RECENT ADVANCES IN SOCIAL WEATHER, COMMON ALERT PROTOCOL AND DISSEMINATION SERVICES THROUGH APIS IN INDIA METEOROLOGICAL DEPARTMENT

1.   India Meteorological Department is the nodal agency for weather forecasting in India that includes all types of forecasting like Nowcasting, short term forecast, long term forecast, city weather forecast etc. Weather forecasters rely on a massive chunk of data for simulations that help to forecast the weather / alert / warning. Dissemination of early warning to stakeholders and common audience is always a major challenge for forecasters. In IMD, dissemination of warnings and weather forecasts is being carried through telefax and e-mails earlier. In addition to that, IMD uses the latest facilities of communication that are used nowadays to broadcast the bad weather to the users which includes dissemination of warnings and weather forecasts especially Nowcast related to thunderstorms, heavy rainfall, Cyclone warning, Agromet advisories *etc*. are disseminated to the registered users through SMS facility on mobile phones by offices of IMD, Use of Social Media (Facebook, Twitter, You Tube *etc*.), National website of IMD (MAUSAM), Mobile Apps (Meghdoot, MAUSAM and DAMINI), Press & Media and Telefax. (Chug *et al*., 2021). Now, to strengthen our dissemination system India Meteorological department (IMD) implemented the Common Alert Protocol (CAP). It has been implemented in coordination with the National Disaster Management Authority (NDMA). Various dissemination systems used by IMD like social media, TV, National website, SMS service, Mobile Apps etc. as shown in Fig. 1.

Common Alerting Protocol (CAP) is an XML based customary message format especially designed for all-Media, All-Hazard, multi-hazard and communication. This system is designed to enable various disaster identifying agencies to revolutionize and incorporate existing alert and warning systems at the national, state, territorial levels in a single unified interface. The system provides a means to alert citizens through multiple communications methods simultaneously, requiring composition of only one alert message and increasing the likelihood that the message will successfully reach the public. Alert generating agencies are IMD, INCOIS, DGRE, CWC, FSI, SDMA of all 36 states and UTs and Alert dissemination agencies are Telecom operators (For SMS based alerts), Satellite message broadcasters (like AAI for GAGAN and ISRO for NavIC).

Fig. 1. IMD Dissemination System

IMD also recently strengthened the dissemination warning system with the help of tool API's *i.e*. Application Programming Interface. The emergence of APIs (what is mostly referred to as web APIs) was, however, witnessed around the year 2000. Since then, APIs have received considerable interest from practitioners and researchers to the extent that some pundits argue that we now live in the API economy (Joshua Ofoeda *et al*., 2019). API's has vast applications in industries and institutions like Weather applications, Financial institutions, Web applications, Streaming services, logistics industries and even automotive industries. API's are nothing but the code and scripts that have to be queried while fetching the data from the server. In a similar way, Weather API's allow weather data to be queried from scripts and code as per the requirement of the user.

IMD presently uses both surface and remote based observations and monitoring systems for detection and reporting of weather events. IMD needs a huge amount of data and observations for simulation (Numerical weather modelling) and visualization of meteorological parameters for forecasting weather. India Meteorological Department (IMD) has a network of 559 Nos. of surface observatories that includes departmental and non-departmental. Another approach to acquiring huge amounts of data is the concept of crowd sourcing, defined by (Dickinson *et al*., 2010) as "getting an undefined public to do work, usually directed by designated individuals or professionals" (Meier *et al*., 2017). With the rapid advances in social and mobile computing, the Internet of Things (IoT) and big data analysis, this space has been known as a new dimension of the real world in addition to existing physical spaces, which has been named the 'social space' (Zhang *et al*., 2018). In this social space, people are not only regarded as message receivers but also as perceivers and producers of weather information (Zhu *et al*., 2019).
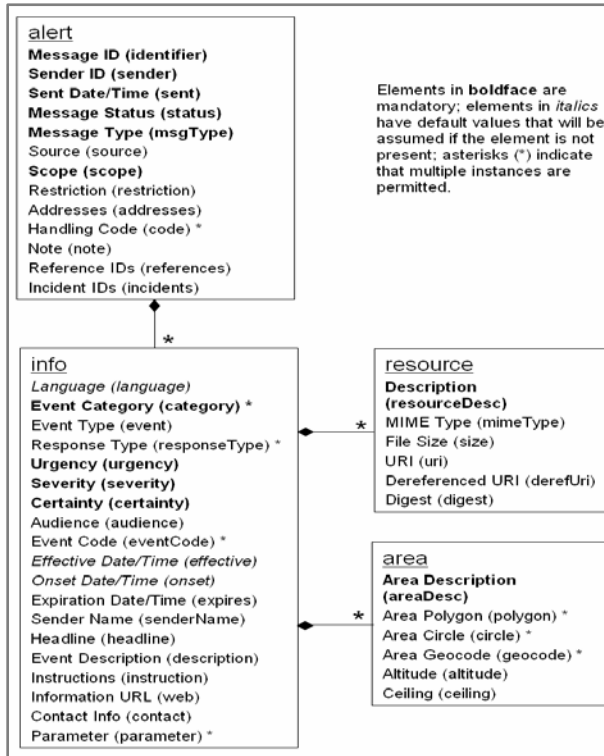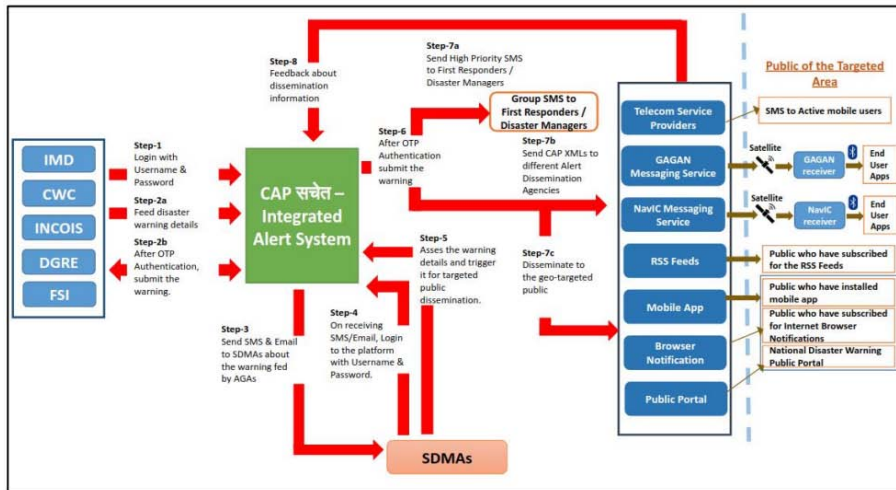
Fig. 2. Structure of CAP Alert message

