Lecture 1 Basics of IBFW: Exercise on Hazard(inclding met event), Impact, Vulnerability and Exposure(map exercise) which introduces the key terminology on impact based forecasting and Warning(IBFW)

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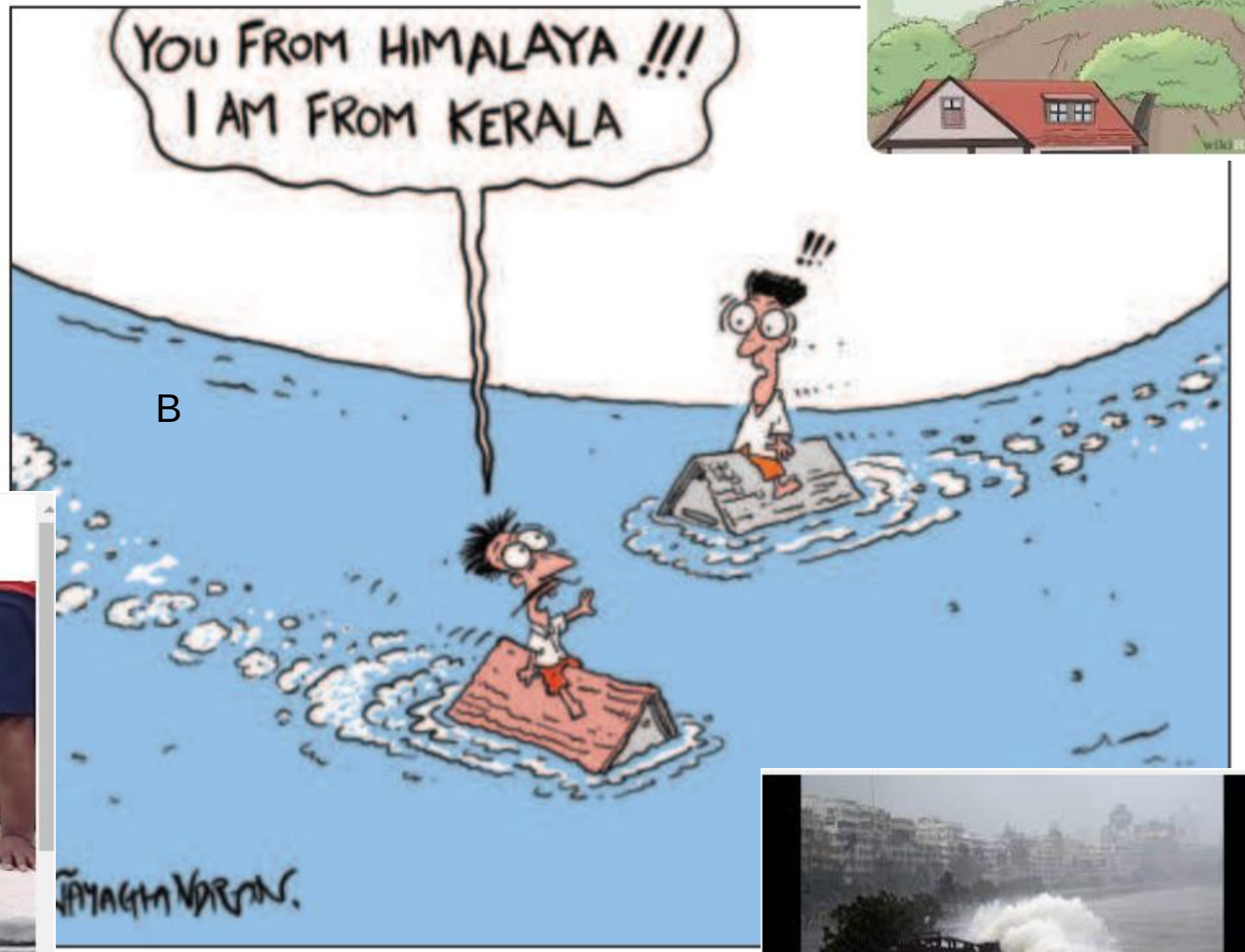
Workshop on Impact-based Forecast and Warning Services (IBFWS)-1st WMO-PTC/GCC Workshop by Panel on Tropical Cyclones and Gulf Countries Council at Muscat

NDMA PPT-IIT MUMBAI

Exposure

{ FAULT-LINE }



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B

SANDRP

सम विज्ञान विभाग
ROLOGICAL DEPARTMENT

IBF and RBW-What to do?

- **Risk analysis of major exposures- using Hazard, Impact, Vulnerability and Exposure –HIVE Data**
- **Am I getting your complete vulnerability data**
- **to give right suggestion/ make you Disaster impact Safety**
- ✓ **Age, Gender biased, Socio- economic conditions, Location of your house/Assets**
- ✓ **withstanding capacity/coping capability to a hazard x-Tidal flooding, flash flooding/ Land slide/ Riverine flooding**
- ✓ **Vulnerability of your school and transport/roads etc (Structural/ Service sector)**

Objective

- What is IBWF and Why IBWF and Risk based Warning
- Hazards and Events
- Hazard, Impacts, Vulnerability, Exposures –Risk –how to compute for Local Major exposures
- Stages of IBWF & Risk based Warning
- Steps to switch over to IBF
- RISK MATRIX
- Components/Effectiveness of MHEWS and IBFW-to reduce losses(refer lecture 2-Part 1)
- IMD methodology and developments for IBFW 2019-2023(refer lecture 2 Part 2)
- Review of progress in the world and IMD in MHEWS-IBF and gap areas, way forward

EVENT AND HAZARDS -Geo- physical Exposure to start -Exercise 1-HAZARD AND EXPOSURES

- MONSOON/TS/EASTERLY WAVE/WESTERLY SYSTEM - HEAVY RAINFALL
- CYCLONE
- HEAT WAVE

Geo- physical Exposure to start -Exercise 1-HAZARD AND EXPOSURES

» **Where-Location, topography, proximity to Hills, plains, coast, river, valley, lakes etc**

News18

WHAT HAZARD AND WHERE? Hills and mountainous reg

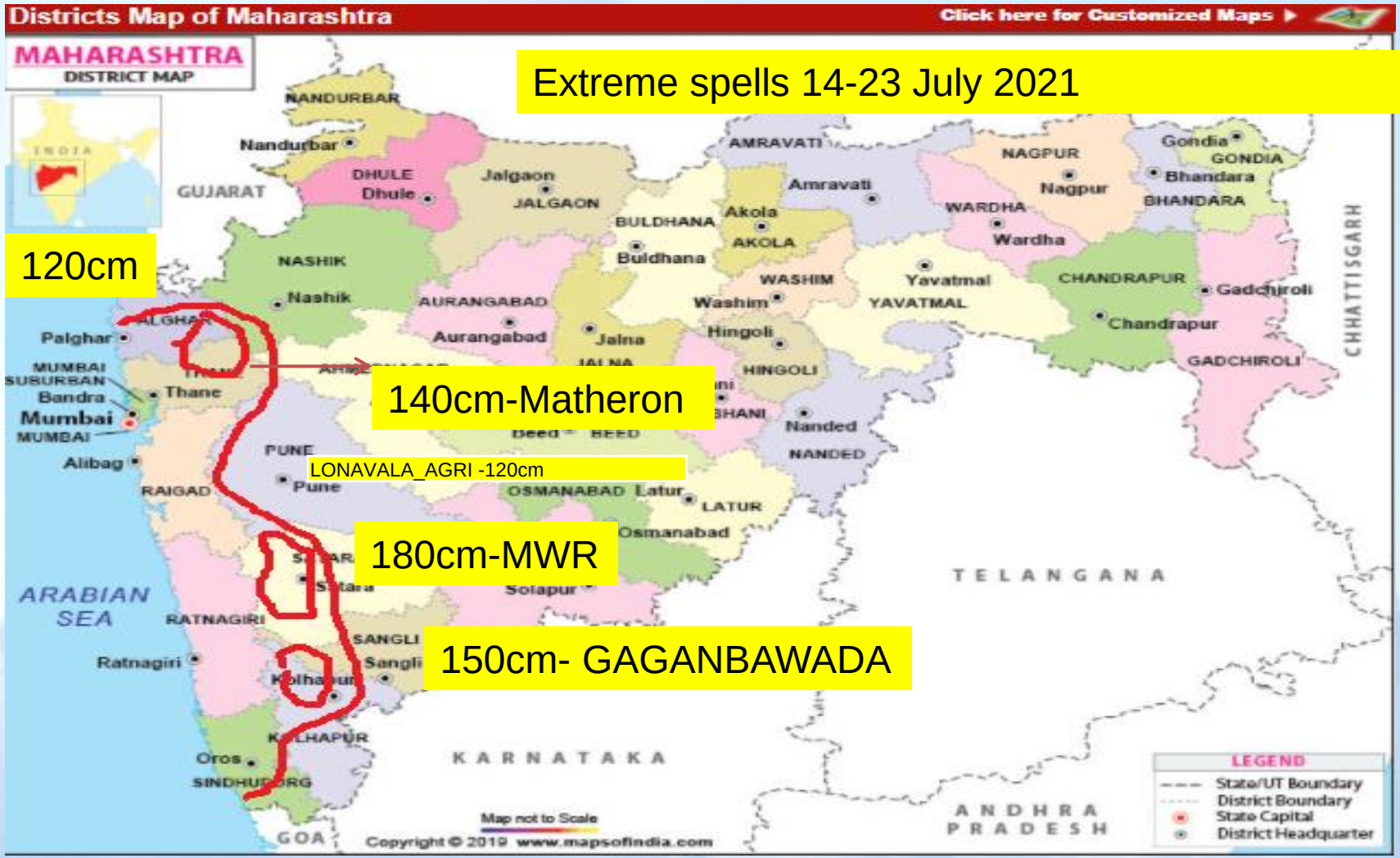
Himachal Rains: Massive Landslide in Kullu's Anni Takes Down Multiple Buildings | Scary Visuals - News18

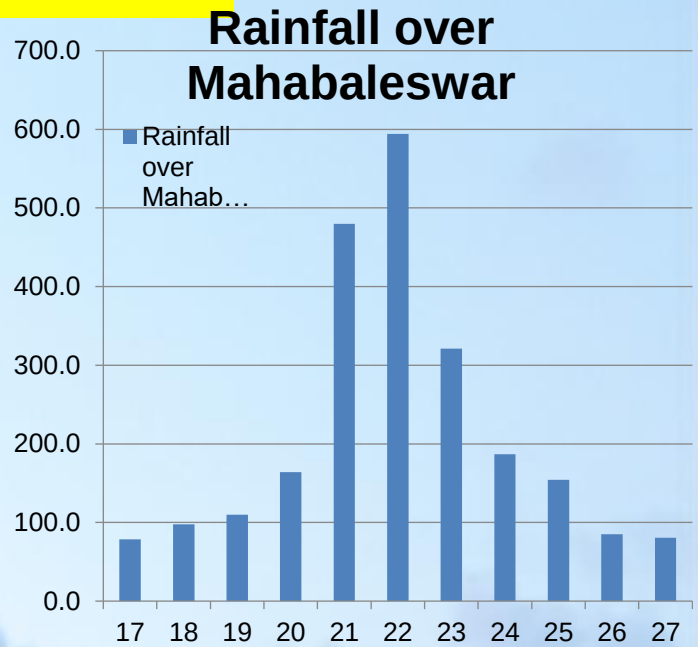
Visit

Flood over Satara Maharashtra
19-23 July 2021-in the plains

INDIA ME

14-23 July 2021(10-days of unusual heavy rainfall spell-1200-1800mm rainfall)



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When Nainital turned into a fl
TOI News


6 days ago

URBAN AREAS UNDER THE SAME EVENT
HAVE DIFFERENT –EXPOSURES AND HAZARDS


MUTP
MH-01
LA-5044
AP

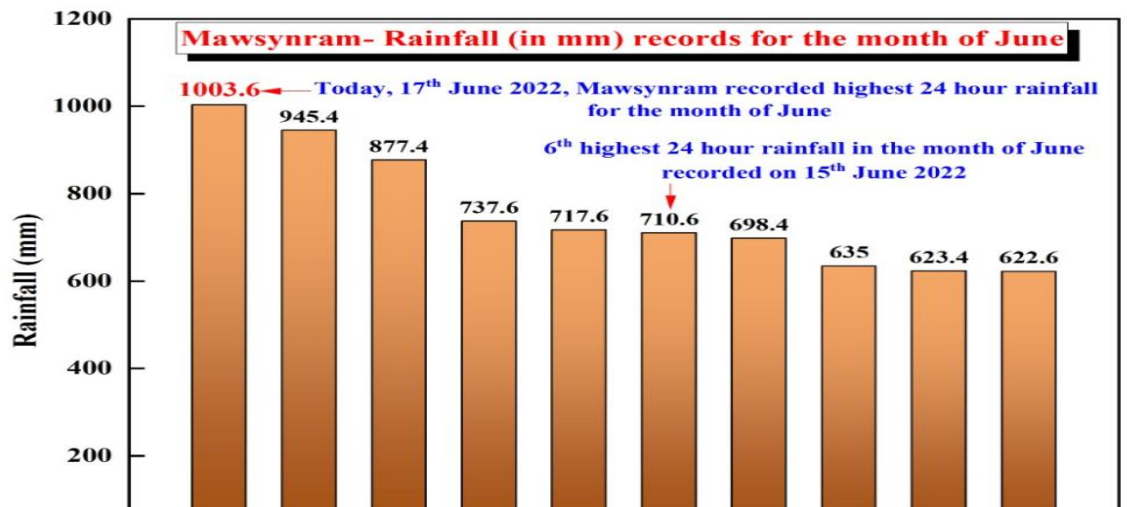
IMPACT SHEET PRILM PART FROM MEDIA
Maharashtra Rain Impact 14-25 July (severe flooding 22 & 23 July, 2021)

Districts Affected: Raigad, Ratnagiri, Sindhudurg, Satara, Sangli and Kolhapur.

1.Lives lost- Death toll 250/100 missing, highest in Raigad with 95"
2.Village Affected: 1020
3.Evacuation: 375000 people (206,000 are from Sangli district and around 150,000 from Kolhapur district)
4.Poultry Death: 28,700
5.Animal Death: 300
6.Crop Damage: 200,000 hectare
7.Infrastructural Damage: Around 800 bridges have been submerged
8.Drinking water supply affected of about 700 villages
9.14,700 electric transformer damage
10.Power supply affected of about 950,000 consumers

Northeast India –Mainly Assam and Meghalaya:10-20 May and 11-21 June 2022 -Both longer spell, but 2nd spell has record high rainfall

- Mawsynram recorded 1003.6mm rainfall 16- 17th June 2022.
- It has broken all earlier daily 24-hours rainfall record in June during last 83-years (1940-2022). The earlier record 6-7 June 1966 when it received 945.4mm.



Heavy rainfall related hazards and impact-Analysis from northeastern states

- Around 127 people lost their lives, and millions have been affected.
- Nearly 300 embankments were breached in 20 districts in Assam.
- Floods impact 229,000 hectares of crops.
- Flood-hit 2,524 villages across 27 districts in Assam
- Inclement weather and incessant rain caused massive landslides and waterlogging at several locations of the Lumding-Badarpur hill section of the North-East Frontier(NFR)zone of Indian Railways.

Cyclone-Hazards and Impact

Cyclone Amphan: A trail of death ...
hindustantimes.com

Cyclone Amphan and Covid-19: Survivors ...
hindustantimes.com

Houses in Kasaragod devoured by sea ...
newindianexpress.com

injured & 10L impacted by Cyclone Yaas ...
economictimes.indiatimes.com

Cyclone Debbie rescue efforts hit by ...
theguardian.com

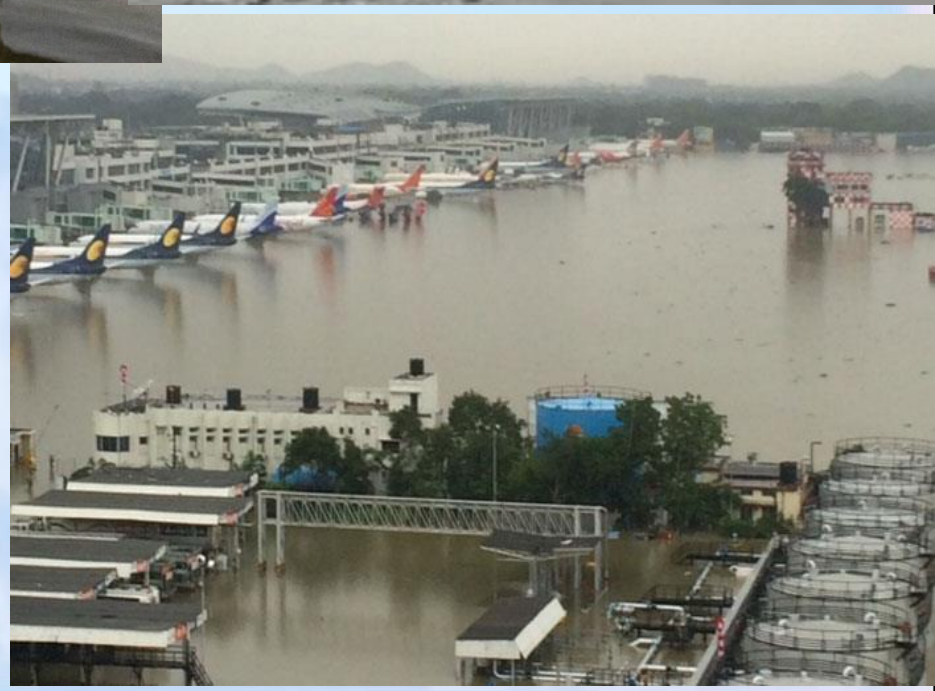
Cyclone Tauktae: House Collapses ...
thequint.com

rubble': Storm Eunice | UK w...
theguardian.com

Ex-Tropical Cyclone Seroja destroys ...
abc.net.au

After Cyclone Amphan, broken houses a...
thethirdpole.net

Impact of Urban Heavy rain spell/Extreme rainfall event



Extreme temperature events –Heat wave and cold wave

HAZARD-HEAT STRESS
AGRICULTURE-
ENHANCE DROUGHTS

Maximum Temperatures (surface manual observatories) Dated 15.05.2022 (>=45°C)	
Rajasthan	
Ganganagar	47.6
Churu	47.9
Bikaner	46.4
Phalodi	46.2
Pilani	47.7
Alwar	46.0
Kota	45.3
Haryana & Delhi	
Hissar	47.3
Bhiwani	46.0
Rohtak	46.7
Narnaul	47.5
Delhi Ridge	47.2
Delhi Safdarjung	45.6
Delhi Palam	46.4
Delhi Ayanagar	46.8
Punjab	
Amritsar	46.1
Ludhiana	45.5
Madhya Pradesh	
Gwalior	46.6
Damoh	45.0
Nowgong	47.4
Khajuraho	47.4
Satna	46.1
Rewa	45.2
Sidhi	45.4
Vidarbha	
Bramhapuri	45.9
Chandrapur	46.8
Nagpur	45.1
Amraoti	45.0
Wardha	45.6

South Uttar Pradesh	
Banda	49.0
Jhansi	47.6
Orai	45.0
Hamirpur	45.2
Prayagraj	46.9
Varanasi	46.0
Churk	45.6
South Bihar	
Dehri	45.8
Gaya	45.6
Jharkhand	
Daltoganj	46.1

