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LETTERS

ROLE OF COMMON ALERT PROTOCOL-BASED WARNING DISSEMINATION SYSTEM AND EFFECTIVE DISSEMINATION METHODOLOGY

1. India is vulnerable to various natural hazards and at risk of various industrial accidents. Disasters have killed nearly a million people over the last decade and resulted in substantial economic losses. In most cases, the death count significantly reduces if people take proper precautions based on timely early warnings. To realize the honorable Prime Minister's vision enshrined in the PM's 10-point agenda for disaster risk reduction, the National Disaster Management Authority (NDMA) and India Meteorological Department (IMD) have taken up an initiative to make India disaster-resilient by implementing a national-level Public Alerting System. The main objective of this initiative is to leverage Information and Communication Technologies (ICT) to improve the efficiency of disaster risk management activities and to take advantage of disaster risk reduction opportunities provided by social media and mobile technologies. This endeavor will help the government substantially reduce disaster risk and losses in lives, livelihoods, and health, as outlined in the US's Sendai Framework guidelines for disaster risk reduction. (<https://dst.gov.in/sites/default/files/Annexure II details of ten point agenda.pdf>)

This work also discusses modern technologies for effectively managing disaster situations based on the Lead time to disaster.

2. *Data and methodology:* The India Meteorological Department (IMD) is India's central nodal organization for weather forecasting, covering various types of forecasts, including nowcasts, short-term, long-term, and city-specific forecasts. Weather prediction relies heavily on extensive data used in simulations to generate forecasts, alerts, and warnings. One challenge for forecasters is effectively communicating early warnings to stakeholders and the public.

Traditionally, IMD disseminated forecasts and warnings via telefax and email. Today, IMD has adopted modern communication technologies to improve the reach and timeliness of weather alerts, particularly for events such as thunderstorms, heavy rainfall, cyclones, and agricultural advisories (AGROMET). These alerts are now shared with registered users via SMS, and through social

media platforms (such as Facebook, Twitter, and YouTube), the national IMD website (MAUSAM), mobile applications (MEGHDOOT, MAUSAM, and DAMINI), press and media outlets, and telefax. In collaboration with the IMD, the National Disaster Management Authority (NDMA) has implemented the CAP to strengthen its dissemination system further. (S Chug and S Nath, 2024)

The types of data used by the CAP system are:

- (i) **Meteorological Data:** Real-time and forecast data of IMD weather services (*e.g.*, temperature, wind speed, precipitation, humidity, atmospheric pressure). Weather Forecasts are generated from meteorological observational data such as SYNOP, Upper Air, RSRW, NWP Models, Radar, and Satellite Data.
- (ii) **Geospatial Data:** GIS-based map layers include administrative boundaries and polygon-based data of affected areas to define impact.
- (iii) **Alert Metadata:** Metadata such as alert category, urgency, severity, certainty, and the alert types based on international CAP standards.

'CAP-based Integrated Alert System' has been developed for the dissemination of geo-targeted early warnings/alerts related to disasters to the citizens of India for all 36 States/UTs using various disseminating mediums like SMS, TV, Radio, Indian Railways, Sirens, Cell broadcast, Internet (RSS feed & Browser Notification), Satellite Receiver of GAGAN & NavIC *etc.*, through integration of all alerting agencies, [India Meteorological Department (IMD), Central Water Commission (CWC), Indian National Centre for Ocean Information Services (INCOIS), Defense Geo-informatics Research Establishment (DGRE), Geological Survey of India (GSI) and Forest Survey of India (FSI)]. Alert Generating Agencies such as IMD, CWC, INCOIS, DGRE, and FSI generate disaster-related alerts in the CAP system, and the SDMAs of the concerned States and UTs moderate them. (<https://pib.gov.in/PressReleasePage.aspx?PRID=1988282>) The system sends alerts to geo-targeted areas in regional languages. There is a web-based dashboard for disaster managers to approve/edit alerts and choose media for dissemination. The system has been used successfully in recent disasters. The various dissemination systems used by IMD include social media, TV, national websites, SMS