Fig. 3. Alert Dissemination flow Steps

2. *Results and discussion*

2.1. *Addition of CAP* : The Common Alerting Protocol (CAP) provides an open, non-proprietary digital message format for all types of alerts and notifications. The CAP format is compatible with emergent techniques, such as Web services, as well as existing formats and is also used as the Emergency Alert System (Oasis Standard, 2004). The CAP data model and structure is specified in terms of the eXtensible Markup Language (XML) for communication compatibility with current technologies as shown in Fig.2. However, the same data model can be represented directly in various other formats (Art Botterell, 2006).

The platform facilitates both Alert Authorizing Agencies and the Alert Generating Agencies to give flexible geo-targeted alert dissemination in English or in
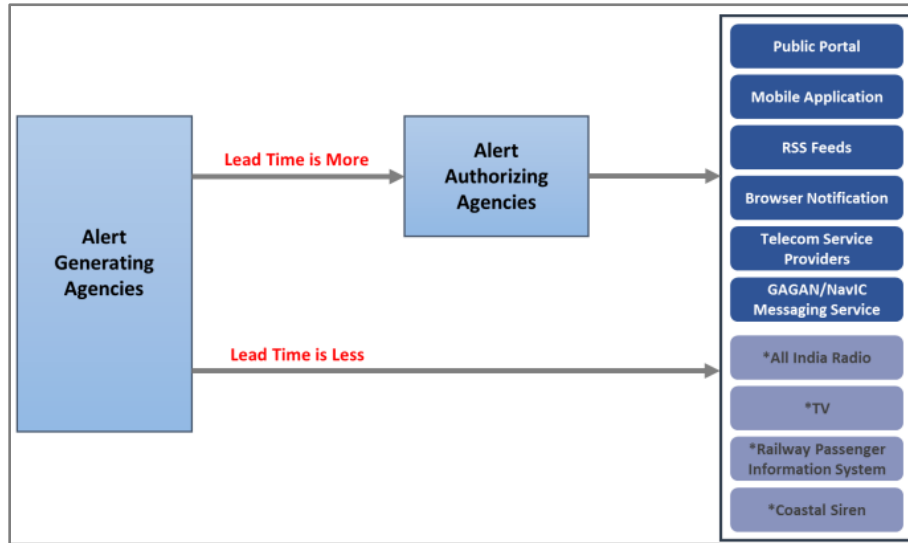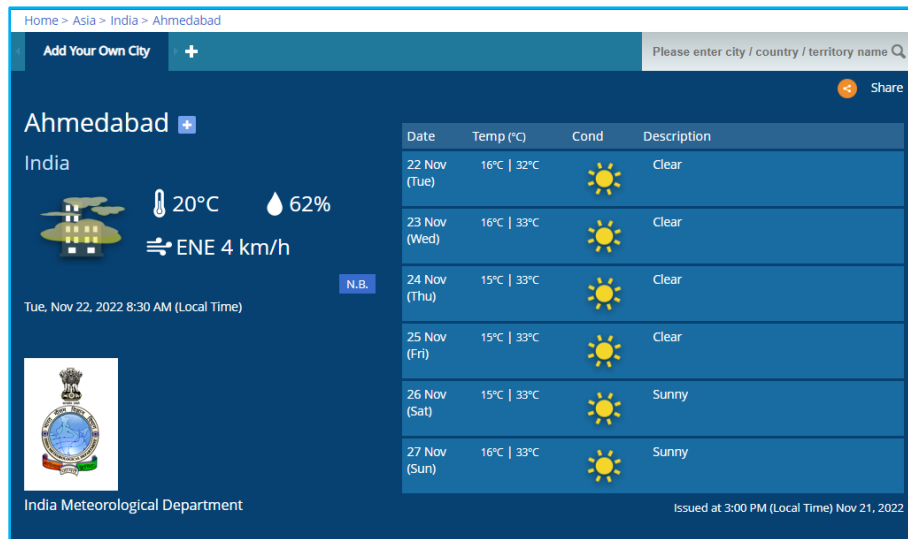
Fig. 4. Alert Dissemination Policy

Fig. 5. World Weather Information Service Forecast having URL (https://worldweather.wmo.int)

vernacular language over one or multiple media to the targeted public, based upon Alert Category (*i.e*., severity type, vulnerable areas and lead time) as shown in Fig. 3.

Alert Generating agencies integrated with the CAP platform are India Meteorological Department (IMD), Central Water Commission (CWC), Indian National Centre for Ocean Information Services (INCOIS), Defence Geo Informatics Research Establishment (DGRE) and Forest Survey of India (FSI). Alert Dissemination agencies that follows the alert dissemination policy which is integrated with the CAP platform to disseminate alerts are Telecom services

providers (TSPs), Airport Authority of India (AAI) and Indian Space Research Organization (ISRO) as shown in Fig.4.