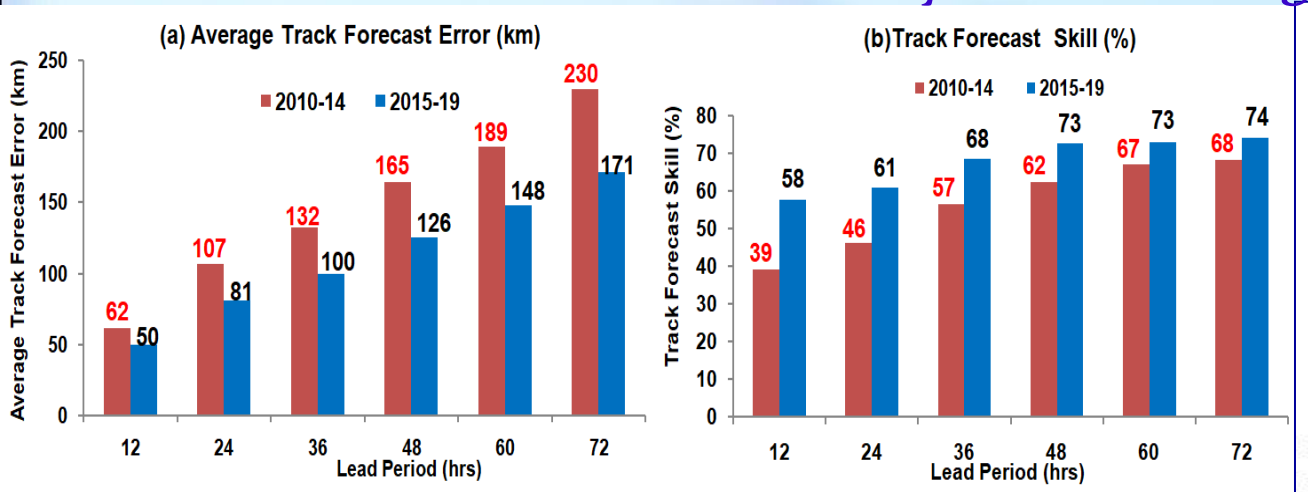
IBFW AND GENERAL FORECAST AND WARNING

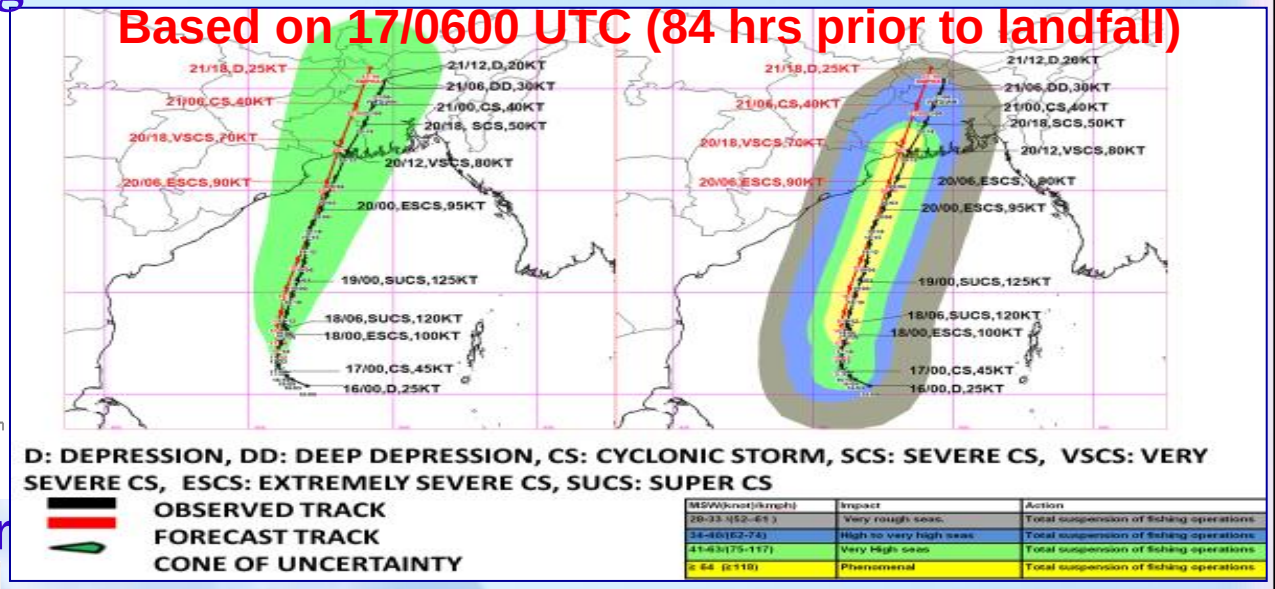
Why A good traditional standalone forecasts and warnings alone result in a poor response?

- **An accurate and timely weather warning does not guarantee safety of life or prevent major economic disruption:**
  - **Weather models and other hazards models not coupled (landslides, storm surge)**
  - **Lack of scientific and technical capacity to translate hazard information into impacts – therefore impacts underestimated**
  - **Inadequate communication channels, which can fail during the event**
  - **Lack of appreciation and utilization of available vulnerability information (Maps) at local level; not shared / not routinely updated and not digital**
  - **No effective decision support system**

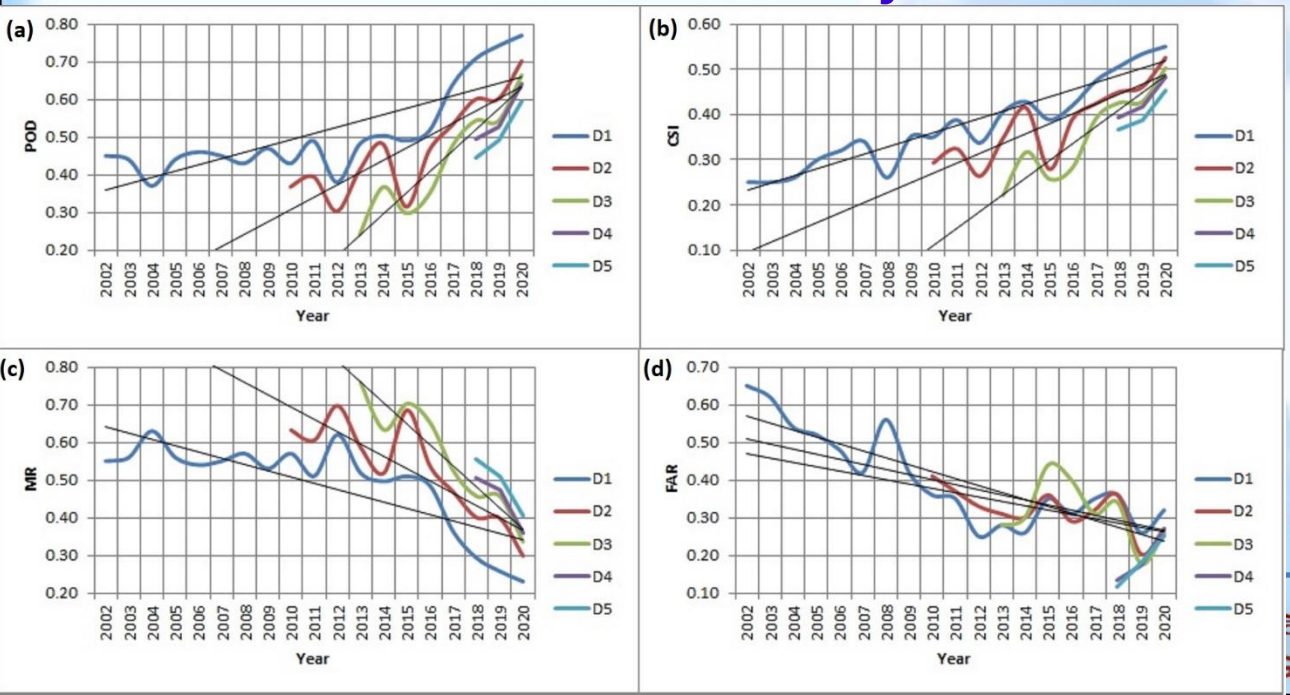
Current Forecasting and warning skill of IMD

Cyclone Warning Skill





Monsoonal Heavy Rainfall Warnir

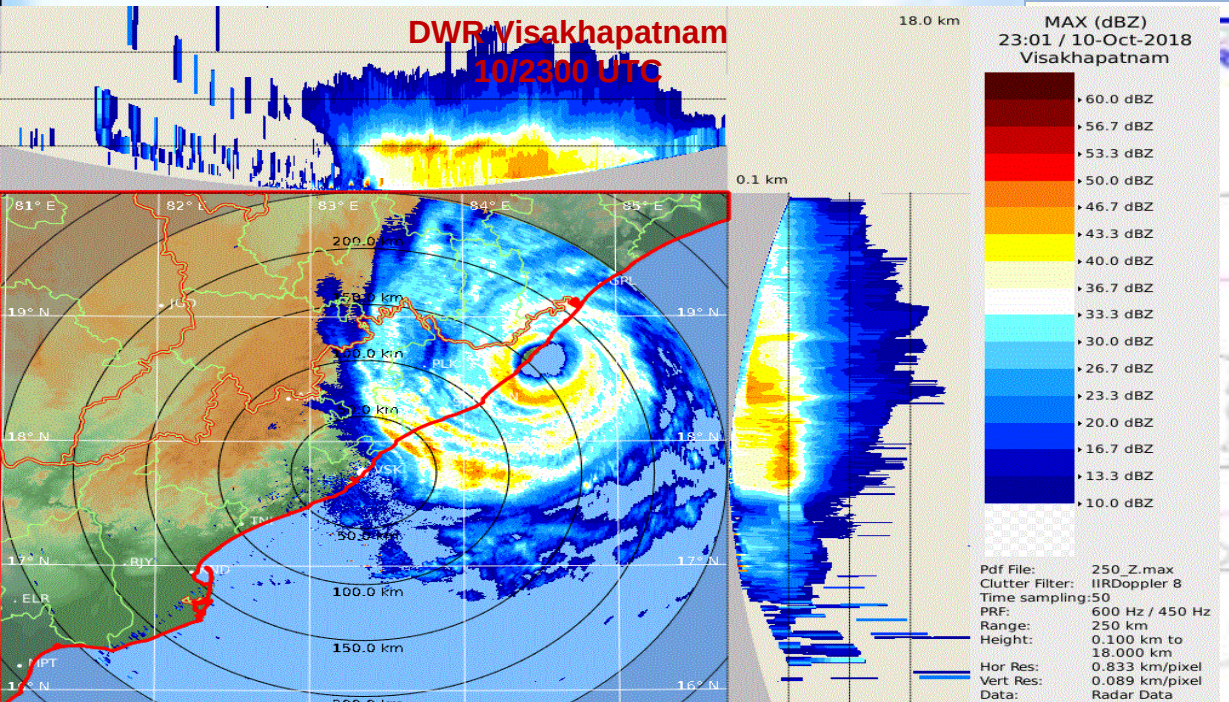


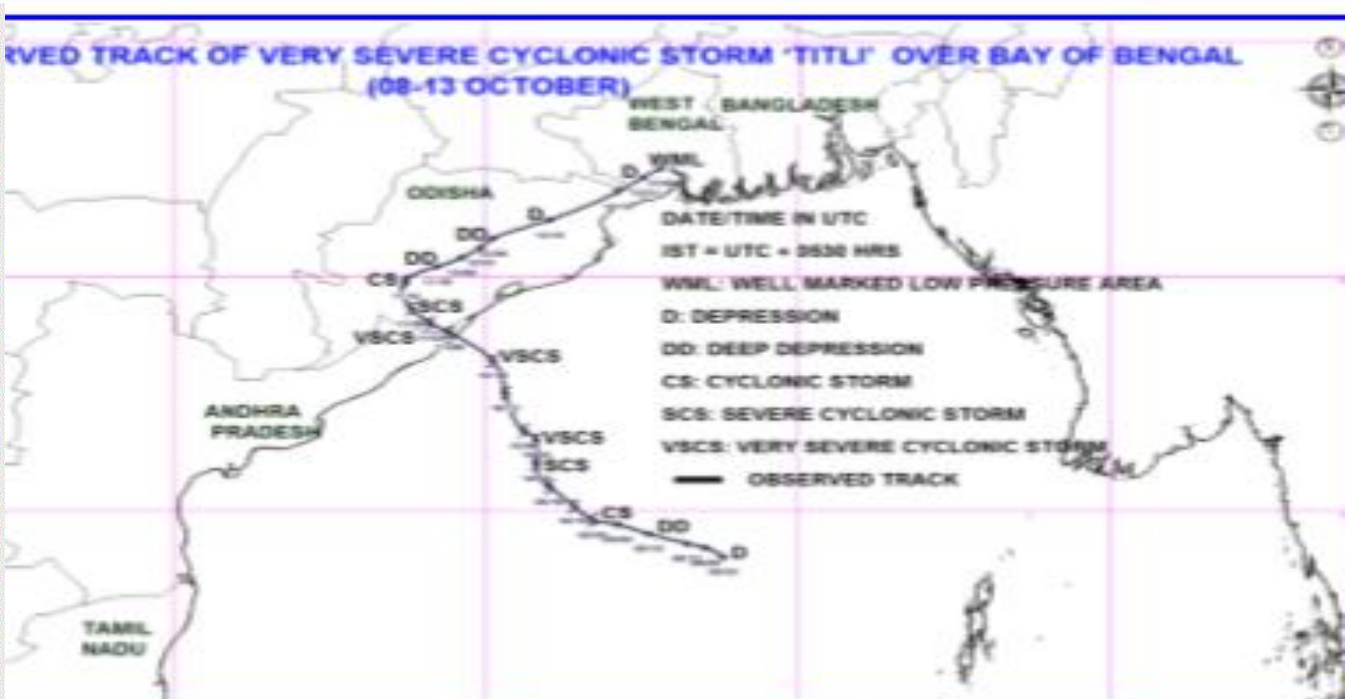
Heat Wave Warning Skill

All India	FAR			MR			CSI			POD		
	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
2017	.07	.06	.02	.33	.51	.77	.40	.32	.19	.67	.49	.23
2018	.03	.04	.02	.09	.28	.52	.54	.40	.32	.91	.72	.48
2019	.11	.10	.08	.08	.15	.38	.49	.47	.38	.92	.85	.62
2020	.03	.03	.02	.00	.05	.10	.41	.38	.39	1.0	.95	.90

Why Impact-Based Forecast and Warnings Services?

- **Experience of Tropical Cyclone, Titli**
- **Good quality forecasts from IMD**
- **77 people died in Odisha due to landslides and floods**
  - **Disaster managers and people expected the wind and rainfall – they did not expect the land slide and flood in south interior Odisha**





Why Impact-Based Forecast and Warnings Services?-Some facts and Gaps

- **Experience of the 2013 flooding in Uttarakhand and Chennai Flood 2015**

- **Uttarakhand case**
  - Thousands killed
  - Many were tourists / pilgrims who were not familiar with the local environment
  - Poor coordination between Met Service, local administration and national administration
  - Impact could not be anticipated

Evaluating Vulnerability

- **How to identify vulnerable areas?**
  - How to track those and adapt forecasts and warnings?
- **Location**
- **Timing**
- **Current Environmental Conditions**

Key Ideas in Impact-Based Forecast and Warning Services

Weather Warning:

—"***Strong winds are expected tonight with wind speeds of 20m/s likely***"

Impact-based Warning:

—"***Strong winds are expected tonight which may result in delays or cancellation to ferry services and keep small fishing boats tied up***"

How can science deliver the last mile?-Communicating actionable warnings and likely impacts

- **Institutional strengthening and improving observing and forecasting systems are necessary but not sufficient prerequisite to reduce impacts**
- **Need to understand why people do not move to safety when a warning is issued? Consistency and accuracy of forecast**
- **Further it mau be due to the fact that:**
  - ✓ **They do not know of the danger? (Lack of awareness)**
  - ✓ **They know it but choose to ignore it? (Pressing need/objective, e.g. visit to a pilgrim place on a specific day)**
  - ✓ **They do not understand the scientific language?**

What is Impact-based Forecasting?

- A fundamental change in focus

From

What the weather will BE

To

What the weather will DO

Impact Based Forecasting

Move from
(Information based forecast)

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

Towards
(Impact based information and
Risk based warning)

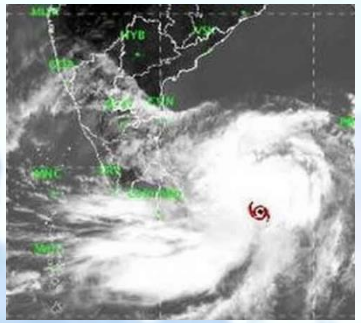
What the weather will ***do***:
- Water logging in low lying areas
- Damage to vulnerable structure

Observations + Forecast
+ Warning

Observations + Forecast +
Expected Impacts + Risk based warning

Impact Based Forecasting

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



(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.

Weather event? When Weather event called Severe?

- An event that is observed or happening, regularly occurring phenomena-it may rain, fog, Snow, DS/TS, strong wind conditions, High/Low Temp event …….
- Severe weather Event/Phenomena are Weather conditions that are hazardous to human life and property
- Historically, these are location/area specific-its types
- Their frequencies, intensity, locations, Areas with period of occurrences etc, if collected and analyzed using longer period data wherever available, then one can able to identify what are types of major severe weather events, that area/location have been prone for such occurrences

Hazards and Types

- **A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.**
- **Annotations: Hazards may be natural, anthropogenic or socio-natural in origin.**
- **Natural hazards(Hydro -Meteorological especially)** are predominantly associated with natural processes and phenomena.
- **Anthropogenic hazards**, or human-induced hazards, are induced entirely or predominantly by human activities and choices. This term does not include the occurrence or risk of armed conflicts and other situations of social instability or tension which are subject to international humanitarian law and national legislation. Several hazards are **socio-natural**, in that they are associated with a combination of natural and anthropogenic factors, including environmental degradation and climate change.
- **Hazards** may be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity or magnitude, frequency and probability. Biological hazards are also defined by their infectiousness or toxicity, or other characteristics of the pathogen such as dose-response, incubation period, case fatality rate and estimation of the pathogen for transmission.
- **Multi-hazard** means (1) the selection of multiple major hazards that the country faces, and (2) the specific contexts where hazardous events may occur simultaneously, cascadingly or cumulatively over time, and taking into account the potential interrelated effects.

