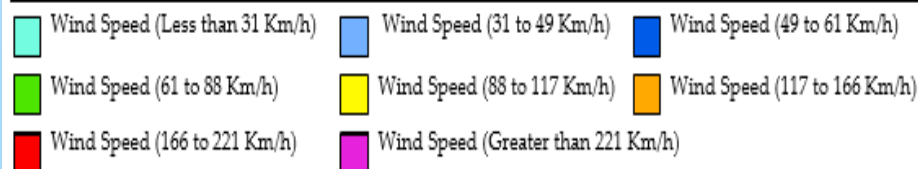
Wind Impact

Flood Inundation

RSMC New Delhi Training Programme on Tropical Cyclone Monitoring and Forecasting (ONLINE, 04th to 14th April, 2022)

Efforts for IBF and Synchronization

- ❑ **India**
  - ➢ MoES organizations are engaged in developing models to provide accurate forecasts for weather and hazard elements
  - ➢ MoES organizations like NCCR and INCOIS are also directly involved in the operational practices of IBF
- ❑ **International**
  - ➢ Time to time direct guidelines from WMO.
  - ➢ MoES WCSSP project component for IBF with UK Met. Office
  - ➢ Working group on IBF within South Asian Hydro-meteorological Forum (SAHF) of RIMES
  - ➢ UN-ESCAP Panel guiding documentations for IBF
  - ➢ Collaboration with other partners (NMHSs)
- ❑ **Synchronization**
  - ➢ The direct guidance from the PR of India in WMO
  - ➢ IMD as a partner in WCSSP
  - ➢ Scientists from IMD in the working groups of RIMES-SAHF
  - ➢ RSMC New Delhi functions closely with UN-ESCAP
  - ➢ Bilateral collaborations

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Thank YOU

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