IMD is working parallelly both with NDMA and WMO to implement CAP in India. IMD's CAP feeds are now operational and it is automatically aggregated to the WMO Alert Hub at https://alert-hub.org. The alerts are also disseminated to, the Global Multi-Hazard Alert System (GMAS) portal https://gmas.asia/. At its Sixteenth Session meetingfrom 12 to 16 February, 2017 in Abu Dhabi, United Arab Emirates, the Regional Association II (Asia) of the World Meteorological Organization (WMO)
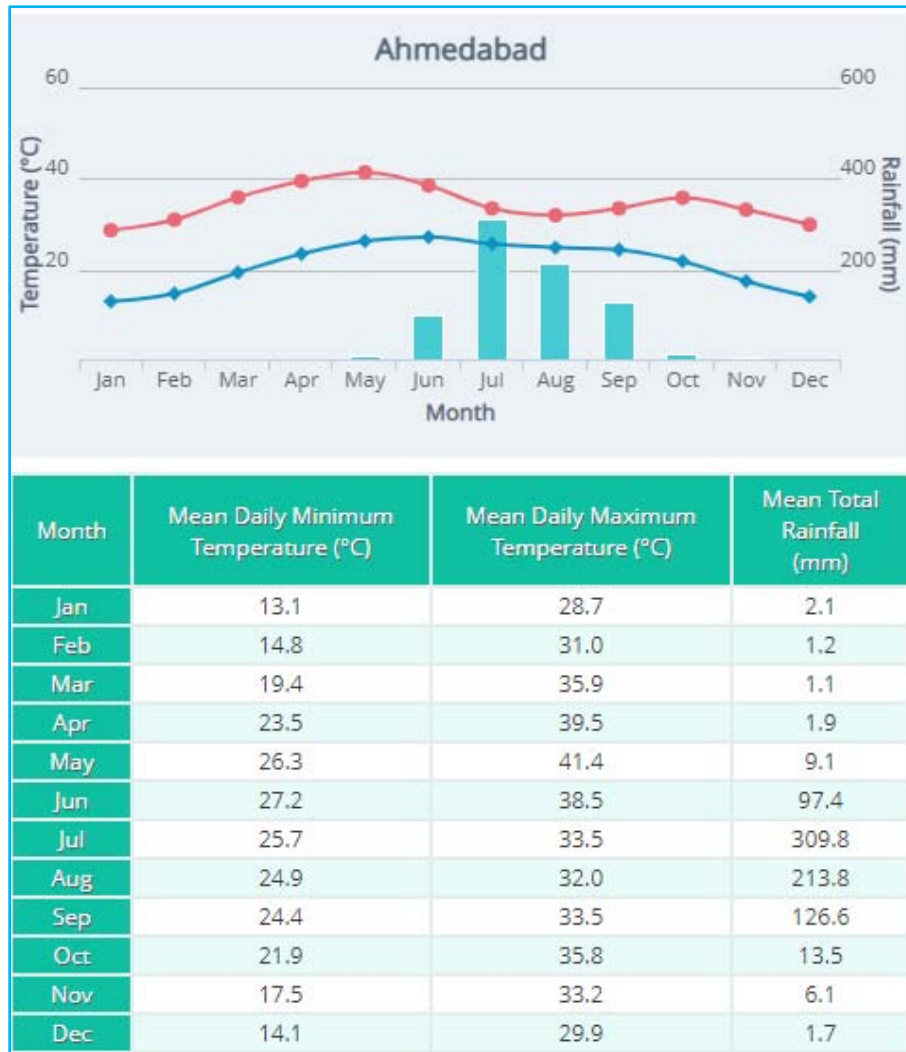
Ahmedabad

Month	Mean Daily Minimum Temperature (°C)	Mean Daily Maximum Temperature (°C)	Mean Total Rainfall (mm)
Jan	13.1	28.7	2.1
Feb	14.8	31.0	1.2
Mar	19.4	35.9	1.1
Apr	23.5	39.5	1.9
May	26.3	41.4	9.1
Jun	27.2	38.5	97.4
Jul	25.7	33.5	309.8
Aug	24.9	32.0	213.8
Sep	24.4	33.5	126.6
Oct	21.9	35.8	13.5
Nov	17.5	33.2	6.1
Dec	14.1	29.9	1.7

Fig. 6. Climatological Information on World Weather Information Service website based on monthly averages for the 100-year period 1901-2000 having URL (https://worldweather.wmo.int)
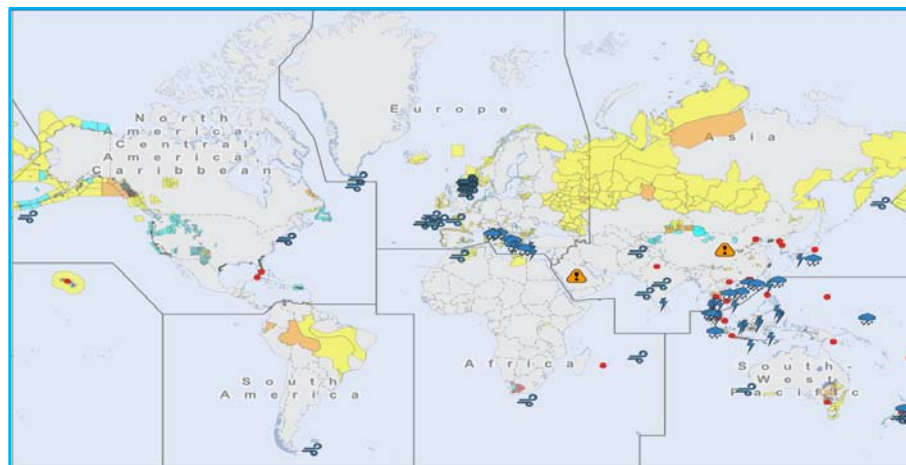

Fig. 7. Display of all CAP alerts on the website of SWIC

agreed to establish a Pilot Project to Enhance the Capability of Meteorological Disaster Risk Reduction (DRR) in RA II. The aims of the Pilot Project are to:

(*i*) Establish a regional meteo-alarm system, based on implementation of CAP and experience in hosting the WWIS and SWIC websites of WMO;

(*ii*) promote experience sharing among National Meteorological and Hydrological Services (NMHSs) in RA II in DRR and to organize related training courses; and

(*iii*) Provide assistance to relevant RA II Members to improve their operational capability in meteorological DRR.

In this connection, a public-facing website (https://worldweather.wmo.int) was set up by WMO to display warnings and alerts along with weather observations, weather forecasts and climatological information for selected cities supplied by National Meteorological & Hydrological Services (NMHSs) worldwide as shown in Fig. 5. In CAP, the severity of an alert is categorized into "Extreme", "Severe", "Moderate", "Minor", and "Unknown". To enable the alerts to be viewed and searched easily, the CAP alerts are highlighted in different colour on a map according to ISO 22324. The colour serves as the visual effect to facilitate viewing and searching and is not related directly to the alerts and warnings. The World Weather Information Service (WWIS) is established as a centralized source on the Internet for the media to access official weather information issued by National Meteorological and Hydrological Services (NMHSs) efficiently and effectively. This global website presents OFFICIAL weather observations, weather forecasts and climatological information for selected cities supplied by NMHSs worldwide, as shown in Fig. 6. The NMHSs make official weather observations in their respective countries.