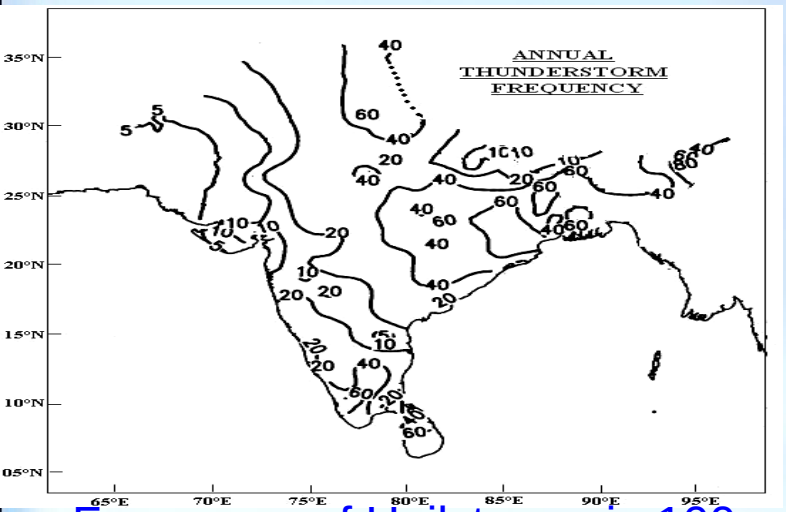
Classification of Severe weather Events and associated Hazards

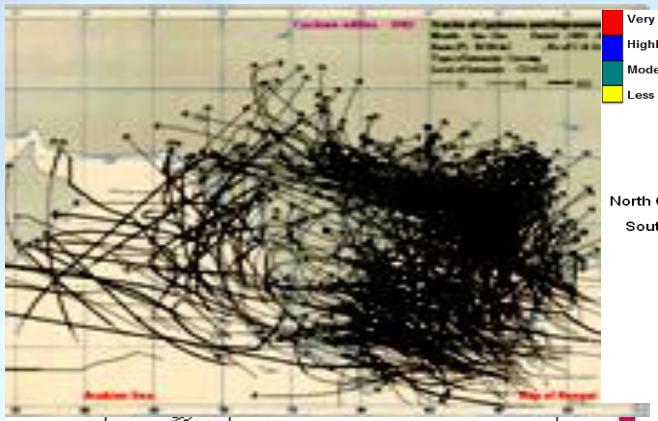
- ❖ Cyclone and associated hazards(Wind, Storm surge and Heavy rains)
- ❖ Cold/Heat Wave
- ❖ Dense fog(Low Visibility)
- ❖ Thunderstorm(Lightning, Winds, Hail Storm, Flash flood)
- ❖ Heavy rainfall

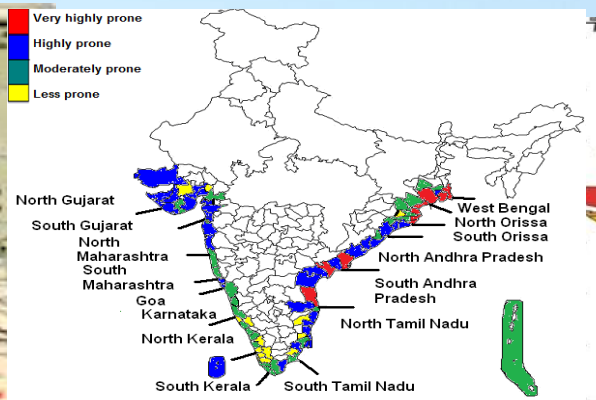
- ➢ **Floods:**
  - Pluvial (Surface Flood)/Flash flooding(especially Urban flooding)
  - Costal flooding(low tide/high tide and rainfall epochs)
  - Riverine flooding
- ➢ **Land slide and Land sink**
- ➢ **Dam burst**

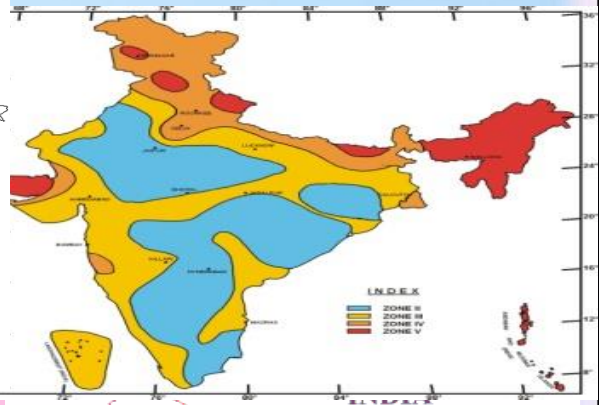
Major Met Events and associated Hazards in India-Map

Thunderstorms

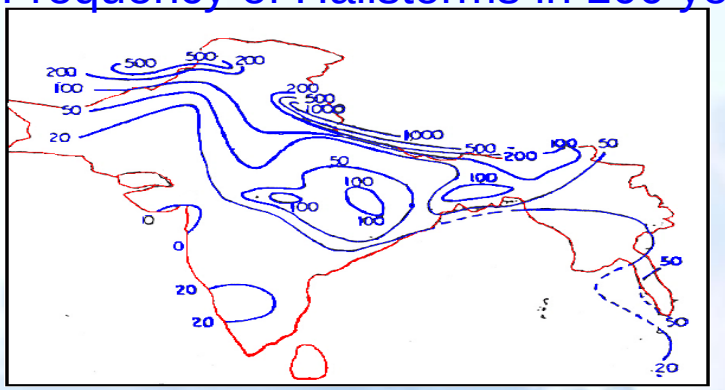


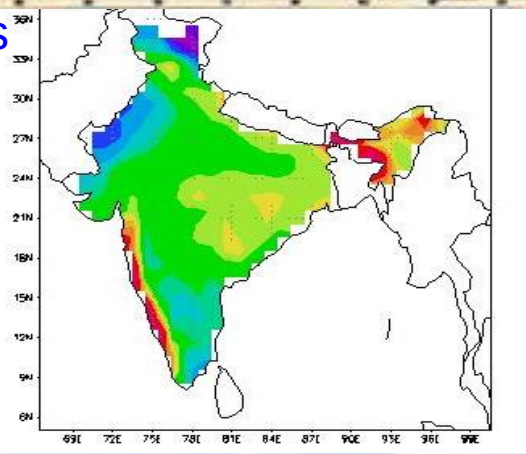


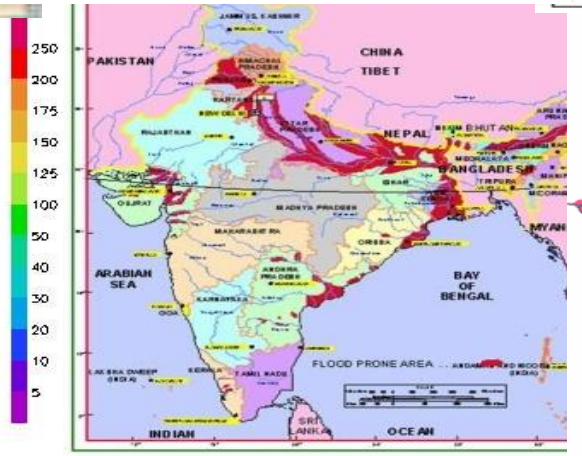


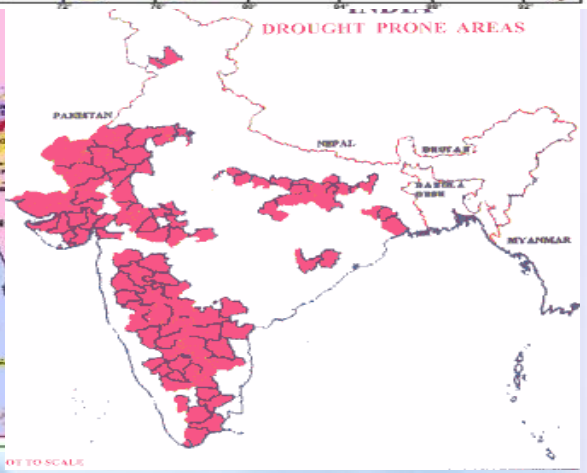


Frequency of Hailstorms in 100 years









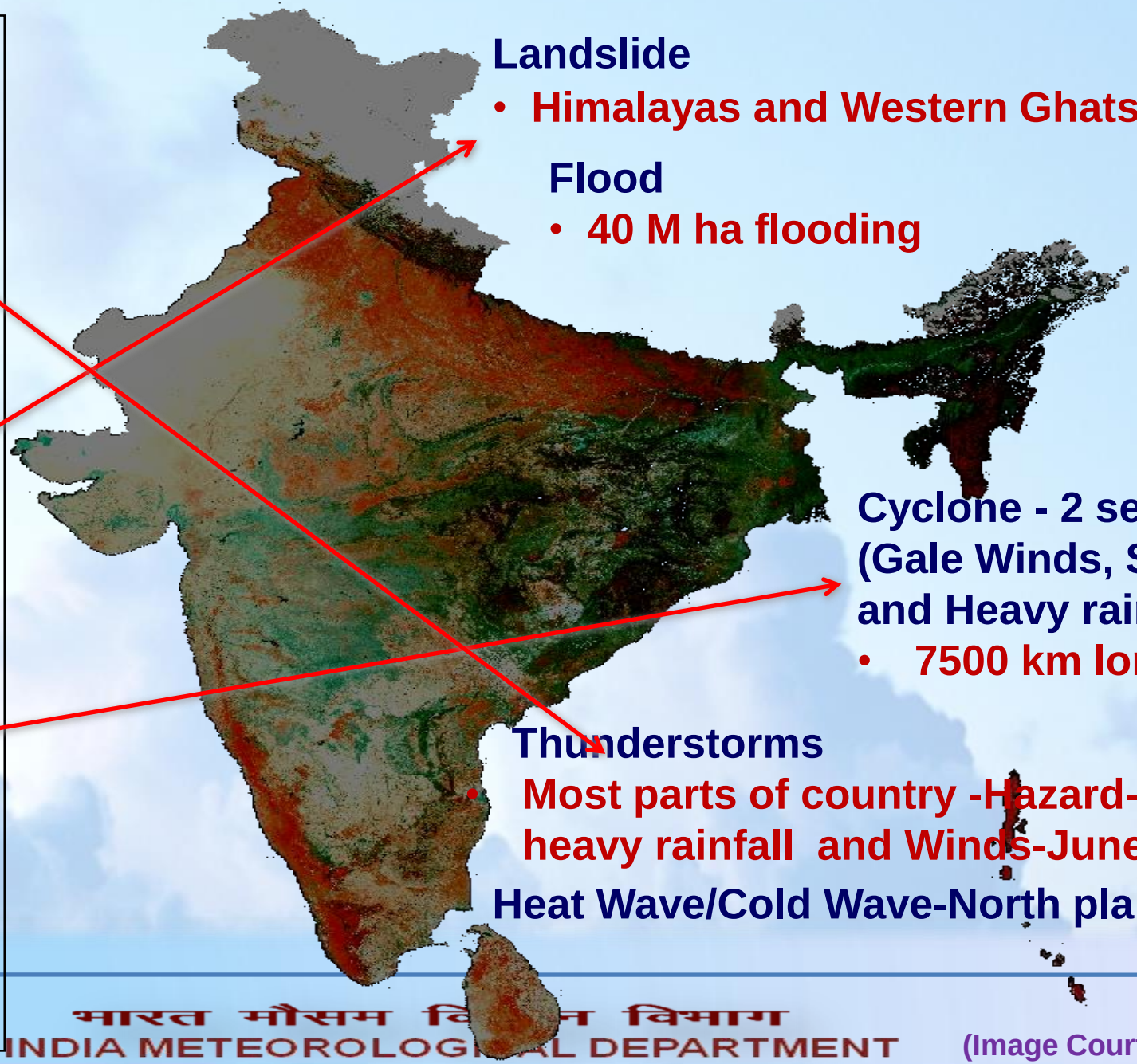
Progress in India : Severe weather Events as per Seasons, Hazards, Vulnerability, RISK

1.Winter Season(Jan-Feb)
- Dense fog, Cold wave, Frost and Heavy Snowfall

2.Summer Season(March-May)
- Thunderstorms, Dust storms and Lightning
- Cyclone Season-I

3.Monsoon Season(June-Sept)
- Heavy Rainfall and Flash Floods

4.Post Monsoon or Northeast Monsoon Season(Oct -Dec)
- Cyclone Season-II
- Heavy Rainfall and Flash Floods mainly in Peninsular India
- Starting Phase of Winter Severe Weather for north India



Landslide
- Himalayas and Western Ghats

Flood
- 40 M ha flooding

Cyclone - 2 seasons (Gale Winds, Storm surge and Heavy rains)
- 7500 km long coastline

Thunderstorms
- Most parts of country -Hazard-Lightning, heavy rainfall and Winds-June-August

Heat Wave/Cold Wave-North plains of India

(Image Courtesy: ISRO)

Weather Warning Services

Different types of Weather Warning

1. **Warnings with fixed thresholds**
2. **Warnings with user-defined thresholds**
3. **Warnings with variable thresholds**

Heavy rainfall Impact classification: Hazard-Flood

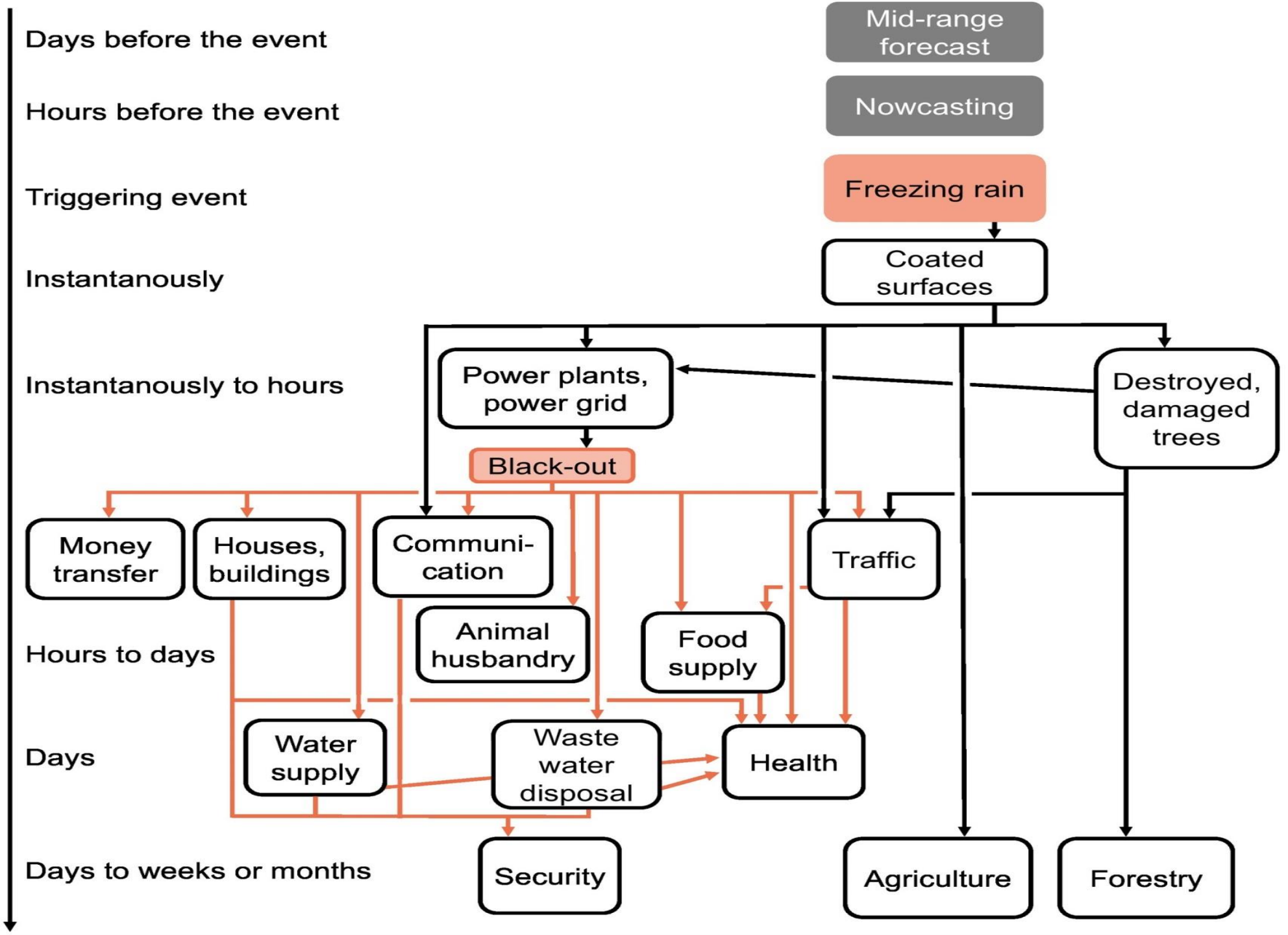
EFFECTS OF FLOOD

PRIMARY	SECONDARY	TERTIARY
Due to direct contact of flood water	Due to result of primary effects	Due to combined effect of 1° and 2°effects
Physical damage • loss of lives • Damage to buildings, bridge, crops, livestock	**Disruption of essential services** • Electricity • Gas • Health hazards	**Long term effects** •Change in location of river channels •Destruction of farm lands and wildlife habitat

PRIMARY EFFECTS

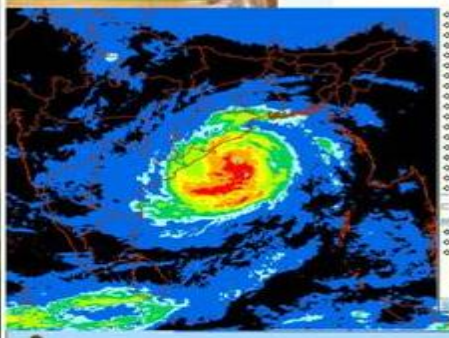
SECONDARY EFFECTS

TERTIARY EFFECTS



b. scheme of the cascading effects of the heavy rain event from say D10 to Day 0 and Day +10 and foot prints of three commonest: event, hazard and impact

Tropical Cyclone-Multi-Hazard



TYPES OF POTENTIAL DAMAGES ACCOMPANYING TROPICAL CYCLONES

CYCLONE
LOCAL TIDES
LOCAL COASTAL CONFIGURATION
STORM SURGE
WIND
RAIN

- FLOODING OF COASTAL AREAS
- EROSION OF BEACHES
- LOSS OF SOIL FERTILITY FROM SALINE INTRUSIONS
- DAMAGE TO STRUCTURES
- LOSS OF POWER/COMMUNICATION
- INJURIES & LOSS OF LIFE
- DESTRUCTION OF CROPS, VEGETATION, LIVE-STOCK
- CONTAMINATION OF WATER SUPPLY SYSTEM
- LAND SUBSIDENCE
- FLOODING OF INLAND AREA

Event and Hazard data

- Spatial –City, Village, Dist and state level
- Temporal-1-h, daily, 3 days upto weeks/month
- For Hazard, event and imapct data- Multi- institutional and multi-disciplinary
- IMD has long period data of Meteorological events and hazard data

Examples of multiple hazards resulting from meteorological event

Event	Primary hazard	Secondary hazard	Tertiary hazard
Tropical Cyclones	• Strong winds • Lightning • Heavy rainfall • Tornados	• Riverine and coastal flooding • Surface water flooding • Flash flooding • Land instability • Storm surge	• Loss of infrastructure systems and services (shelter, transportation, schools, hospitals, energy supply, communication) • Infectious diseases • Water insecurity • Widespread economic losses
Monsoons	• Strong winds • Heavy Rainfall • Thunderstorms	• Riverine and coastal flooding • Surface water flooding • Flash flooding • Land instability	• Loss of infrastructure systems and services (shelter, transportation, schools, hospitals, energy supply, communication) • Infectious diseases • Widespread economic losses
Convective rainstorms	• Strong winds • Tornados • Lightning • Heavy rainfall	• Riverine flooding • Surface water flooding • Flash flooding • Land instability	• Loss of infrastructure systems and services (shelter, transportation, schools, hospitals, energy supply, communication) • Infectious diseases • Local economic losses
Prolonged period of hot weather	• Heat	• Thunderstorms (and their associated hazard phenomena) • Drought • Dust/smog/haze	• Land instability • Non-infectious diseases • Algal blooms • Food insecurity/nutrition • Water insecurity • Widespread economic losses
Prolonged period of dry weather	• Reduced rainfall	• Dust/smog/haze/fog • Reduced ground water flow • Deteriorating water quality • Drought	• Loss of infrastructure systems and services (energy supply) • Non-infectious diseases • Infectious diseases • Food insecurity/nutrition • Water insecurity • Subsidence • Widespread economic losses
Excessive cold with frost	• Cold • Frost	• Wind chill	• Loss of infrastructure systems and services (energy supply) • Non-infectious diseases

Priority Hazards For a minimum viable MHEWS

- Priority Hazards For a minimum viable MHEWS, not all hazards that occur, or have the potential to occur, within a member state need to be included in the warning system.
- Overtime, MHEWS may be expanded to include all relevant hazards, however, the custom indicators focus on priority hazards. Priority hazards are those which are considered to present sufficient risk to make the hazard of national interest.
- Priority hazards may include primary or secondary hazards that cascade from an initial hazard. Each country will be able to define the priority hazards within their own context. Priority is likely to be determined based on a combination of the potential impact of a hazard and how frequently the hazard is likely to occur.
- Consideration should be given to hazards which are statistically unlikely but would have extremely high consequences should they occur. For the remainder of this document, the term ‘priority hazard’ is used to mean those hazards for which warnings are issued, that have been agreed as a national priority.

Effectiveness of a multi hazard approach - from Hydrometerlogical events

- Effectiveness of a multi hazard approach to reducing disasters by understanding how a meteorological or hydrological hazard can produce a series of social consequences
- The emphasis on impacts, therefore, also implies the warnings should be related to multiple hazards since the initial event can cause a series of cascading threats or consequential effects – public health, accidents, infrastructure damage, civil unrest, food insecurity, etc. Ideally, each of these should also be considered and the means to predict their likelihood developed.
- Obviously, these are not necessarily the responsibility of NMHSs; however, an inclusive approach to coping with multiple hazards would be more effective.
- This highlights not only the technical requirements, but also the need for an effective operational partnership among stakeholders. It also highlights the need to distinguish between forecasting an event, such as a tropical cyclone, from the numerous hazards resulting from that event – flash floods, riverine floods, storm surges, high winds and wind gusts.
- It is to the latter that we want to relate to impact-based forecasts and warnings

Table 3 Examples of sectorial interdependencies for 7 sectors (source Rogers et al. 2016)

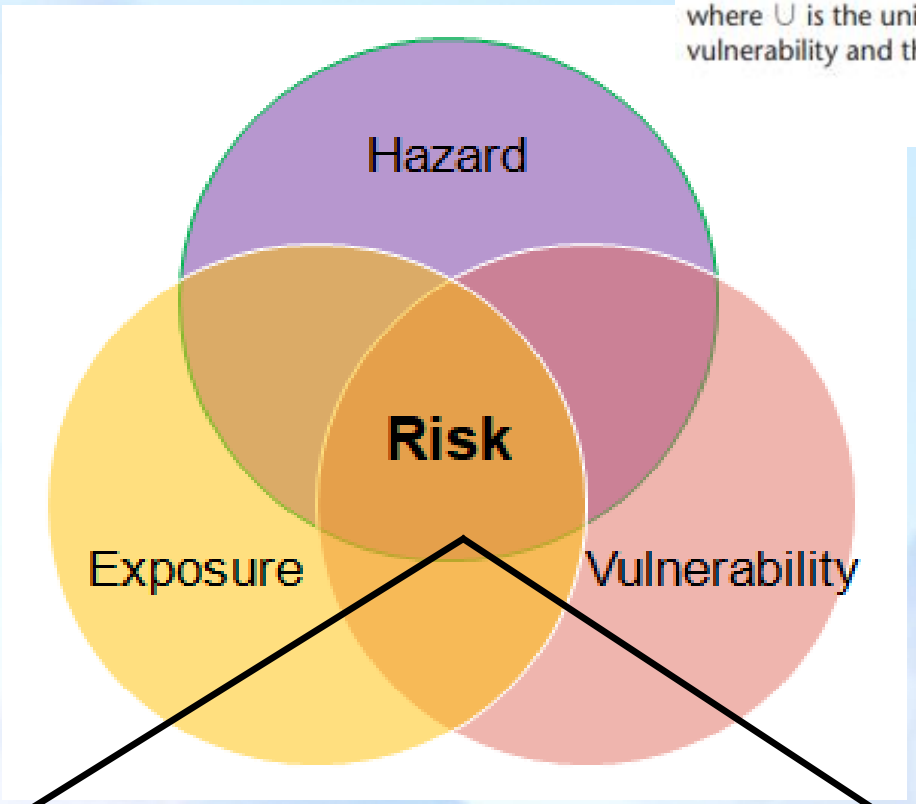
Sector	Dependencies on Infrastructure	Impacts on other sectors
Food	• Water for irrigation • Transport infrastructure for agricultural activities and food supply • Energy for storage and agricultural activities	• Domestic is dependent on food supply
Energy	• Water for cooling in power stations, fuel refining and energy production • Transport for fuel supply and workforce • ICT for control and management systems of electricity	• Transport is dependent on energy • Food production is dependent on energy • Water is dependent on energy for pumping, treatment and supply • Domestic is dependent on energy for heating and cooling and many other functions
Social and Domestic	• Food, Water ICT, Transport, Energy for all aspects of life and livelihoods • Emergency services providing continuity to operate while recovering from an event	• All sectors dependent on workers and efficient domestic consumption of sectorial resources • Health is dependent on general well-being of population to avoid overwhelming sector • Water depends on well-managed sanitation systems to avoid contamination of water supply • Emergency services infrastructure depends on people for effective response
ICT	• Energy for all services • Transport for maintenance workers	• All sectors dependent on ICT
Transport	• Domestic infrastructure for travel to and from work, school, etc. • Energy infrastructure for fuel and electricity • Drainage infrastructure to prevent flooding • Internal dependencies with and across modes (road, rail, sea, and air)	• All sectors depend on transport
Water	• Energy for treating, pumping and processing • ICT for control systems • Transport for workers and supplies for processing	• All workplaces and domestic homes require water for people and sanitation • Cooling water for some energy infrastructure • Energy infrastructure may depend on water for generation • Food production requires water
Emergency Services	• Transport (all modes) for safe and rapid evacuation, and emergency supplies • Energy to manage emergency pumps to relieve flooding and operate flood controls • Health infrastructure to respond to emergency situations • Water infrastructure to extinguish fires • ICT to respond effectively to emergency situations • Domestic infrastructure to provide security for population	• All sectors depend on emergency services for safety and security during emergency situations • Health infrastructure for emergency response

Risk Assessment

Risk may be mathematically expressed as:

$$|\,Risk\ of\ impact\ (x,\ t)\,| \equiv |\,hazard\ (x,\ t)\,| \cup |\,vulnerability\ (x,\ t)\,| \cup |\,exposure\ (x,\ t)\,|$$

where ∪ is the union of the level of hydrometeorological forecast uncertainty, the degree of vulnerability and the level of exposure. Risks:



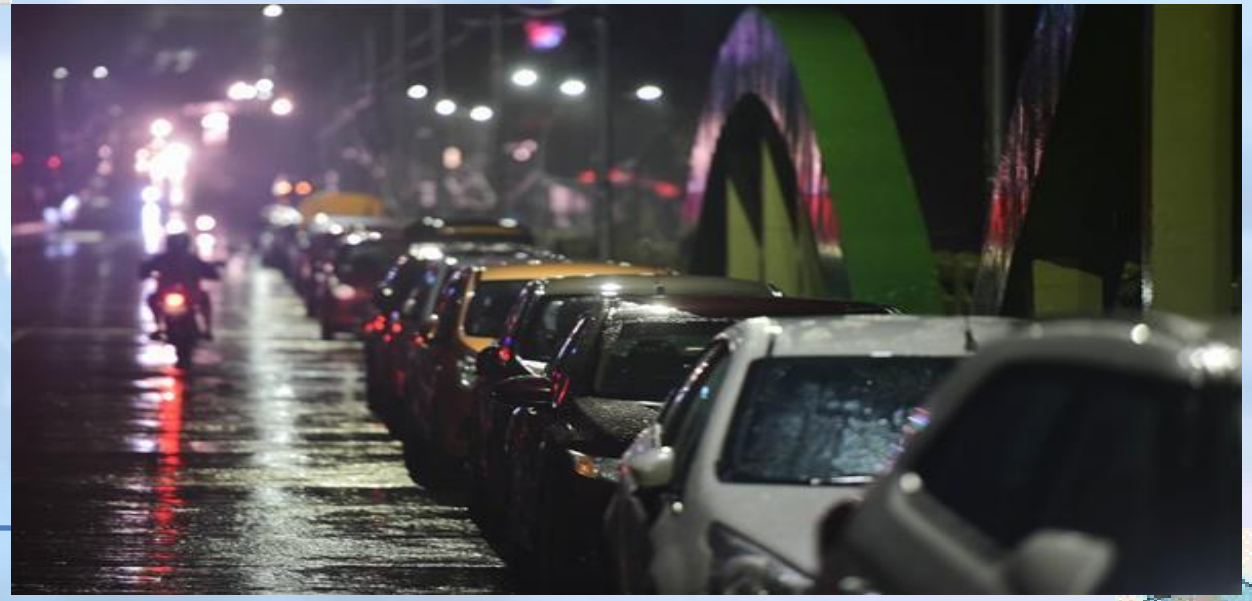
Subjective

Climatological/past impact and discuss impact with stakeholders

Objective

Impact models using vulnerability & exposure data set and meteorological information

Wind /Rainfall Impact-Risk based warning



Key Ideas in Impact-Based Forecast and Warning Services

Exposure

—Who or what may be affected in an area where a hazard may occur

Vulnerability

—The liability of exposed human beings, their livelihoods and property, to suffer bad effects when affected by a hazard

Risk

—The probability and magnitude of harm possible to humans, their livelihoods and assets because of exposure and vulnerability to a hazard

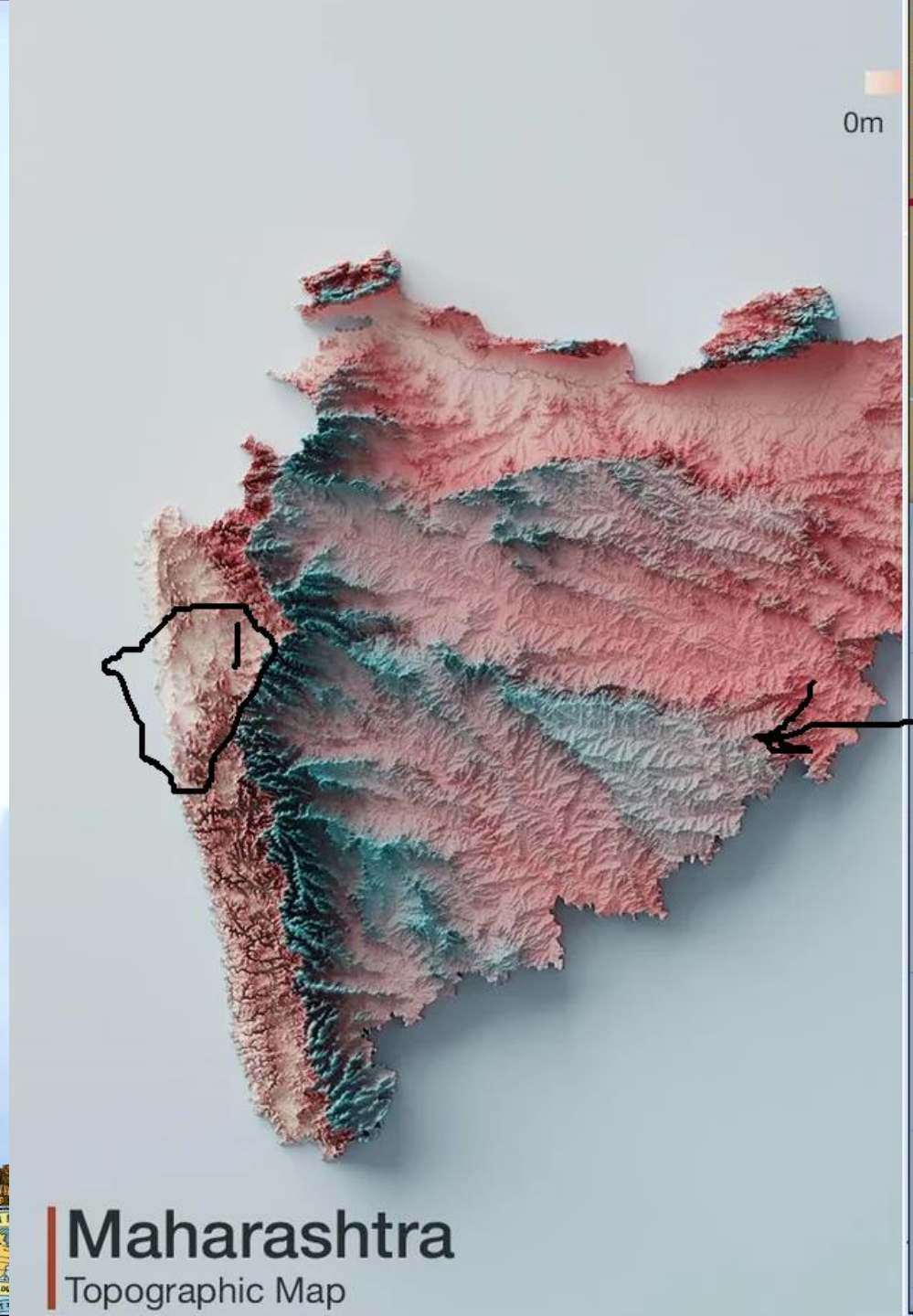
Geo- physical Exposure to start -Exercise 1-HAZARD AND EXPOSURES, IMPACT/VULNERABILITY

» **Where-Location, topography, proximity to Hills, plains, coast, river, valley, lakes, rivers etc**

Heavy rains and Flood-2021-Event, Hazard, Exposure and Impact and real time IBF IMD

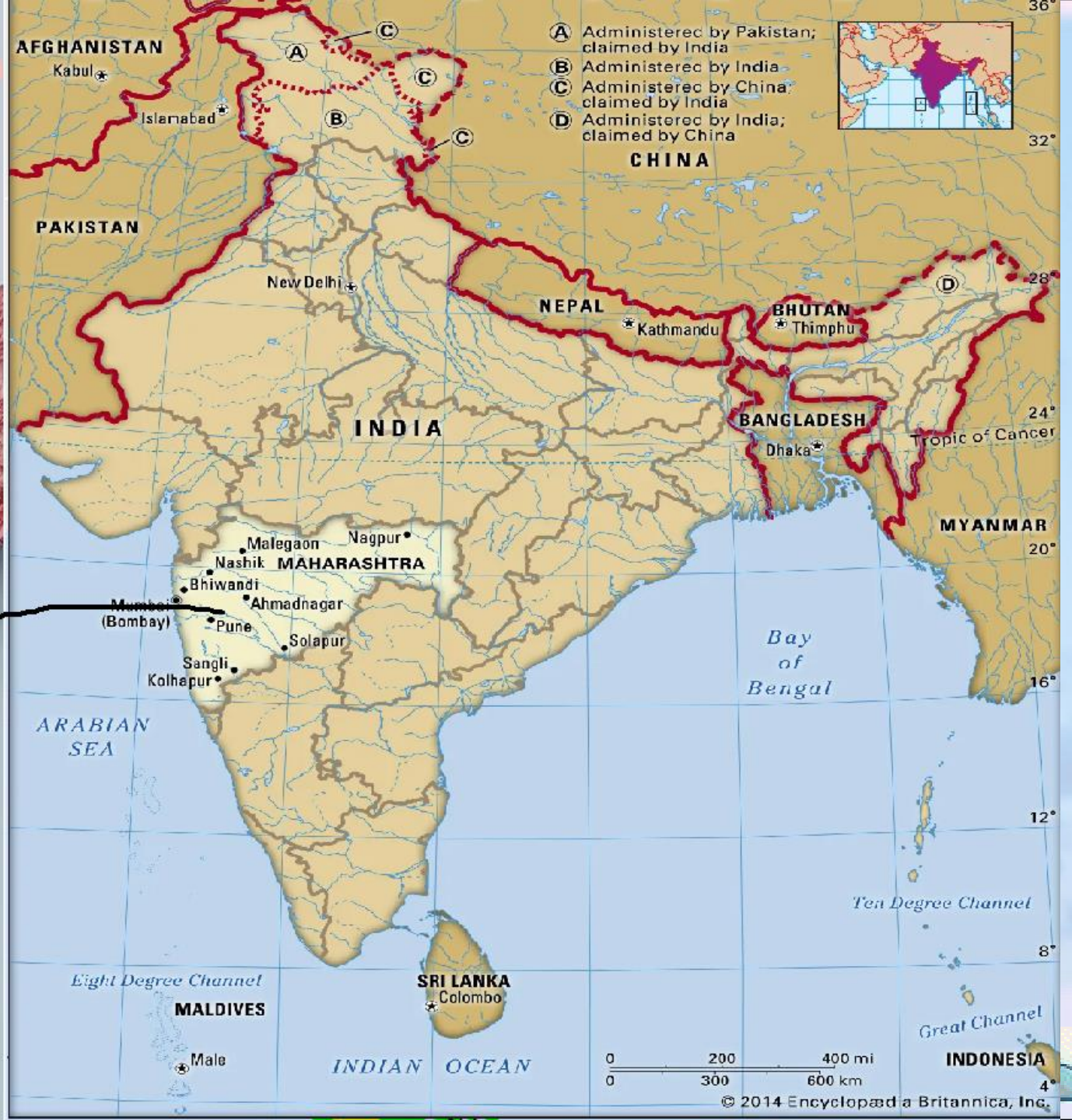
Maharashtra Rains

- **Maharashtra Flood: 14-23 July 2021(10-days of unusual heavy rainfall spell-1200-1800mm rainfall)**
- **Mumbai- 15-22 July 2021(a week of unusual spell-80-1200mm rainfall)**



Maharashtra

Topographic Map

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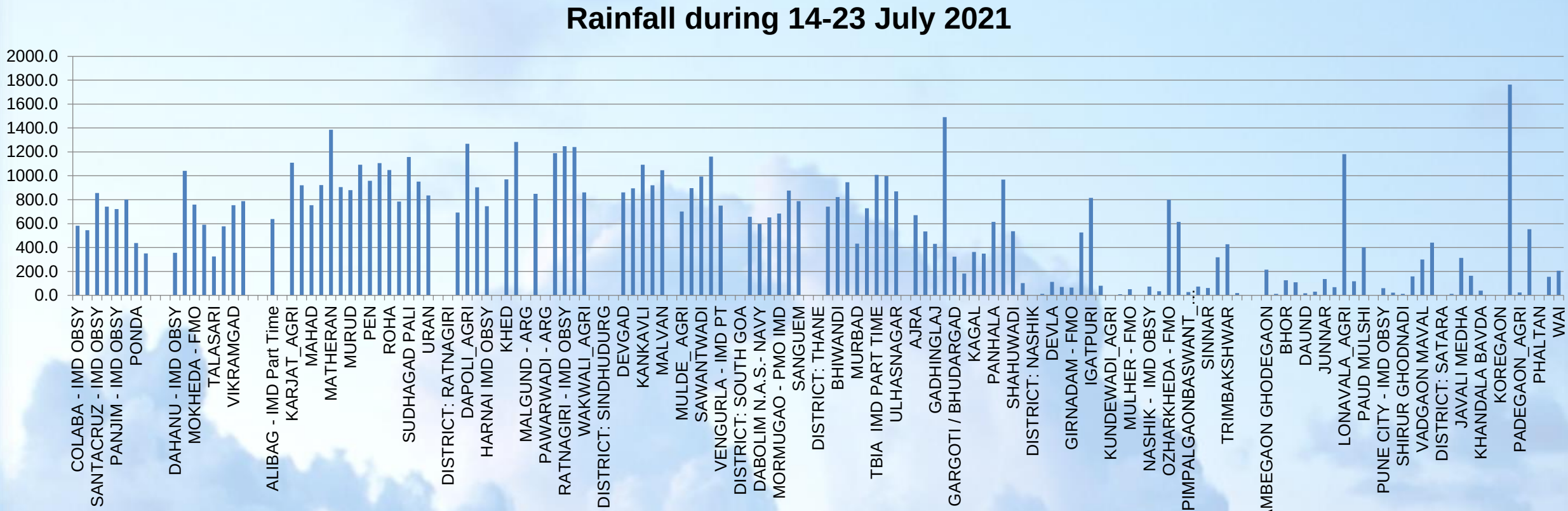
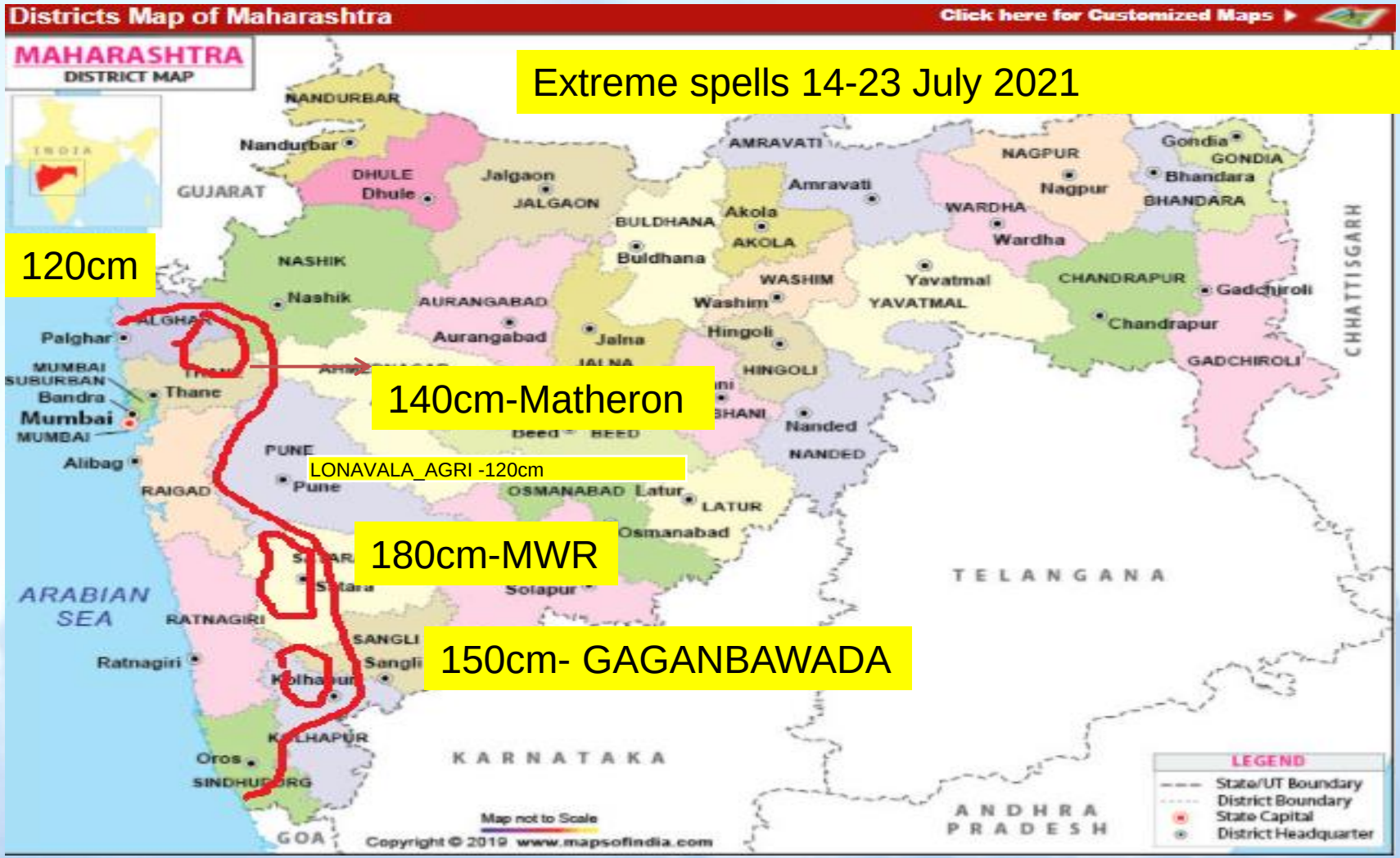
When Nainital turned into a fl
TOI News