The Severe Weather Information Centre (SWIC) is a World Meteorological Organization (WMO) website that provides a single and centralized source for the media and the general public to access official warning and information issued by National Meteorological and Hydrological Services (NMHSs) efficiently and effectively. The information provided or linked to; by the SWIC website; were advisories issued by Regional Specialized Meteorological Centres (RSMCs) and Tropical Cyclone Warning Centres (TCWCs) on basic information of the current tropical cyclones, and official warnings issued by NMHSs for their respective countries or regions. Apart from tropical cyclones, the SWIC
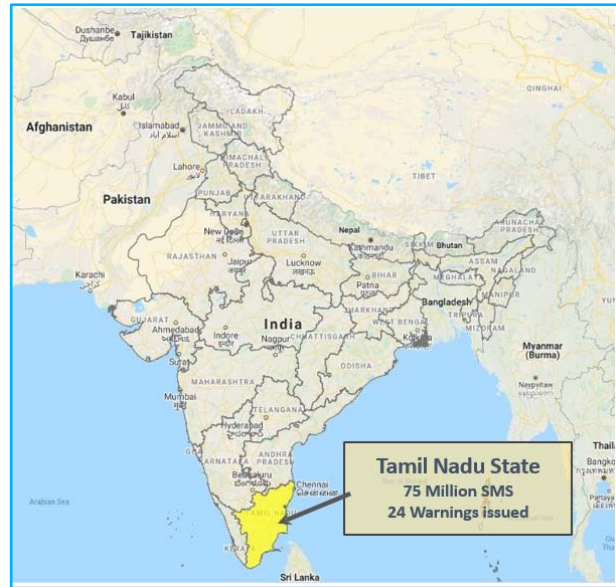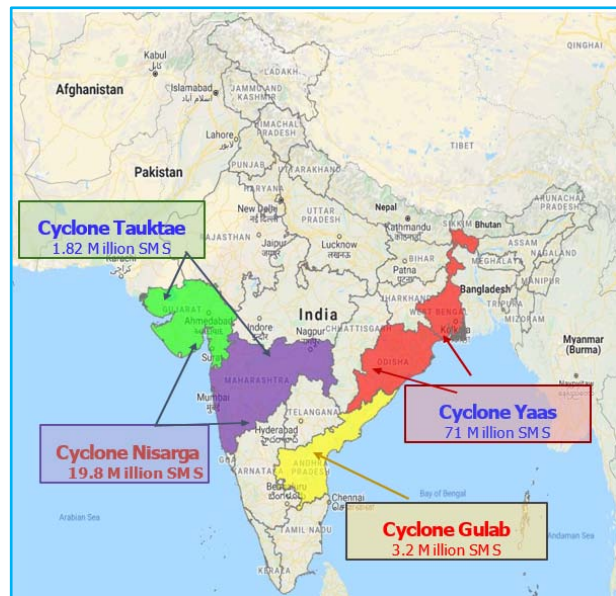

Fig. 8. CAP pilot project in Tamil Nadu

Fig. 9. CAP in use during Cyclone warning

TABLE 1

A Cyclone formed in BOB and the Arabian Sea (April to September 2020)

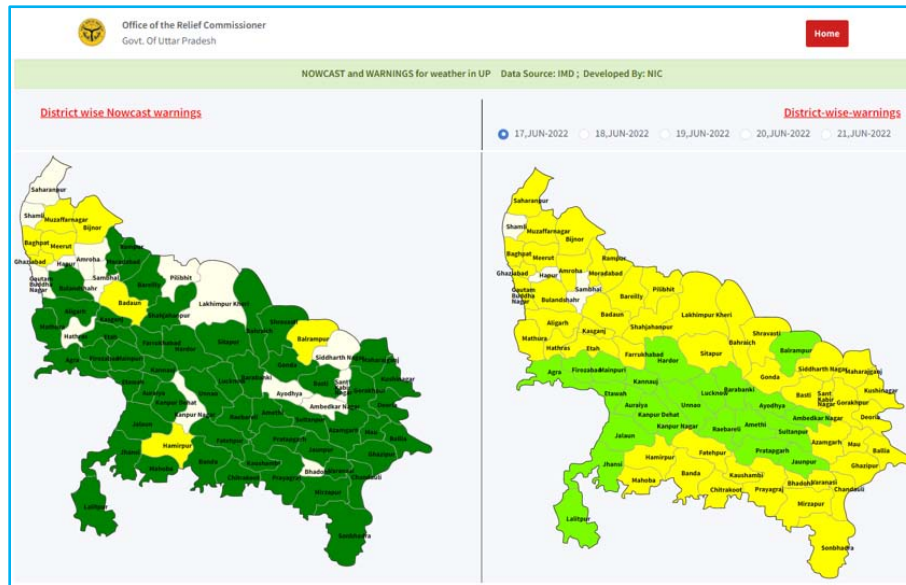| Cyclone Name	Month	Affected Area
Cyclone Nisarga	June 2020	Gujarat and Maharashtra
Cyclone Tauktae	May 2021	Gujarat and Maharashtra
Cyclone Yaas	May 2021	West Bengal and Odisha
Cyclone Gulab	September 2021	Andhra Pradesh

Fig. 10. Display of Warning on Office of the Relief Commissioner's website using API's