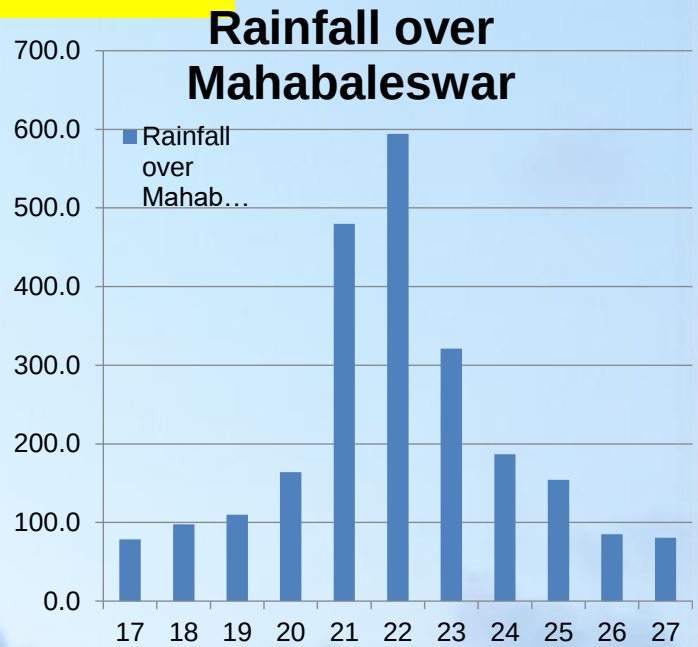

6 days ago

Maharashtra Flood: 14-23 July 2021(10-days of unusual heavy rainfall spell-1200-1800mm rainfall)



14-23 July 2021(10-days of unusual heavy rainfall spell-1200-1800mm rainfall)





Maharashtra Rain Impact 14-25 July (severe flooding 22 & 23 July, 2021)

Districts Affected: Raigad, Ratnagiri, Sindhudurg, Satara, Sangli and Kolhapur.

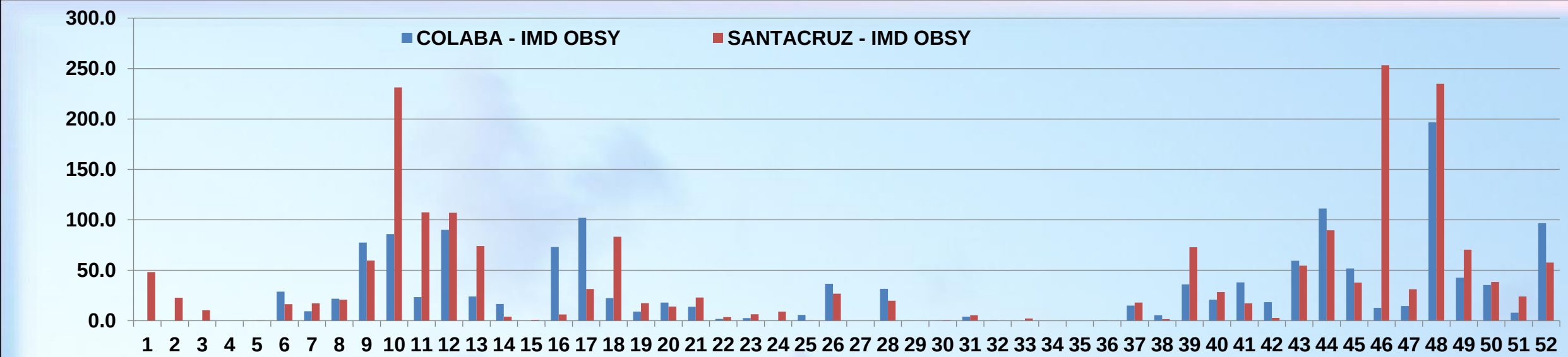
1. Lives lost- Death toll 250/100 missing, highest in Raigad with 95"
2. Village Affected: 1020
3. Evacuation: 375000 people (206,000 are from Sangli district and around 150,000 from Kolhapur district)
4. Poultry Death: 28,700
5. Animal Death: 300
6. Crop Damage: 200,000 hectare
7. Infrastructural Damage: Around 800 bridges have been submerged
8. Drinking water supply affected of about 700 villages
9. 14,700 electric transformer damage
10. Power supply affected of about 950,000 consumers

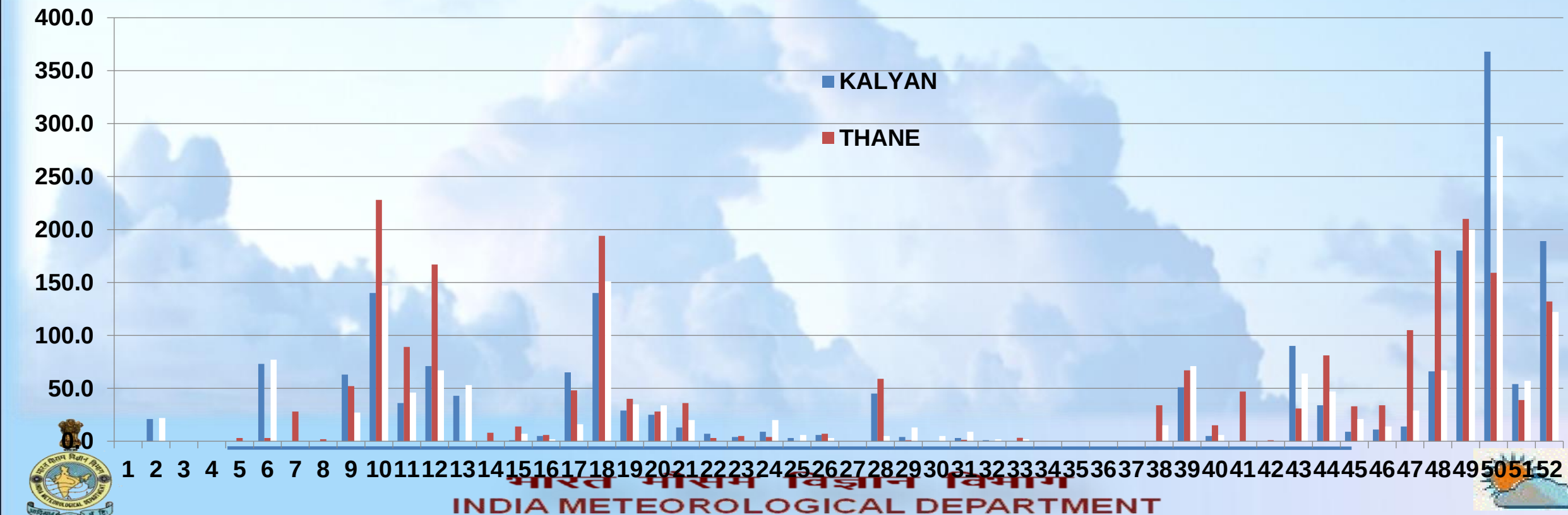
Components of IBF assessments of Maharashtra Heavy rainfall and Flash Floods, Landslides and related Hazards 2021

- **Event- 120-180cm in 10days- Heavy rainfall unusual higher and longer spell-Climate extremes)**
- **Period-14-25 July 2021 with floods severity 22-25 July**
- **Hazards caused-**
- **Primary-Flash flood, Land slides, Riverine flood**
- **Secondary – Long term inundation affecting lives further**
- **AGRICULTURE AND LIVESTOCK**
- **Urban Floods**

Mumbai- 15-22 July 2021(a week of unusual spell-800-1200mm rainfall)

- 15-16 July- SCZ-25.2cm Convective-Start of event with max in 2-3 hours at early morning
- 16-17 July-11cm Thane
- 17-18- 20-24 cm over Colaba and SCZ with max at 1-3am (occurrence of a CB over VIKHROLI-CHEMBUR areas of Mumbai in the early hours on Sunday)
- 18-19-8-10 cm- Main Mumbai IMD, but sub-urban SANPADA-19CM, Thane and Ullahsnagar-20-22cm
- 19-20- Rammandir-21cm, Kalyan 37 and Ullahsnagar-28cm
- 20-21-8-11cm with moderate over the main city IMD stations and Sanpada 11 cm
- 21-22- Mahahlaxmi 14cm, Colaba-10cm, 13-18cm Kalyan and Thane
- **Major Impacts of the spell-17-18- occurrence of a CB over VIKHROLI-CHEMBUR areas of Mumbai in the early hours on Sunday with 20-22cm triggered 3-4 landslide causing house collapsed, flooding low-lying areas, and electrocutions that resulted in the deaths of at least 31 people)**


COLABA - IMD OBSY
SANTACRUZ - IMD OBSY
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52


KALYAN
THANE
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

DATA BASE-SENDEI FRAME WORKS-IMD

- IMPACT AND HAZARD
- IMD, NDMA,SDMA, MEDIA, CROWED SOURCING
- CURRENT DATA AND UPDATED
- POST RELIEF MONEY ALLOCATION IS TO DATA
- IMD USE IBFW –DSS CYCLONE IMPACTS FORECASTS FOR IMPACT FINANCING

Weather Type	Category(in terms of Impact)	Duration of occurrence	Year, date & Month (--/--/--)	State	Location/ Area affected (District/ Tehsil/Block)	Associated Impact		
						Types	Primary/Secondary/ Tertiary	Data
						Human casualties	Death	
							Injury	
							Missing	
						Livestock with type of species	Death	
							Injury	
							Missing	
						Evacuation	Number of people	
							Number of different livestock	
						Trees uprooted(Types and estimated numbers)	Small, medium, large	
						Infrastructural Damage	Crop (Type of crop, area & stage of crop)	
							Type of House and number	
						Affected community services	Hospital	
							School	
							Water supply	
							Other services	
						Transportation	Rail (name of route/rail traffic disruption)	
							Road/Highway (name of route/traffic disruption)	
							Airports (name)	
						Communication	Telephone towers (no of uprooted/bent)	
							Electricity supply {no of poles & towers (11/22/33 Kw lines)uprooted/bent}	
						Occurrence of flooding/ inundation /landslide	If yes, then area of occurrence of flood/Inundation and location/areas of landslide	

REQUIREMENTS AND APPLICATION

Operational Shifts needed

Phenomenon-Based Forecasts	→	Impact-Based Forecasts
Products-Based Services	→	Decision Support Services
Meteorological Threshold-Based Warning	→	Impact Threshold-Based Warning (Risk based warning)

Deterministic (best forecast) → Probabilistic (uncertainty range)

Resident of the Nolia Nua Gaon, Odisha explaining community resource and hazard maps (Photo: Sanne Hogesteeger/Climate Centre)

Understanding Risk and Impact-Role of Communities and end users

- Risks arise from the combination of hazards, exposure of people and assets to the hazards and their vulnerabilities and coping capacities at a particular location. Assessments of these risks require systematic collection and analysis of data and should consider the dynamics and compounding impacts of hazards coupled with vulnerabilities resulting from unplanned urbanization, changes in rural land use, environmental degradation and climate change. The level of risk can change depending on the actual impacts and consequences of hazards. Therefore, the risk assessment must include an assessment of the community's coping and adaptive capacities. It is also important to gauge the perception of the level of risk faced by those who are vulnerable- **Multi-hazard Early Warning Systems: A Checklist, 2017, WMO)**
- **Risk knowledge is the baseline needed before undertaking further action.**
- **When addressing end-users through an early warning system, it is fundamental that the importance and potential of the system are well understood by the community itself.**
- **To achieve this, the public must be informed about risks, risk communication channels, and emergency plans.**

It gives High returns Return-of-Investment ratios

- Triggers action through effective warning messages
- Impact-based warnings increased the likelihood that people would take protective action- **Washington Post**
- The return in investment in IBF is 250-720% - the cost effectiveness of early actions (triggered by impact-based forecasts)- An early interventions **(Global Dialogue Platform on FbF-Berlin 2018)**

Benefits of an Impact Warning Service

- Relays a message to enable those at risk to take appropriate actions
- Improved planning for different scenarios based on different impacts
- Contains information about level of confidence in the forecast for better decision-making
- Provides post-event analysis of multi- hazard impacts to assist in planning, response and mitigation of impacts
- Coordinated process to address disaster response and preparedness
- Common situational awareness

Risk Matrix

Green: No severe hydromet hazard expected

Yellow: Be aware

Orange: Be prepared

Red: Take action

LIKELIHOOD				
HIGH		2	6	10
MED		1	5	9
LOW			4	8
VERY LOW			3	7
	VERY LOW	LOW	MEDIUM	HIGH

IMPACT

Minimal	Minor	Significant	Severe

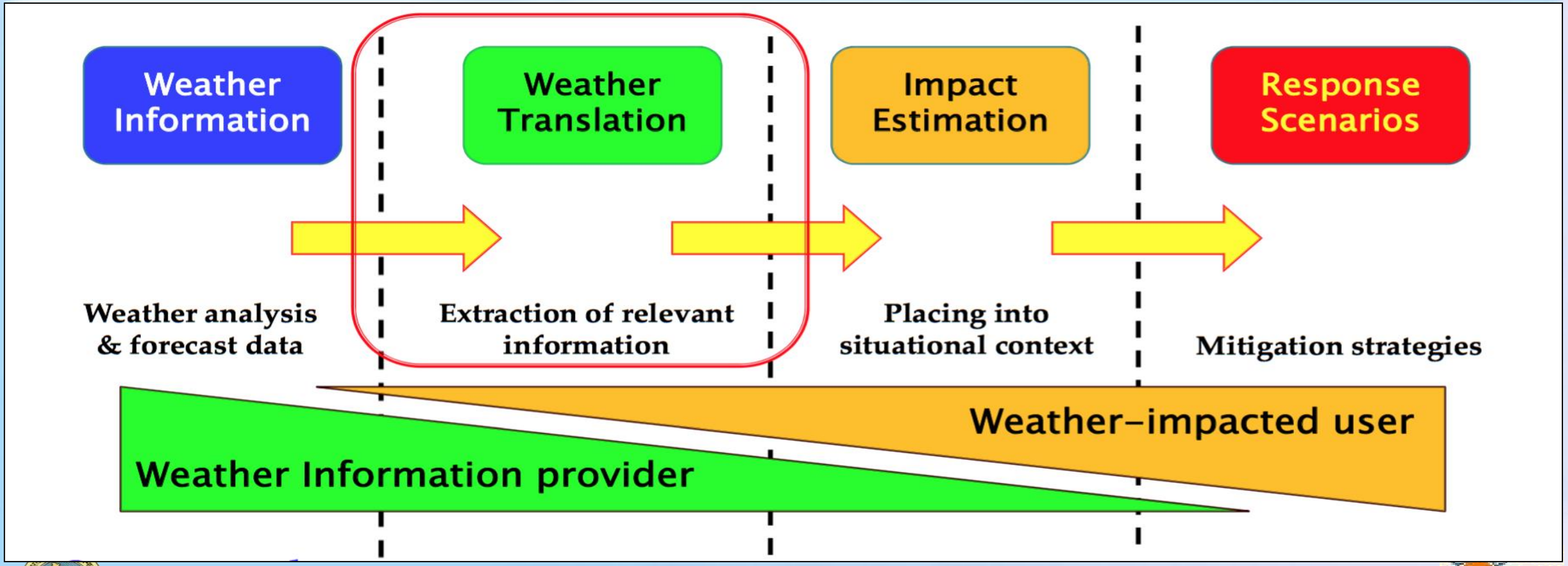
GREEN	**NO SEVERE WEATHER EXPECTED**
YELLOW	**BE AWARE**. There is a moderate risk of severe or a low risk of extreme weather occurring. *Remain alert and ensure you access the latest weather forecast.*
AMBER	**BE PREPARED.** There is a high risk of severe or a moderate risk of extreme weather occurring. *Remain vigilant and ensure you access the latest weather forecast. Take precautions where possible.*
RED	**TAKE ACTION**. There is a high risk of an extreme weather event occurring. *Remain extra vigilant and ensure you access the latest weather forecast. Follow orders and any advice given by authorities under all circumstances and be prepared for extraordinary measures.*

Assign a colour to the warning which is a combination of potential impact and likelihood (source: Met Office)

Impact-based Forecasting

An illustration on how weather information can be translated to response actions

- Relevant information from weather information is extracted and placed into the situation context to produce impact estimations;
- With potential impact information available, response scenarios can be set-up



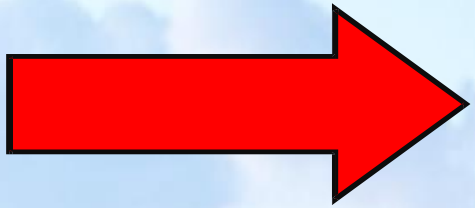
Source: Baode Chen and Xu Tang (2014) Translating weather forecasts into impact-relevant information

BROAD METHODOLOGY AND SCIENTIFIC FRAME WORKS AND DATA –STAGE 1 TO STAGE 4 –GIS BASED DSS IBFW

- STANDARDAS PER WMO 2015, 2021 ETC
- BROAD METHODOLOGY AND SCIENTIFIC FRAME WORKS AND DATA WITH STAKE HOLDERS
- STAGE 1 TO STAGE 4
- GIS BASED DSS IBFW
- FOR EVENTS HAZARDS(HEAVY RAINFALL, TC, HW/CW, TS, DS, STRONGER WINDS)
- IBFW DATA- WHAT EUROPEAN COUNTRIES DO MORE? SURVEY RESULTS
- Events vs warnings –lead time