TABLE 2

Application programming interface title along with link

S. No.	API Title	Link
1.	Nowcast	https://mausam.imd.gov.in/api/nowcastapi.php?id=Jaipur or https://mausam.imd.gov.in/api/nowcastapi.php
2.	Nowcast District wise	https://mausam.imd.gov.in/api/nowcast_district_api.php?id=5 or https://mausam.imd.gov.in/api/nowcast_district_api.php
3.	Current weather	https://mausam.imd.gov.in/api/current_wx_api.php?id=42182 or https://mausam.imd.gov.in/api/current_wx_api.php
4.	City weather forecast for 7days	https://city.imd.gov.in/api/cityweather.php?id=42182 or https://city.imd.gov.in/api/cityweather.php
5.	City weather forecast for 7days with latitude and longitude	https://city.imd.gov.in/api/cityweather_loc.php?id=42182 or https://city.imd.gov.in/api/cityweather_loc.php
6.	State wise rainfall	https://mausam.imd.gov.in/api/statewise_rainfall_api.php
7.	District wise rainfall	https://mausam.imd.gov.in/api/warnings_district_api.php or https://mausam.imd.gov.in/api/warnings_district_api.php?id=1
8.	RSS Feeds	https://mausam.imd.gov.in/imd_latest/contents/dist_nowcast_rss.php

website also covers other severe weather types such as heavy rain/snow, thunderstorms, gale, and fog, as shown in Fig. 7. During the 17th World Meteorological Congress (Cg - 17), it was noted that the SWIC, as a centralized source of official weather warnings, could be enhanced as another channel for disseminating weather warnings in Common Alerting Protocol (CAP) format. Considering the progress and accomplishment made by the SWIC in

strengthening the recognition of NMHSs by providing a centralized and authoritative source of official weather warnings to the public and media, Cg - 17 requested to enhance the SWIC to enable the website to disseminate official weather warnings that would be provided in CAP format by WMO Members. In addition to tropical cyclone advisories and warnings as well as severe weather observations on SWIC, the SWIC 2.0 also provides weather warnings in CAP format issued by about 60 WMO Members.

To operationalize the CAP protocol fully in day – to - day forecasting and to sub offices of IMD all over of the India, we run a pilot project in Tamil Nadu in which the Regional Meteorological Centre in Chennai broadcast 24 warnings to the public in which 75million SMS messages are sent to the public as shown in Fig. 8. The State Disaster Management Authority (SDMA) disseminated approx. 7.6 million SMS in Tamil Nadu during Cyclone Burevi crossed over Tamil Nadu which formed on 30 November 2020 and dissipated on 5th December, 2020 and made landfall in Sri Lanka. Around 65 million SMSs sent by SDMA for Heavy rainfall and Thunderstorm and 1.4 million SMSs to warn the public regarding the flood situation due to water release from Chembarambakkam Lake that generates potential flood threat in different parts of the states.

After successfully implemented the Pilot project in Tamil Nadu, CAP was implemented in other states in a similar manner. From April 2020 to September 2020, four cyclones formed in the Bay of Bengal (BOB) and the Arabian Sea which affected four different states.

During Cyclone Tauktae and Cyclone Nisarga 1.82 Milliion and 19.8 Million SMSs were disseminated respectively to the affected states of Gujarat and Maharashtra. Similarly, during Cyclone Yaas, state authorities disseminated 71 Million SMSs which had a major impact on West Bengal and Odisha. During Cyclone Gulab, state authorities disseminated around 3.2 million SMSs to the public of Andhra Pradesh as shown in Fig. 9.

Dissemination of Information using Application Programming Interface - API stands for Application Programming Interface. It is like a messenger that takes our request to a system and returns a response back to us *via* Seamless connectivity. IMD has developed APIs for all types of forecast and warnings such as station, district and sub-division levels for 5 day warning, Nowcast warning, Rainfall warning, City weather forecast and Current weather, Sea Area and Coastal area bulletin *etc*. as mentioned in Table 2. API's of IMD used by various stakeholders to extract data from our server and utilize the

Fig. 11. Display of warning on Mobile application of Relief Commissioner Office's using API's
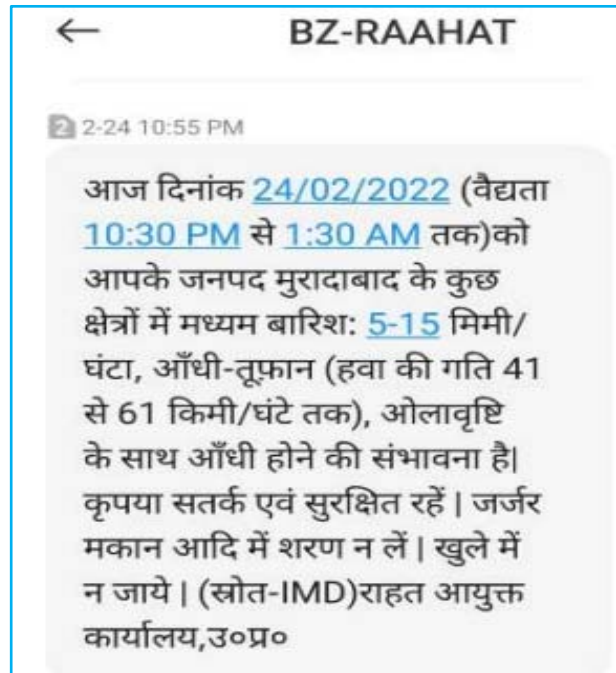

Fig. 12. Dissemination of SMS warning to public by Relief Commissioner Office's

same for further applications developed by them. Access of these APIs has been restricted by applying IP base restriction. For using the APIs, users had to provide its static public IP to India Meteorological Department office so that the same can be white-listed at their end.
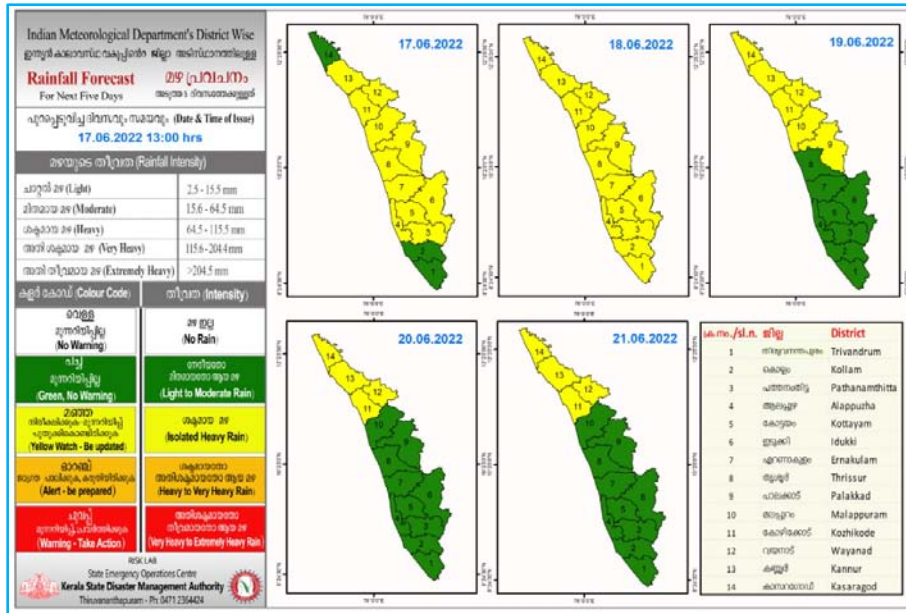
Fig. 13. Display of warning on the office of Kerala state disaster management in their local language using IMD APIs