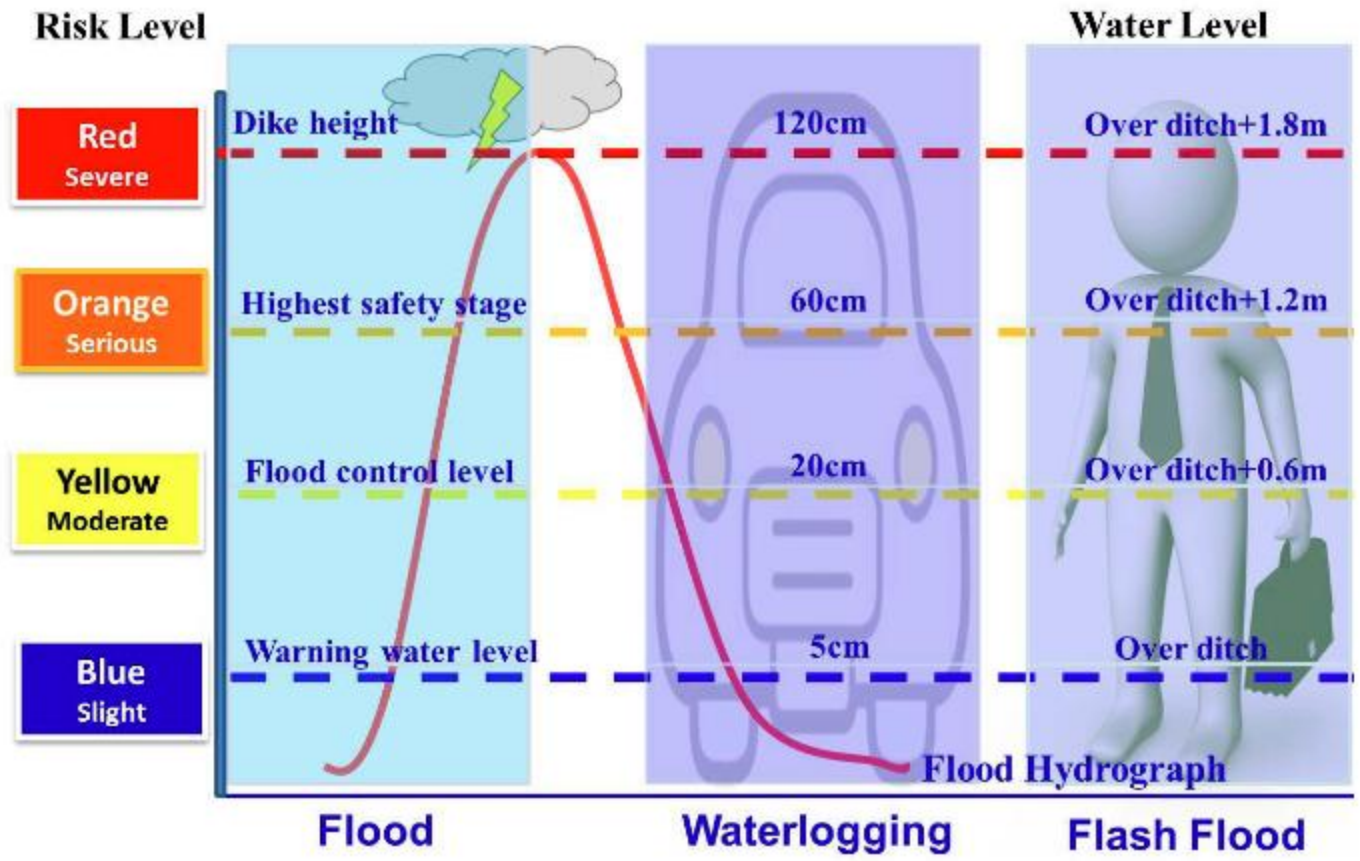
Why move to Impact-Based Forecasting?

Weather Forecasts and Warnings

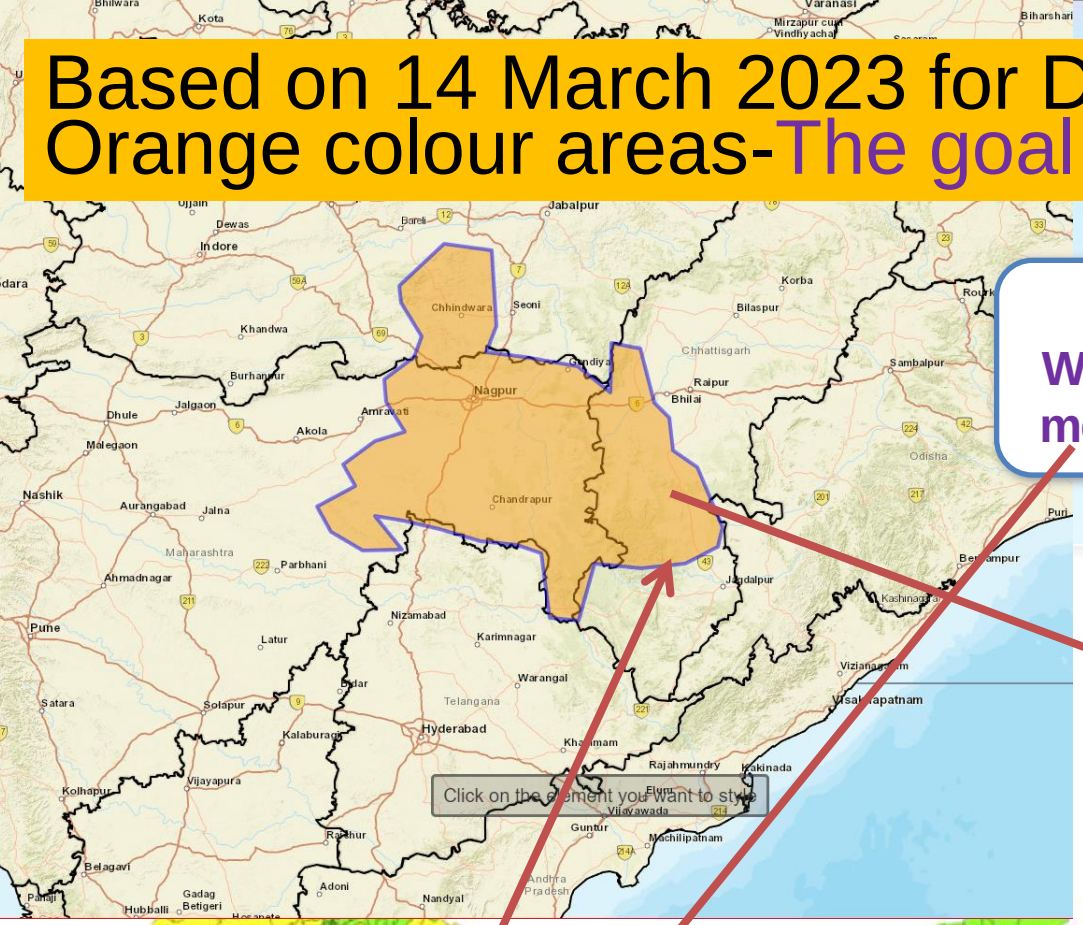


Impact-Based Forecast and Warning Services

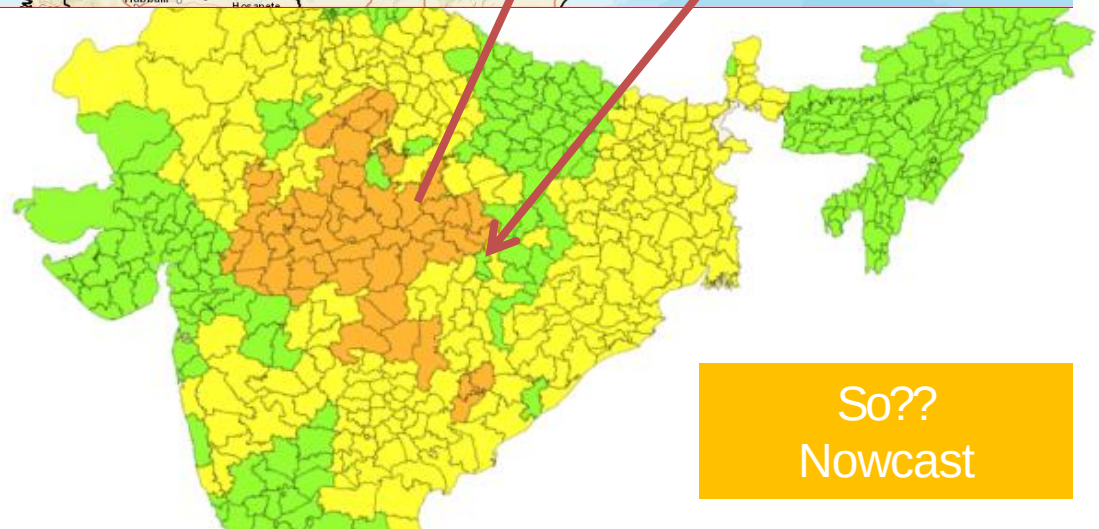
Risk-based warning levels of flood, waterlogging and flash flood in China



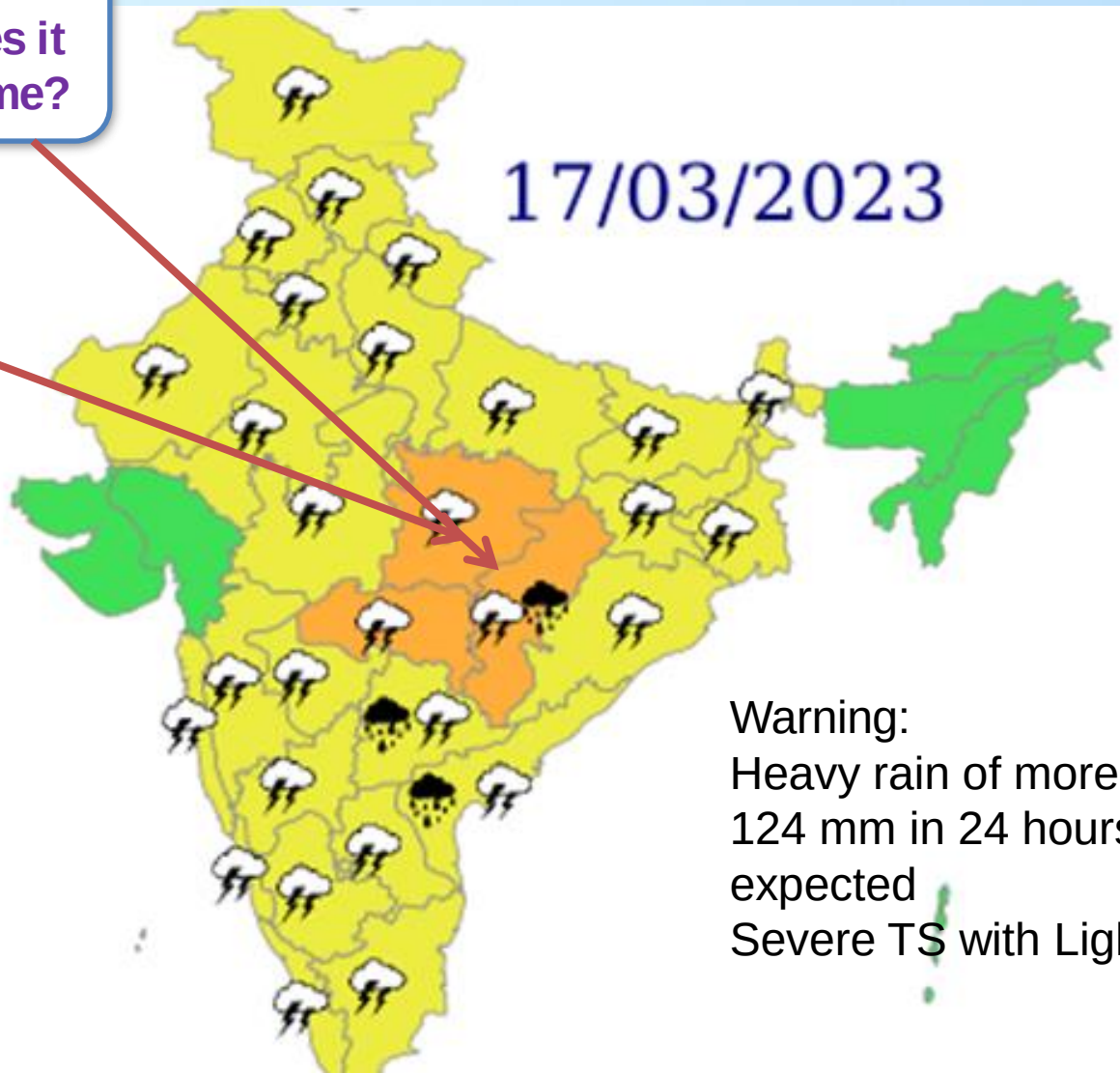
Based on 14 March 2023 for Day 4 for 17th March –MHEW without IBF
Orange colour areas-The goal is to change from this type of forecast …



So??
What does it mean to me?



So??
Nowcast



Warning:
Heavy rain of more than 124 mm in 24 hours is expected
Severe TS with Lightning

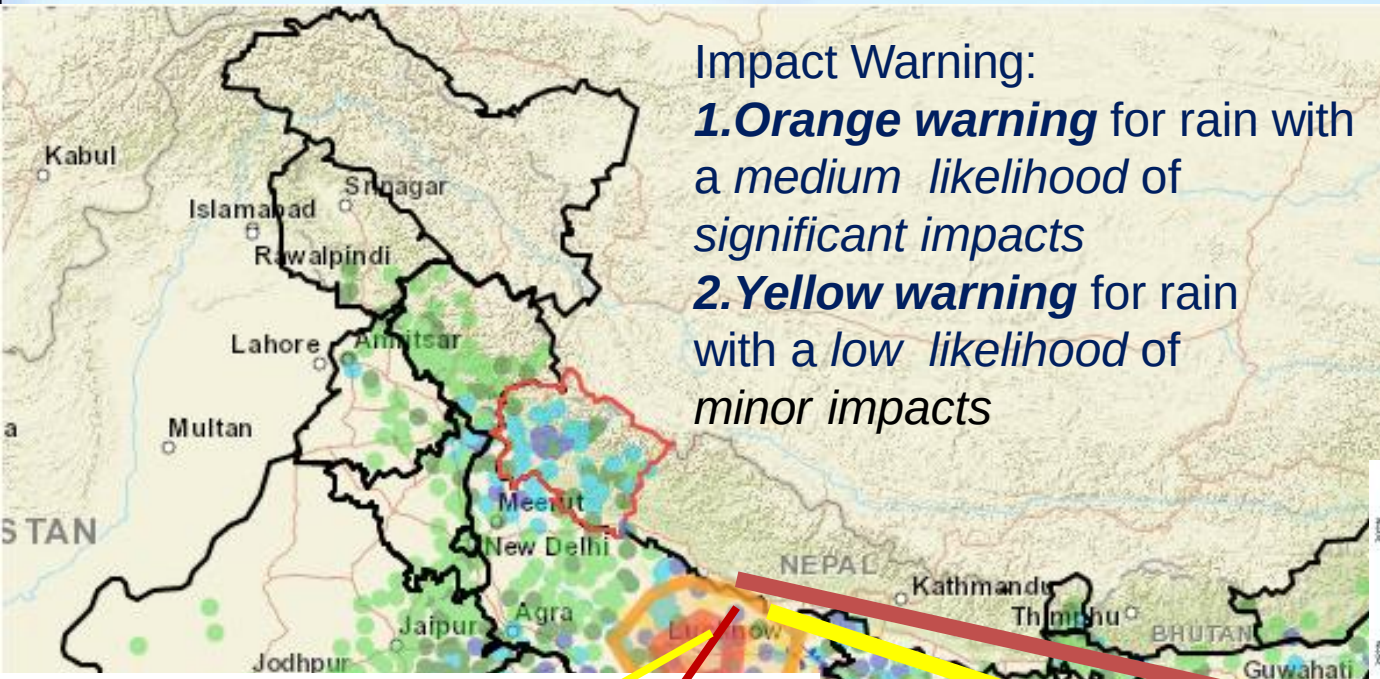
Example – To an Impact-based Early Warning Forecast System

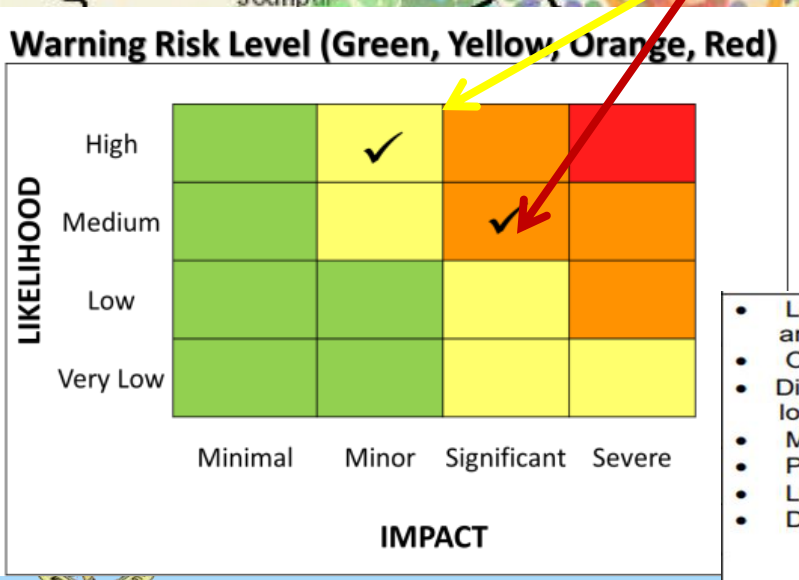
Impact Warning:

1.Orange warning for rain with a *medium likelihood* of *significant impacts*

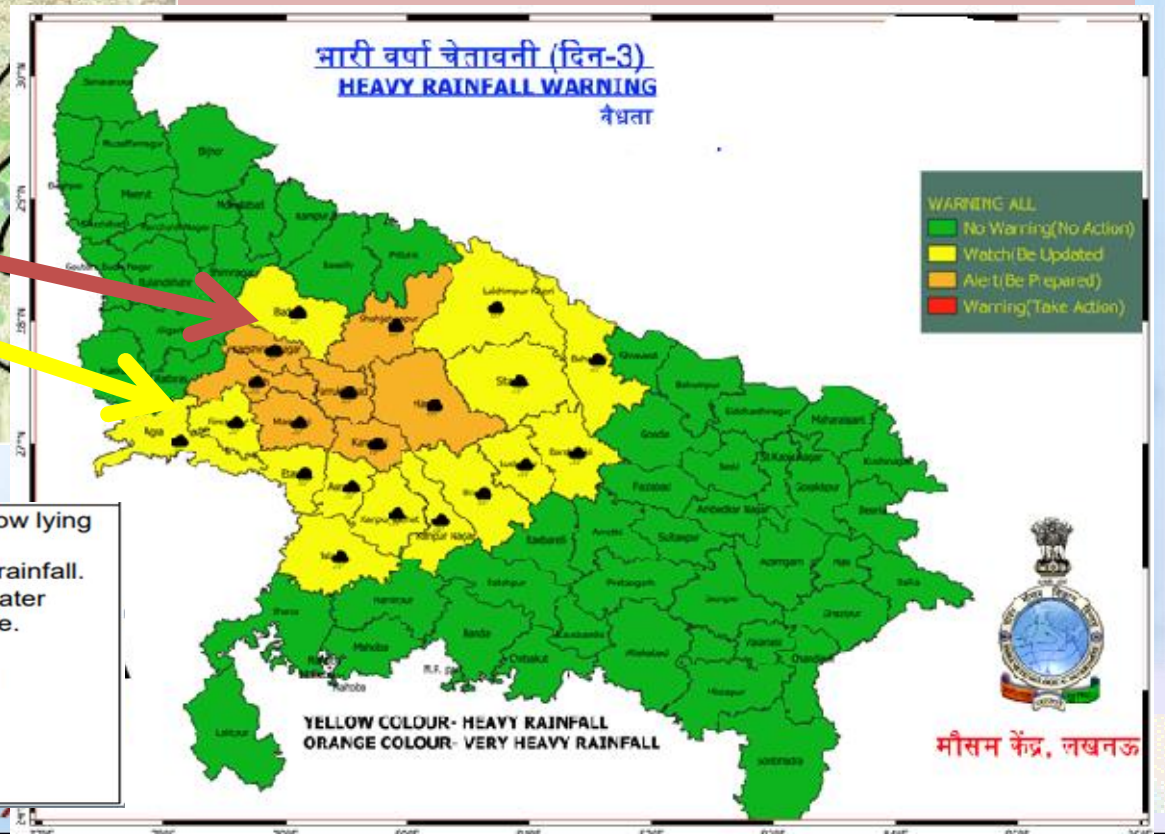
2.Yellow warning for rain with a *low likelihood* of *minor impacts*

- **Important to note the difference in impact and likelihood of the yellow and orange warnings**
- **These warnings require a different response from disaster management**





- Localized Flooding of roads, water logging in low lying areas and closure of underpasses.
- Occasional reduction in visibility due to heavy rainfall.
- Disruption of traffic flow in major cities due to water logging in roads leading to increased travel time.
- Minor damage to Kutch roads.
- Possibilities of damage to vulnerable structure
- Localized Mudslides.
- Damage to horticulture crops



Methodological Framework of IBWF and Warning Service WMO, 2015 and 2021

» The foundation for an effective IBFWS over for any area at Dist-wise, is built when knowledge and understanding of geophysical hazard threats are combined effectively with knowledge and understanding of vulnerability and exposure relating to all elements of society.

United Nations Development Programme

UNDP

Empowered lives. Resilient nations.

FIVE APPROACHES TO BUILD FUNCTIONAL

EARLY WARNING SYSTEM

World Meteorological Organization

Weather · Climate · Water

WMO-No. 1150

WMO Guidelines on
Multi-hazard Impact-based
Forecast and Warning Services

THE FUTURE OF FORECASTS:
IMPACT-BASED FORECASTING
FOR EARLY ACTION

Reviews of Geophysics

Review Article | Open Access

Impact Forecasting to Support Emergency Management of Natural Hazards

Bruno Merz, Christian Kuhlicke, Michael Kunz, Massimiliano Pittore, Andrey Babeyko, David N. Bresch, Daniela I. V. Domeisen, Frauke Feser, Inga Koszalka, Heidi Kreibich ... See all authors

First published: 24 August 2020 | https://doi.org/10.1029/2020RG000704 | Citations: 1

WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services

Part II: Putting Multi-hazard IBFWS into Practice

2021 edition

BAMS Bulletin of the American Meteorological Society

Volume 100: Issue 10

Sections

References

Figures

Cited By

Editorial Type: Article

Evolving the National Weather Service to Build a Weather-Ready Nation: Connecting Observations, Forecasts, and Warnings to Decision-Makers through Impact-Based Decision Support Services

Louis W. Uccellini[1] and John E. Ten Hoeve[1]

View More

Print Publication: 01 Oct 2019

DOI: https://doi.org/10.1175/BAMS-D-18-0159.1

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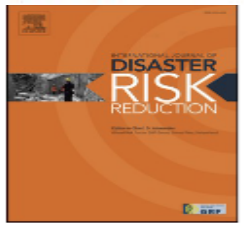


Check for updates

'Where oh where is the data?': Identifying data sources for hydrometeorological impact forecasts and warnings in Aotearoa New Zealand

Sara E. Harrison [a,b,*], Sally H. Potter [b], Raj Prasanna [a], Emma E

[a] Massey University, New Zealand

National Weather Service (NWS) Service Description Document (SDD)
Impact-Based Decision Support Services for NWS Core Partners
April 2018

Contents

"What the weather will do" – results of a survey on impact-oriented and impact-based warnings in European NMHSs

Rainer Kaltenberger, Andreas Schaffhauser, and Michael Staudinger

Zentralanstalt für Meteorologie und Geodynamik (ZAMG), Vienna, Austria

भारत मौस
INDIA METEORO

Risk Assessment

Risk may be mathematically expressed as:

$$|\,Risk\ of\ impact\ (x,\ t)\,|$$
$$\equiv |\,hazard\ (x,\ t)\,| \cup |\,vulnerability\ (x,\ t)\ | \cup |\,exposure\ (x,\ t)\,|$$

where ∪ is the union of the level of hydrometeorological forecast uncertainty, the degree of vulnerability and the level of exposure. Risks:

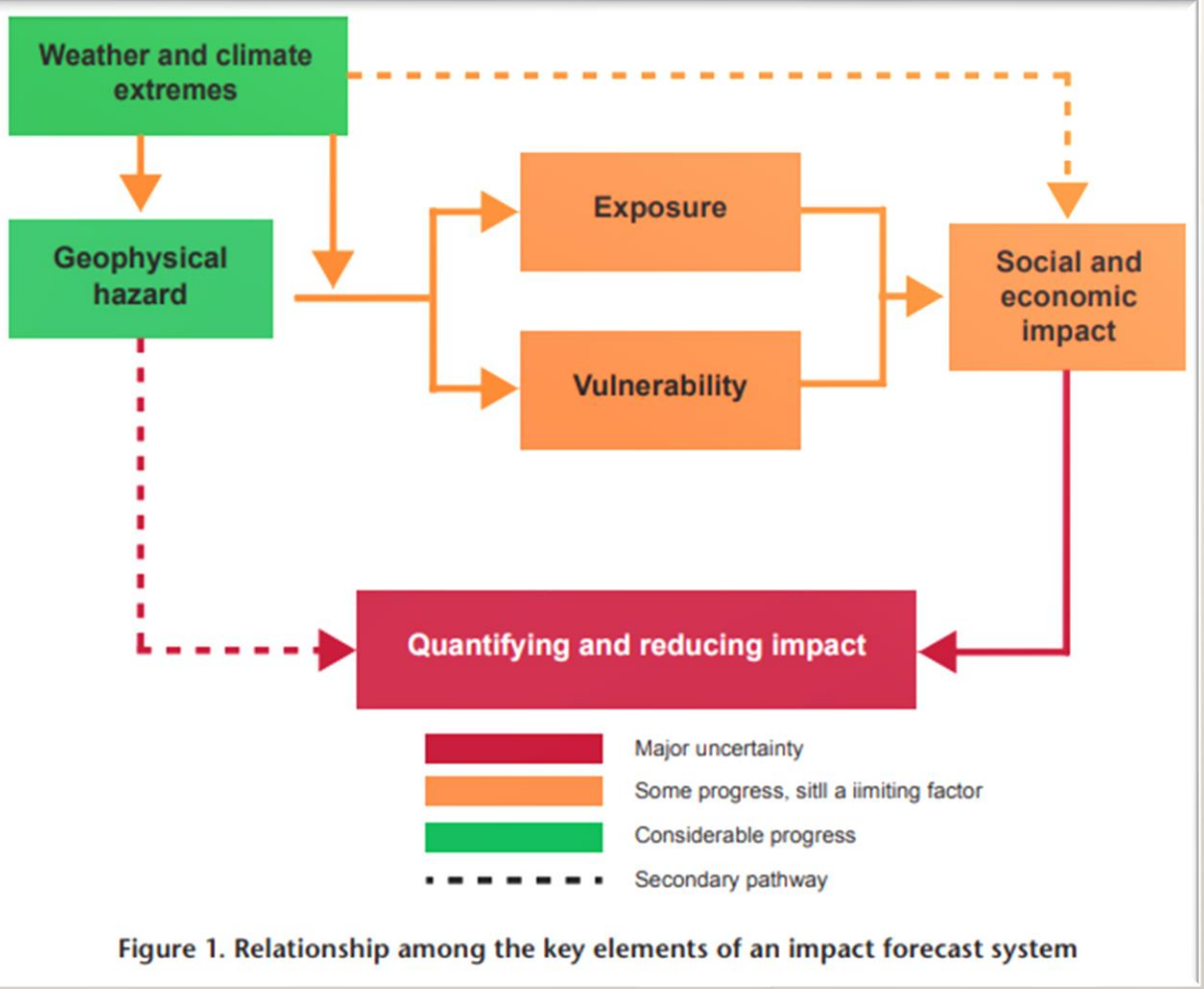


Figure 1. Relationship among the key elements of an impact forecast system

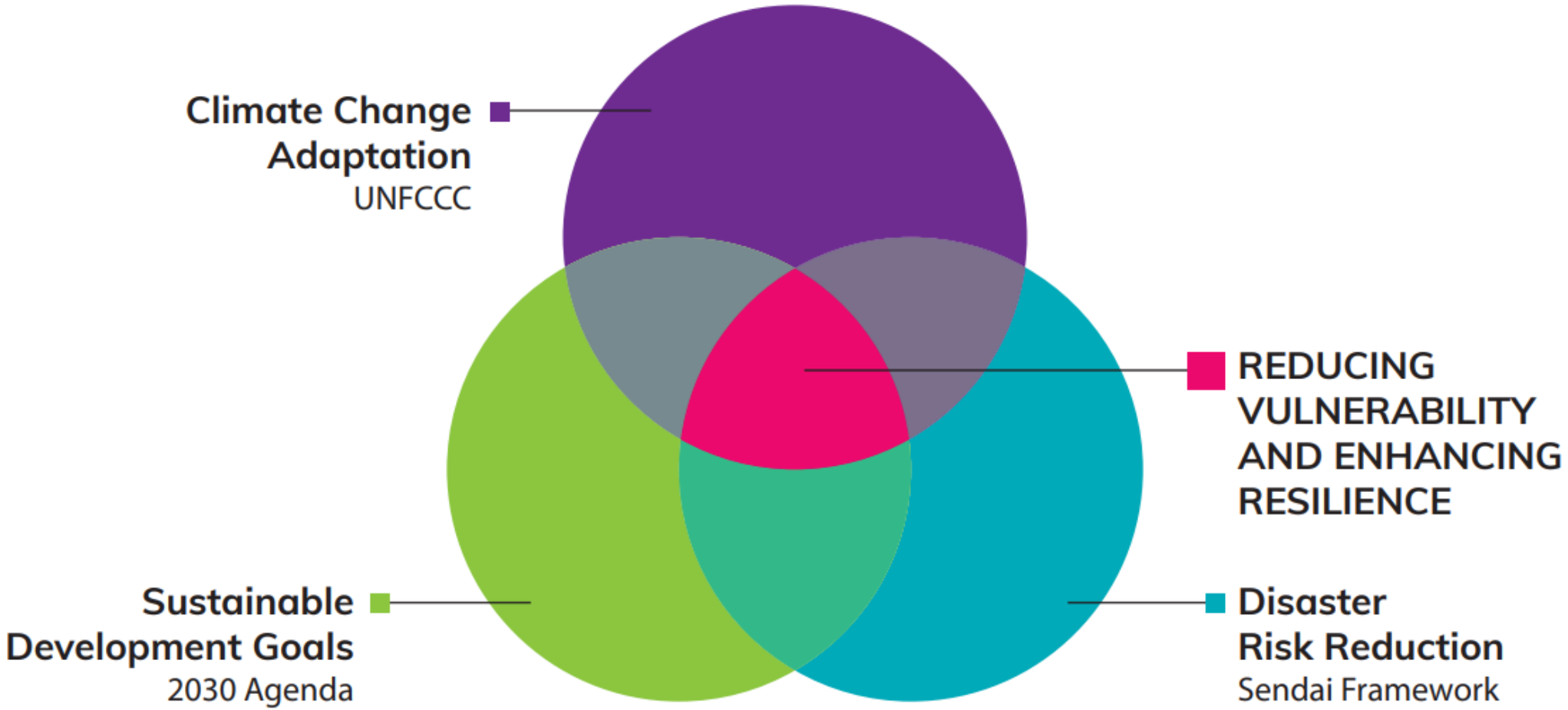
Subjective

Climatological/past impact and discuss impact with stakeholders

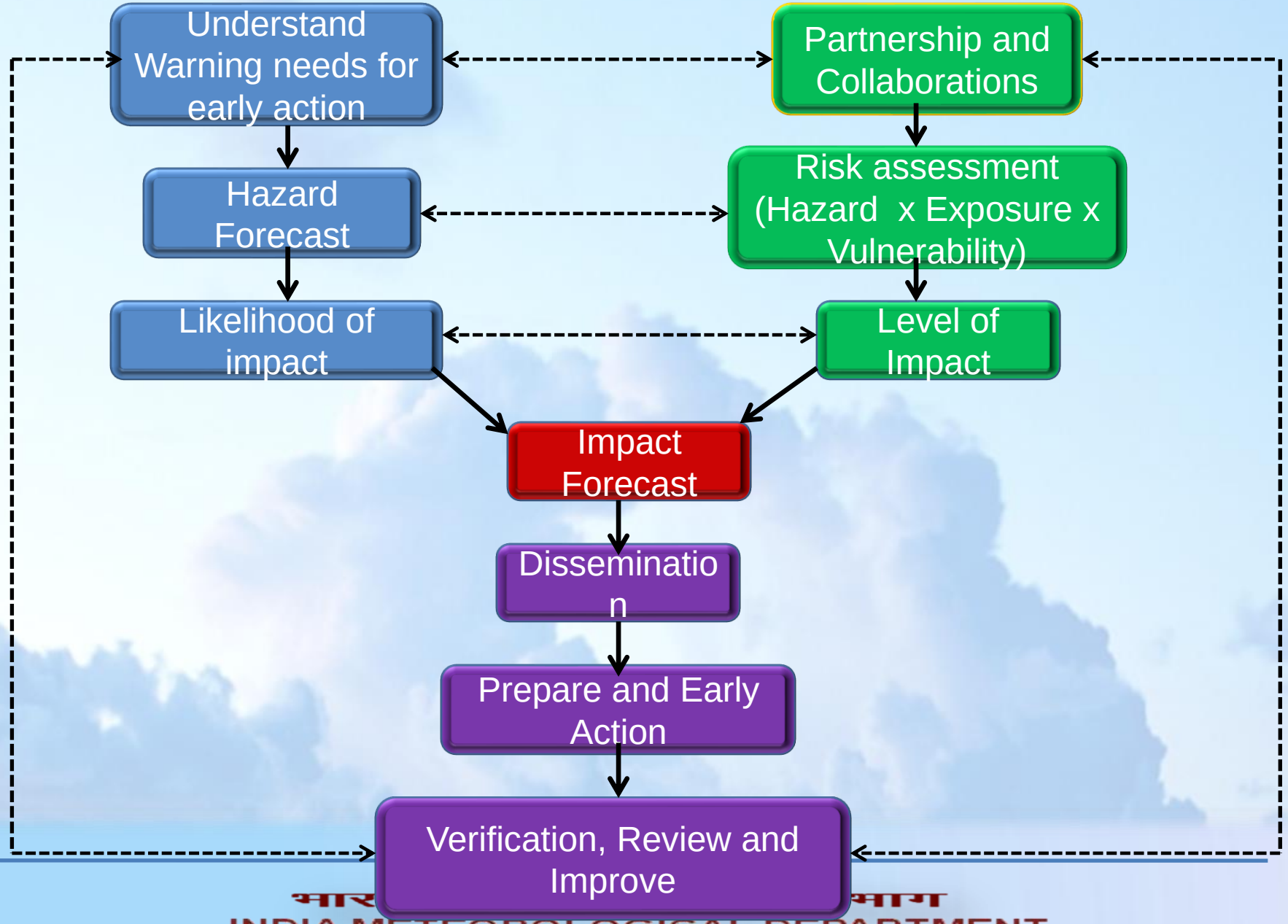
Objective

Impact models using vulnerability & exposure data set and meteorological information

Figure 2. Conceptual representation of the intersection between the SDGs, DRR, and CCA agendas 2015-2030 (UNFCC C, 2017)



Impact based Forecasting and Warning Services



Acknowledgement

Special Thanks to:

Dr. Mrutyunjay Mohapatra, DG IMD

And

IMD GIS Team & NWFC and RSMC Team

How NHMS co- developing IBFW and HIVE data status

“What the weather will do” – results of a survey on impact-oriented and impact-based warnings in European NMHSs

- From August 2018 to May 2019 a survey, consisting of 79 items, was conducted on the status of implementation of IoWs and IbWs, with attention to: warning format, legislation and production process of warnings, dissemination and verification of warnings, impact databases, warning strategy and cooperation, legal obstacles and cross-border collaboration. The survey was carried out among 37 NMHSs participating in the EUMETNET EMMA/Meteoalarm project, an integrated, regional warning system currently supporting 33 languages and 12 hazards to visualize warnings from European NMHSs in an easy and understandable way and make them available to re-users (EUMETNET, 2020a, b; Dupuy et al., 2011).

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Received: 01 Mar 2020 – Accepted: 12 Mar 2020 – Published: 31 May 2020

Are they also objective based(likelihood vis-a- vis risk quantitative thresholds for each warning level, run any hazard and impact model), language

- » color code
- ➢ The survey found that a four-level color code (green, yellow, orange, red) is well established and very high numbers-84 % of NMHSs
- » Dist scale
- ➢ Majority, 53 % of NMHSs and 19 % are issuing warnings on municipality
- ➢ Free polygons in the future: a majority of 56 % are planning to issue their warnings in this way; 31 % do not know and 9 % are not planning to do so.
- » Objective based IBF(likelihood vis-a- vis risk
- ➢ Asked whether NMHSs are including a quantitative estimation of the certainty (likelihood) of the event into public weather warnings, a majority of 41 % replied “No”, 28 % answered “Yes” and 22 % responded “Not yet, we are planning to do so”.
- » Language
- ➢ Regarding languages, 50 % of European NMHSs are currently issuing warnings in one language, 38 % are supporting two languages, 9 % are publishing warnings in three languages and one NMHS features four languages
- » If quantitative thresholds for each warning level made publicly available on your website- 47 % replied “Yes, for all parameters”, “No”.
- Any Hazard and Impact models- A majority of 69 % of European NMHSs, currently do not run impact

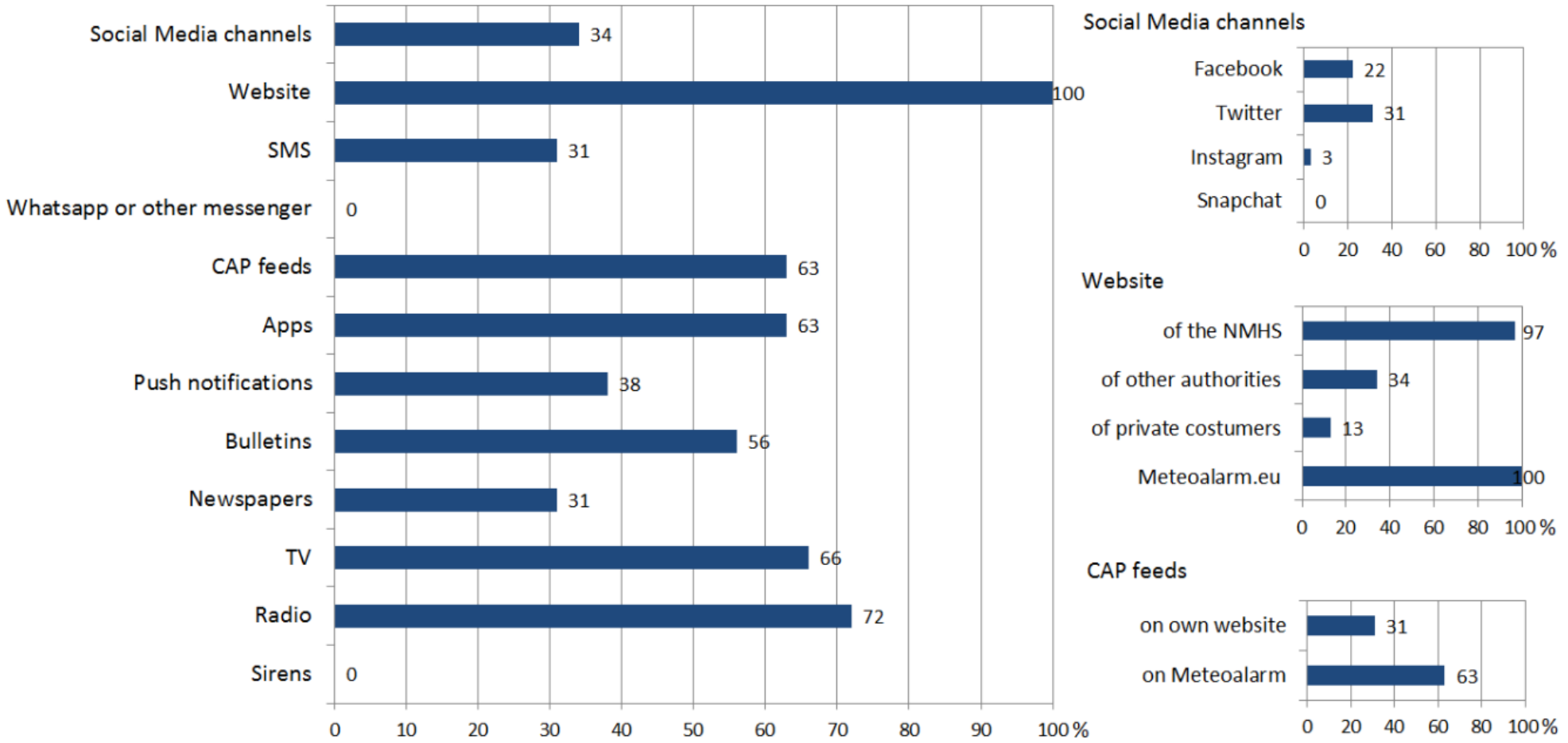


Figure 5. Dissemination channels regularly used for hydrometeorological warnings as surveyed at 32 of the 37 NMHSs participating in the EUMETNET Meteoalarm project. Further regular dissemination channels include email, ftp, YouTube and podcast/MP3.