The stakeholders who are using IMD API's are Uttar Pradesh Government, Telangana Government, Kerala Government, Umang App, DD News, NDMA, Incredible India, KRC Network, NITI aayog, Kerala State Disaster Management, Chandigarh Smart City Limited, Apple.com, Tomorrow.io, Uttarakhand Toursim, National Rice Research Institute Odisha, Madhya Pradesh Government, RMSI private limited, TV - 9, CDAC *etc*.

Application of IMD API used by Uttar Pradesh Government - Among the many stakeholders, one of the stakeholders using our API's is Uttar Pradesh Government. They are using the API's for dissemination of the Weather forecast on the website of the Relief Commissioner Office's having URL: https://rahat.up.nic.in in which they are broadcasting District wise Nowcast warnings and 5-days District wise warnings as shown in Fig. 10 & Fig. 11. They also used warning from IMD to send SMS warning to the users and state authorities in the particular warning area as shown in Fig. 12.

Application of IMD APIs used by Kerala State Disaster Management - Kerala state Disaster Management used IMD APIs to disseminate the 5-day district wise warning in their local language through their website https://sdma.kerala.gov.in/rainfall-2/. They also disseminate Flood, lightning, strong wind and lightning warnings on their website as shown in Figs. 13&14. They also display the Maximum and Minimum temperature of a particular day.
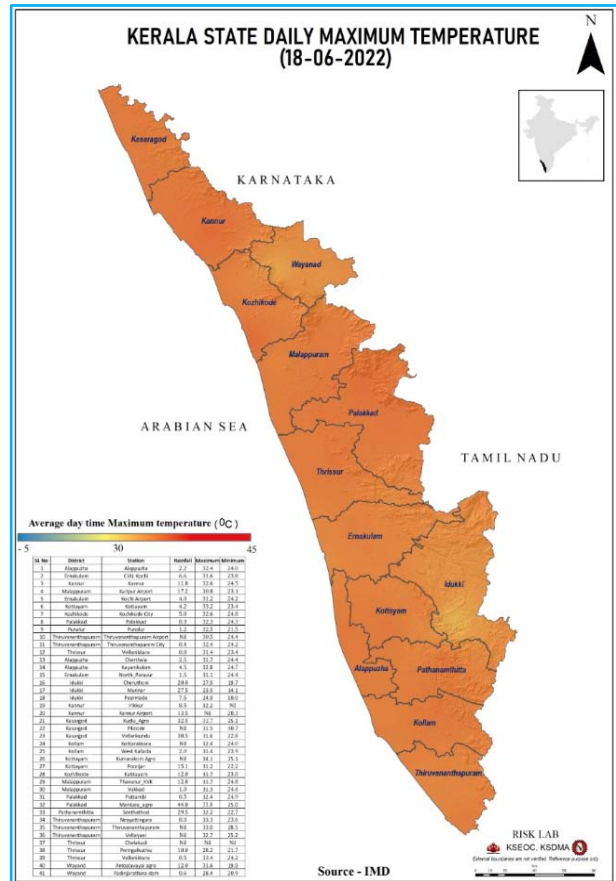

Fig. 14. Display of Maximum Temperature on the office of Kerala State Disaster Management using IMD APIs
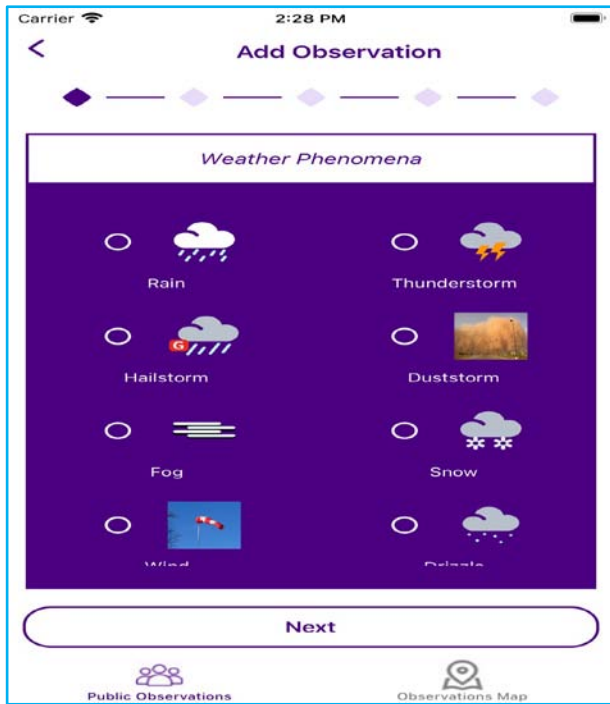
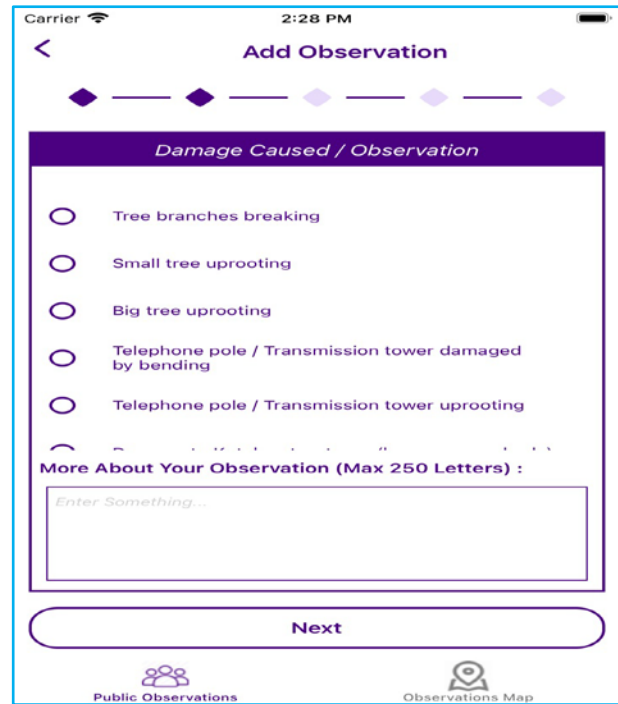**Fig. 15.** Inclusion of Weather Phenomena through Crowdsourcing App