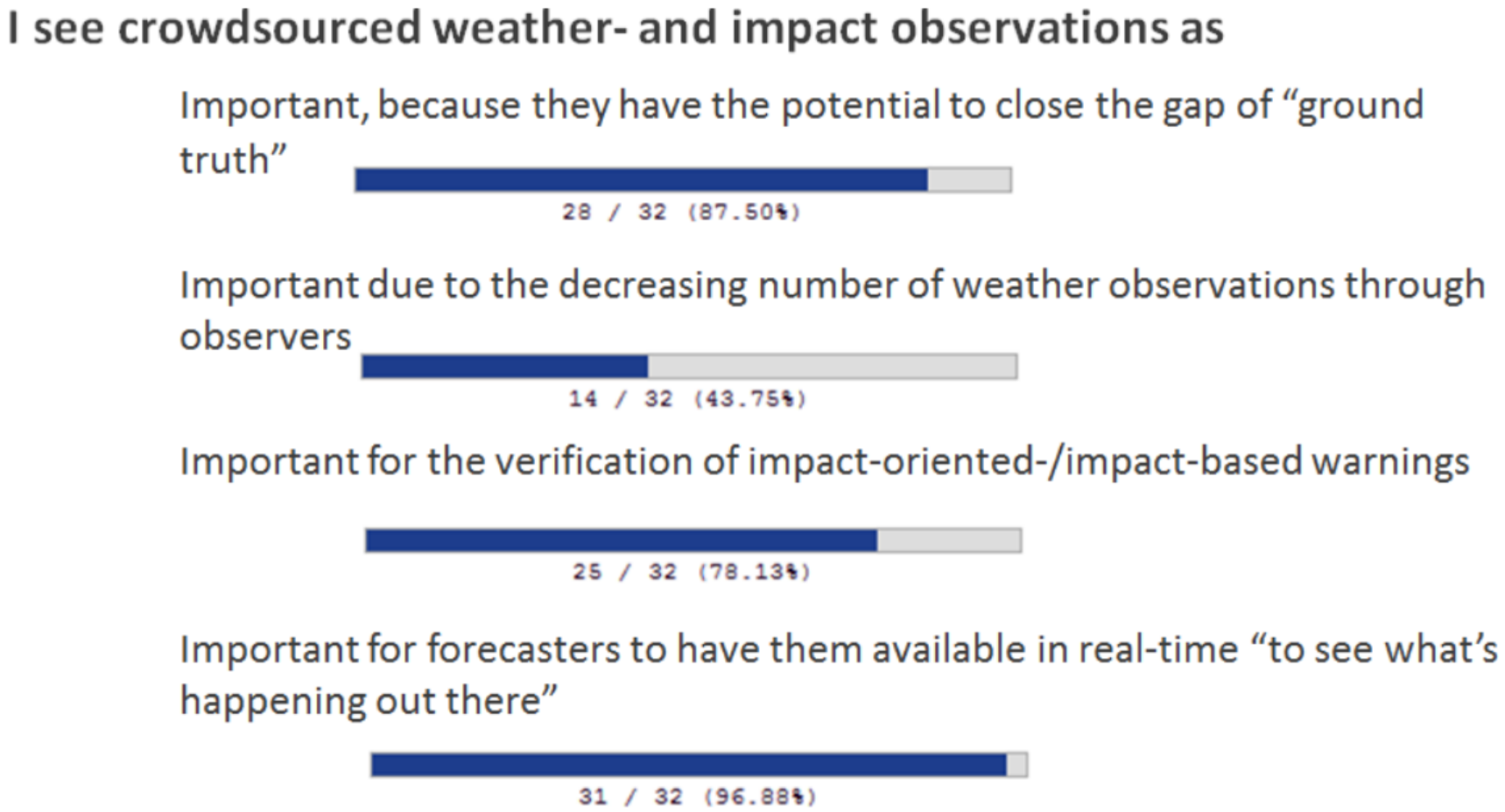


Figure 6. Opinions regarding crowdsourced weather- and impact observations of 32/37 respondents. Crowdsourcing is seen as an appropriate way to close the gap of "ground truth" and important for the verification of IoWs/IbWs. Especially the real-time availability to "see what's happening out there" in order to adapt warnings in terms of a feedback loop is considered to be important for operational meteorologists.

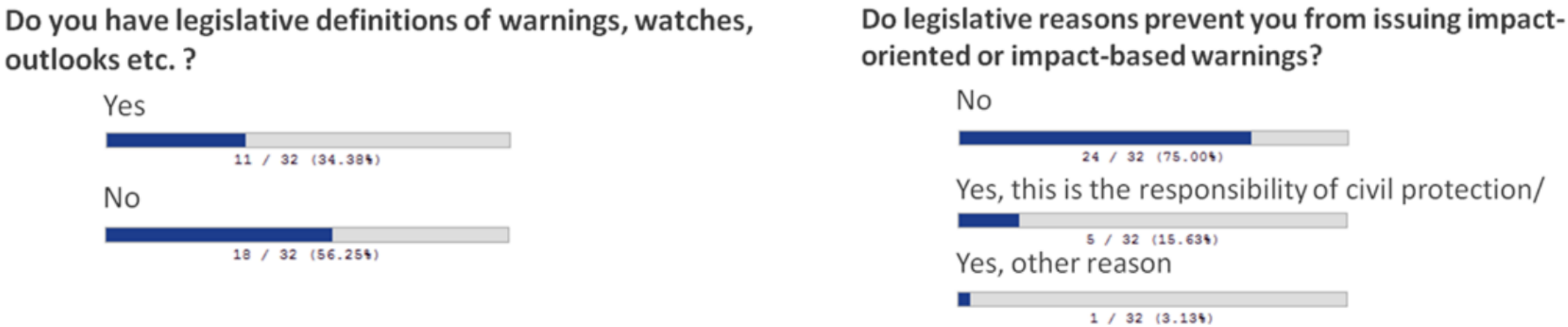


Figure 3. Legal aspects of warnings. 75 % of the surveyed NMHSs do not have legislative reasons preventing them from issuing impact-oriented or impact-based warnings. However obstacles are identified in fragmentation of responsibilities of authorities, fears of CPAs to "lose control" in the decision process, federalization and high number of authorities involved, as well as cooperation to CPAs and other authorities, among others.

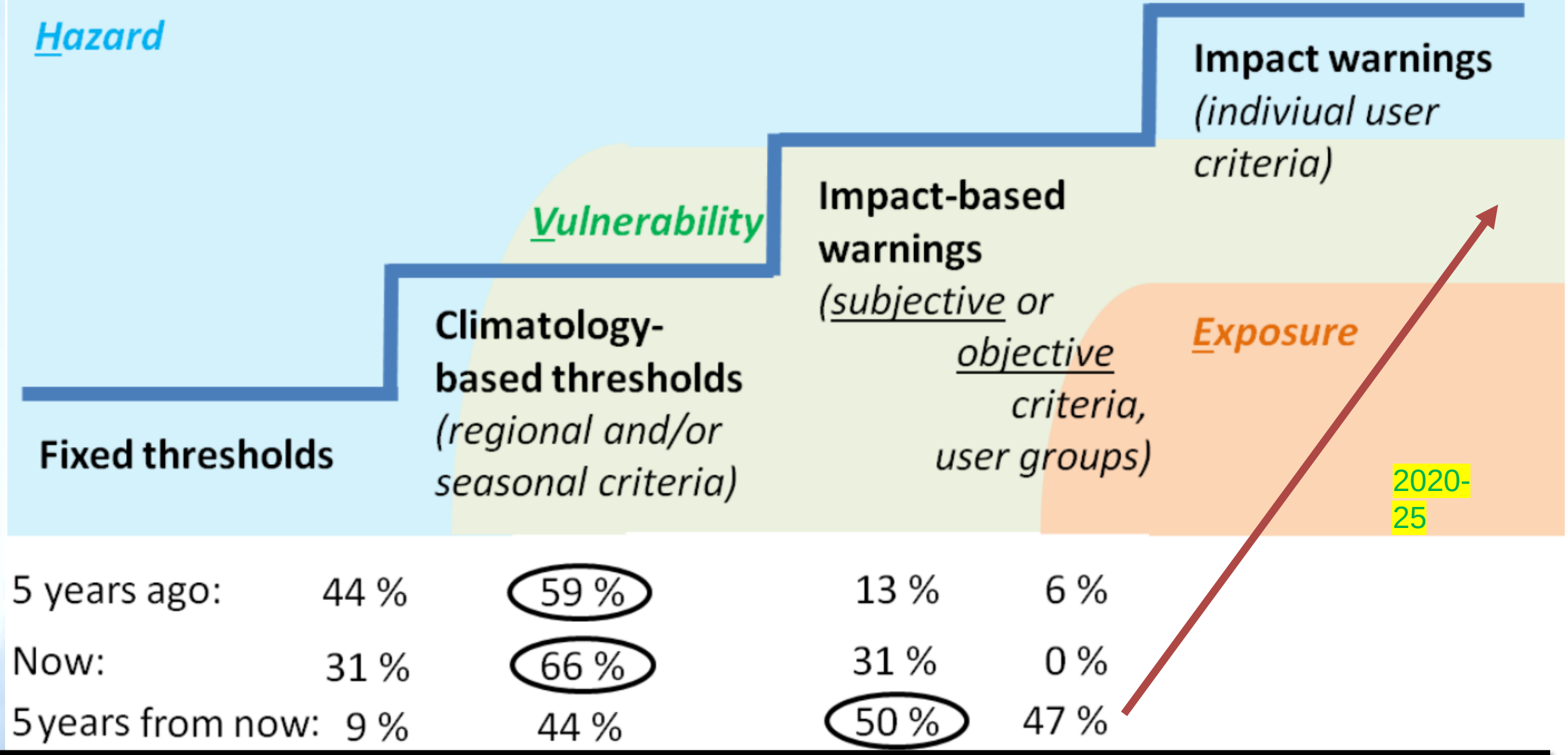
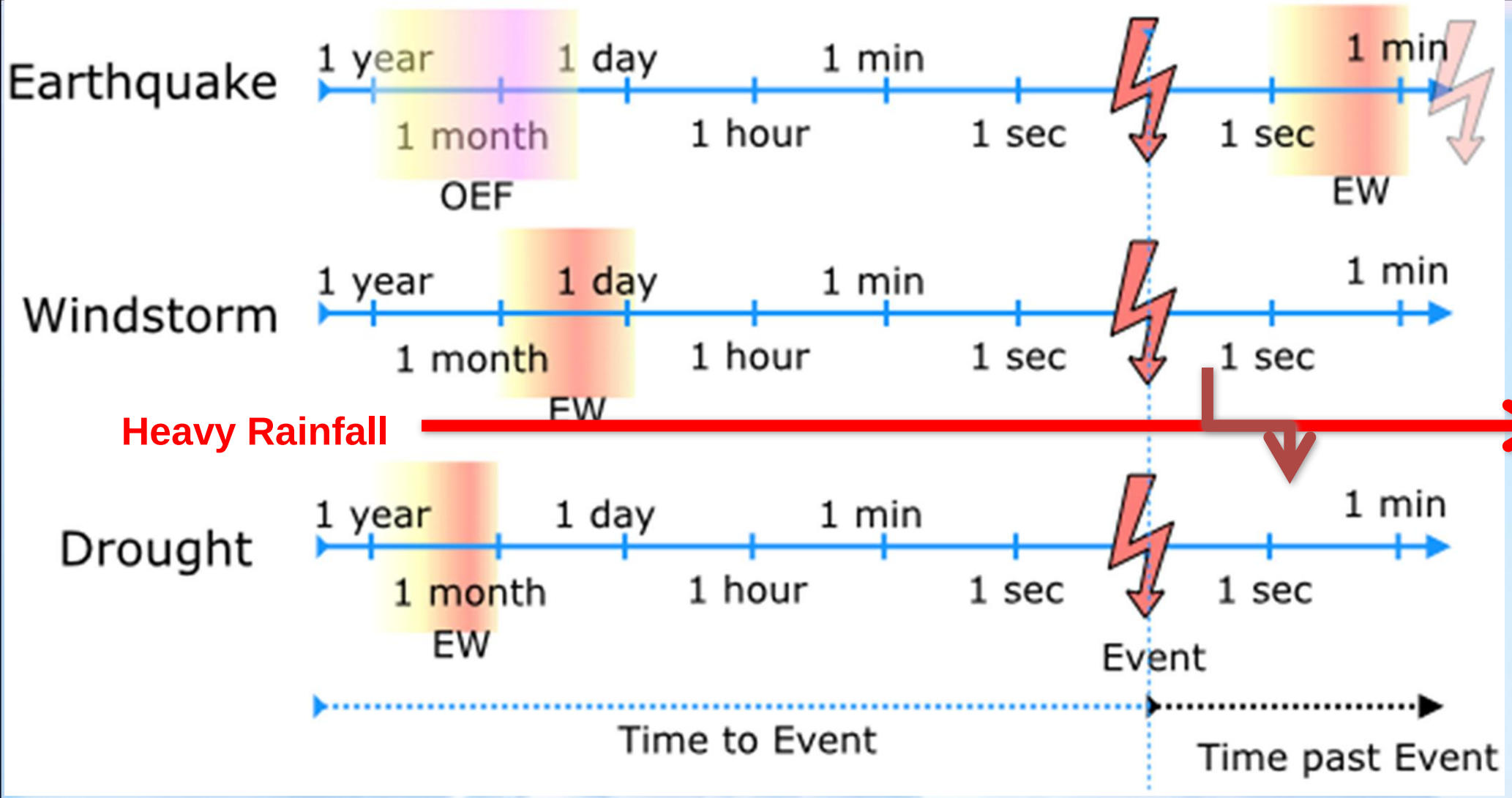


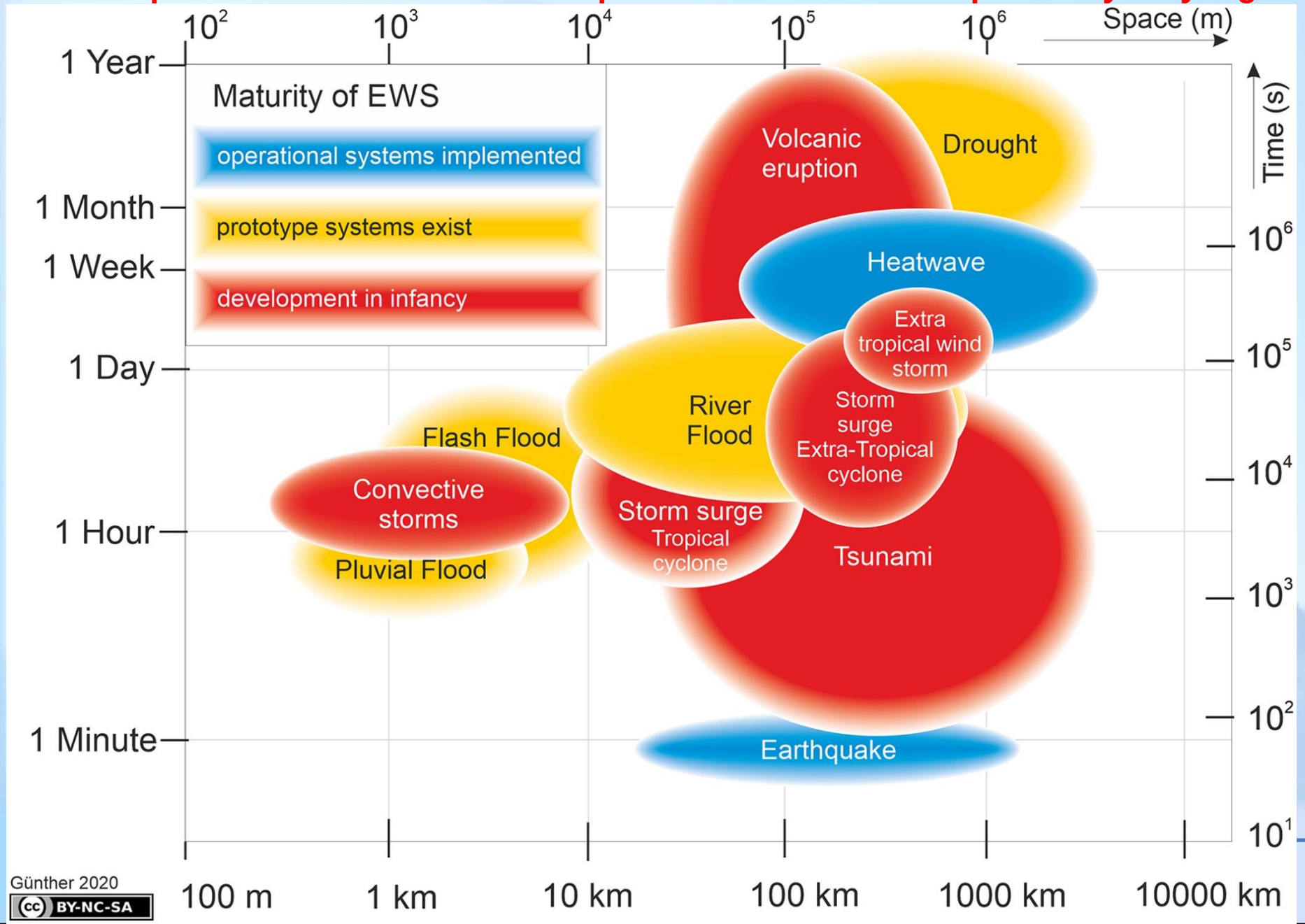
Figure 4. Evolution of public weather warnings, incorporating information on hazard, vulnerability and/or exposure. Warning criteria used at 32/37 European NMHSs participating in the EUMETNET Meteoalarm project 5 years ago, now (2018/2019) and 5 years from now. Maximum values marked with an ellipse. European NMHSs are currently in the transition phase from fixed thresholds or climatology-based thresholds to impact-based warnings based on subjective or objective criteria.



b. scheme of the cascading effects of the heavy rain event from say D10 to Day 0 and Day +10 and foot prints of three commonest: event, hazard and impact

- **Windstorms and Heavy rainfall can be forecasted with lead times from a couple of hours to several days. The lead times of droughts are even longer, in the range of one to several months.-Merz et al, 2020- https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020RG000704**

Hazards-natural phenomena with a specific magnitude that unfold with a given space-time footprint and with the potential for adverse consequences. The event footprint may vary significantly across hazards.



Günther 2020

- Examples are short-term, local-scale events, for example, localized heavy rainfall event causing pluvial floods with event duration and extent in the order of 1 hr and 1 km, to drought/riverine flooding covering 100s of km and for days - **Merz et al, 2020**

A lot of future lies with IBF;Weather – Impact on consumer demand and Market

- Exploring true extent of sales as driven by weather.
- The range of weather dependent verticals very vast

Weekly increase in sales when temperature is 1° F hotter

- 2% soft drinks 
- 24% air conditioners 
- 11% suncare products 
- 4% Infant Apparel 
- 13% hedge trimmers 

Weekly increase in sales when temperature is 1° F colder

- 2% Soup 
- 15% Portable heater 
- 25% Mousetraps 
- 2.5% Softline goods 
- + 5000 units lipcare 

Source: 'Profit of One Degree' by wxtrends.com

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Thank you