Fig. 16. Inclusion of Impact of weather/damage caused through Crowdsourcing App

2. `*Implementation of Crowd Sourcing in IMD* : India Meteorological Department has taken various initiatives in recent years for improvement in data reception and dissemination of weather forecast and warning services based on the latest tools and technologies. Crowdsourcing resources are also named as Citizen weather stations, where the public will share observations and current weather they are experiencing at a particular location from their personal electronic devices. To enhance this initiative, India Meteorological Department, has launched its Crowd source web interface in the month of January 2021 and the mobile App "Public Observation" on 14th January, 2022 to allow users to make their own observations. There are various features of the Crowdsourcing app which help people to record quick observations of the weather and helps IMD to record the number of observations through human weather stations.

(*i*)   Registration by user is not required to send observations and the associated weather phenomena.

(*ii*)   Users can report their observations along with their state, district, location and time of the events.

(*iii*) It captures the exact Location of the user with coordinates.

(*iv*)   Various weather phenomena may be reported, such as Rain, Thunder/lightning, Hailstorm, Dust storm, Fog,
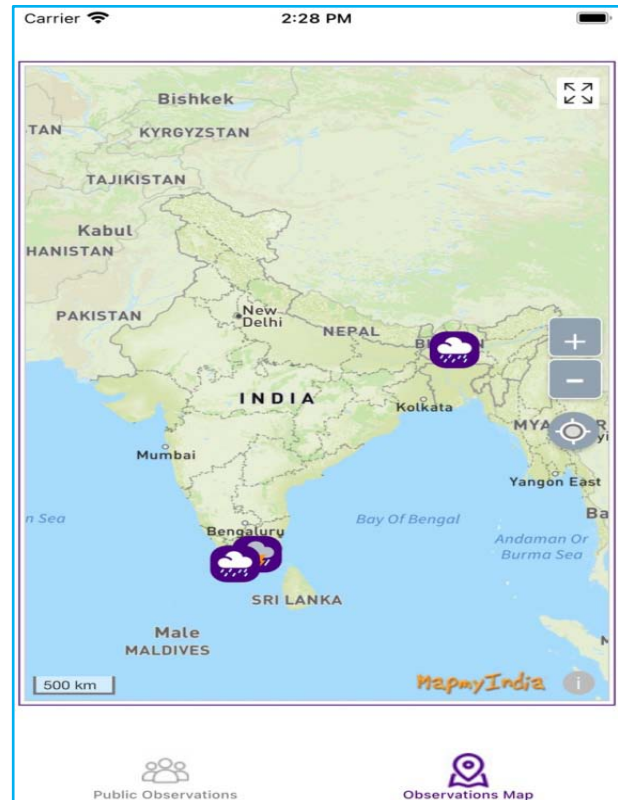

Fig. 17. A Display of weather data received from the public is displayed on map of INDIA
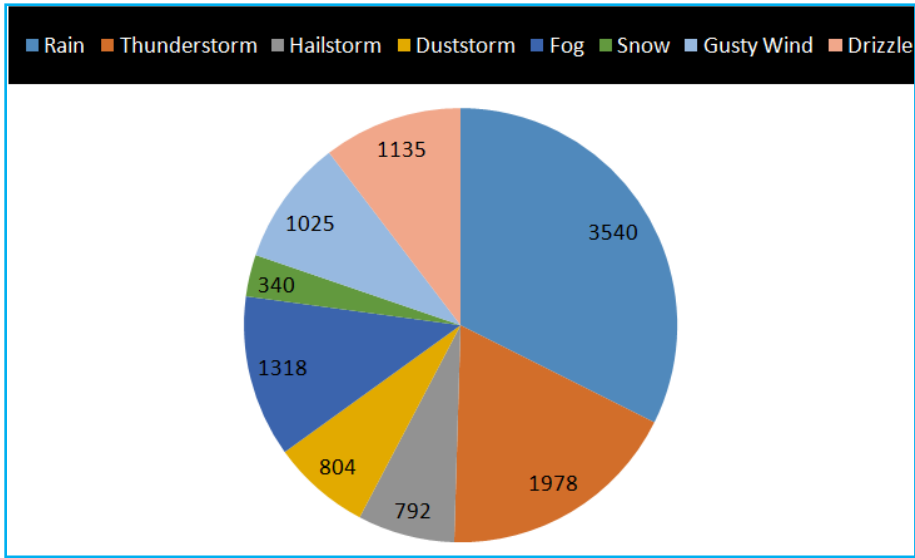
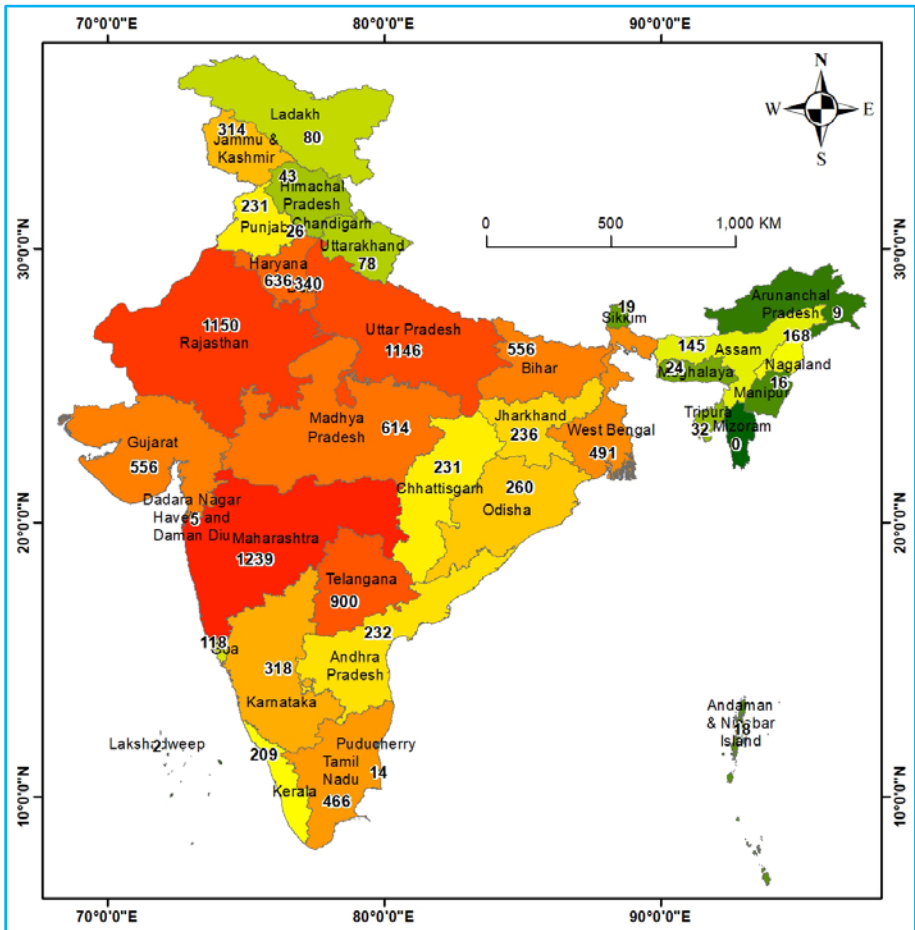**Fig. 18.** Total No. of Observations recorded through Crowdsourcing resource

Fig. 19. Representation of number of observations received from individual states in Map of India from January 2021 to May 2022

Snow, Gusty wind and the associated damage caused, such as breaking of tree branches, uprooting of small/big trees, Telephone pole/ Transmission tower damaged by bending, Telephone pole/ Transmission tower uprooting, Damage to Kutcha structures (houses, cowsheds), Damage to Pukka structures (houses, shelters), Flooding of land, Damage/Death to livestock, Damage/ Death to Humans, Damage to vegetation/crops etc. as shown in Fig. 15.

(*v*) Each phenomenon also includes additional information field that can be filled with customized text as shown in Fig. 16.

(*vi*) Instant photos may be clicked and uploaded in jpg, jpeg, png& gif format.

(*vii*) This app is currently available in 12 languages

(*viii*) Weather data received from the Public is displayed in symbolic form on map of India as shown in Fig. 17.

Crowdsourcing data can be used to improve the data-driven model including results of numeric weather modelling used by the forecasters to take as reference while issuing forecast. We have received good response from the public to record the huge number of observations from January 2021 to May 2022 during bad weather like Dust storm, Heavy Rainfall, Hailstorm, Thunderstorm &Lightning, Snow, Gusty winds etc. as shown in Fig. 18.

Among the total observations we received from people, we found the maximum observations we received from Maharashtra, Rajasthan and Uttar Pradesh as shown in Fig. 19. Area and population of these states may be the reason for receiving the maximum number of observations. As per the observations we displayed on the Map of India we can conclude that we are getting a good amount of observational data from human weather stations which can be used in numerical weather modelling for improvement in data-driven forecasting models, Validation of observational data, improvement in urban climate change etc. Further, planning for installation of instruments in areas where the impact of bad weather is severe can also be explored.

Verification of crowdsourcing data : A Question raised by many forecasters and researchers, whether crowdsourcing data can be utilized in numerical weather models or in day-to-day forecasting of weather. The answer is yes, but need more long term verification and validation of observations. We have verified the Crowdsourcing data input by the social weather station for the stations Delhi, Tamil Nadu and Maharashtra region for 3 months, *i.e.*, March to May 2022. We found the good number of entries by the public weather stations. We concentrate only for those entries which are for Thunderstorm/lightening in a particular district.

The Indian Institute of Tropical Meteorology (IITM) Pune, an autonomous research institution under MoES, has established a lightning location network at 83 places in the country to detect and locate lightning strikes with the utmost accuracy. The central processor of this network located at IITM Pune, receives and processes the signal received from the network and identifies the location of lightning strikes with less than 500 metres accuracies. The output from this network is shared with IMD and various State Governments and is used for nowcasting purposes. We have verified Crowdsourcing data with a lightening network of IITM sensors.

After verifying the crowdsourcing data having thunderstorm/lightening value, wefound that Delhi data accuracy shows 75%, Maharashtra data has an accuracy of 71% while Tamil Nadu data accuracy was 81%.

Conclusion **-** In this paper we have study recent advances in dissemination services of the India Meteorological department. The Common Alerting Protocol (CAP) provides an open, non-proprietary digital message format for all types of alerts and notifications. IMD operationalize the CAP fully in day-to-day forecasting and to sub - offices of IMD all over India. IMD also developed APIs which is used by various stakeholders to extract data from our server and utilize the same for further applications developed by them. Currently, around more than 40 stakeholders are using IMD APIs and disseminate weather information to the public through their dissemination tools. Some of the stakeholders even disseminate the weather information in their regional languages. India Meteorological Department, has also launched its Crowd source web interface in the month of January 2021 and the mobile App "Public Observation" on January 2022 to allow users to make their own observations. We are getting a good response from the social weather station. To answer the question of the forecasters whether the same data can be used in day - to - day forecasting, verification of 3 month data for 3 states has been done, which shows there is a good amount of scope to include the data in our forecasting tools.

Disclaimer : The contents and views expressed in this study are the views of the authors and do not necessarily reflect the views of the organizations they belong to.

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