TABLE 1

Advantages of CAP vs traditional methods of communication

Feature	Common Alerting Protocol (CAP)	Traditional Alerting Methods
Standardization	Uses an open, internationally recognized XML-based standard.	Often proprietary or incompatible across systems.
Delivery of alerts in multiple media	Supports delivery across various media (TV, radio, SMS, Mobile App, Cell Broadcast, etc).	Typically limited to one or two communication media
Interoperability	Seamless integration between CAP-compliant systems.	Difficult or nearly impossible without parsing data from one form to another.
Geotargeting	Alerts targeted to specific geographic areas.	Usually broadcast-based
Multilingual Support	Can include messages in multiple languages in a single alert.	Often monolingual or requires separate systems for translation.
More Content Support	Supports images, maps, and URLs.	Limited to text and voice alerts.

services, mobile apps, *etc.* The NDMA CAP EWS (Early Warning System) with all disaster agencies under one umbrella, save precious time for coordination. The advantages of CAP over traditional methods shown in Table 1. (<https://community.wmo.int/en/common-alerting-protocol>)

CAP is an XML-based customary message format specially designed for all-media, All-Hazard, multi-hazard, and communication. (<https://docs.oasis-open.org/emergency/cap/v1.2/CAP-v1.2-os.html>)

Reason for opting for CAP (<https://www.undrr.org/early-warnings-for-all/common-alerting-protocol>)

(i) CAP is the globally accepted ITU-T X. 1303 disaster alert information exchange standard. The structure of CAP message is shown in Fig. 1.

(ii) Geo-targeted warning increases effectiveness and sanctity as information reaches only the targeted public.

(iii) CAP ensures last-mile reachability to the citizens using all possible dissemination method. The NDMA CAP system alert flow is shown in Fig. 3.

(iv) CAP lies on the basis that Any Hazard, Any Media and to anyone as in Fig. 2.

(v) With CAP, we shift our paradigm from a Reactive approach to a Proactive approach.

(vi) Support of Vernacular languages also ensures understandability among the local population.

Issuing a CAP Alert: The Polygon Approach

The flowchart for issuing a CAP alert for the Nowcast warning is as follows.

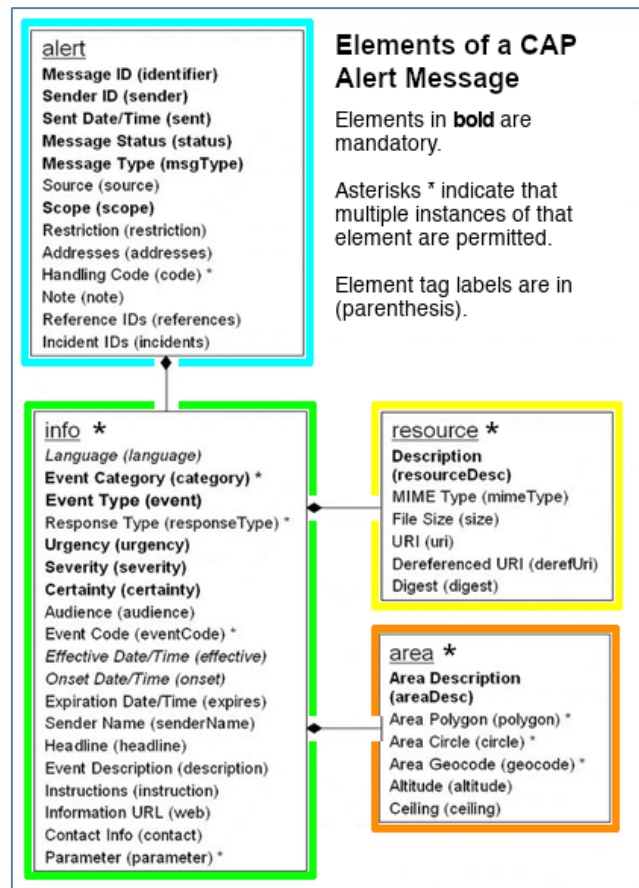


Fig. 1. Structure of a CAP message

Step 1: IMD User logs in to the CAP Platform with the provided credentials

Step 2: Select New Warning to issue a new CAP warning

Step 3: It shows the types of warnings the IMD user can issue on the CAP platform

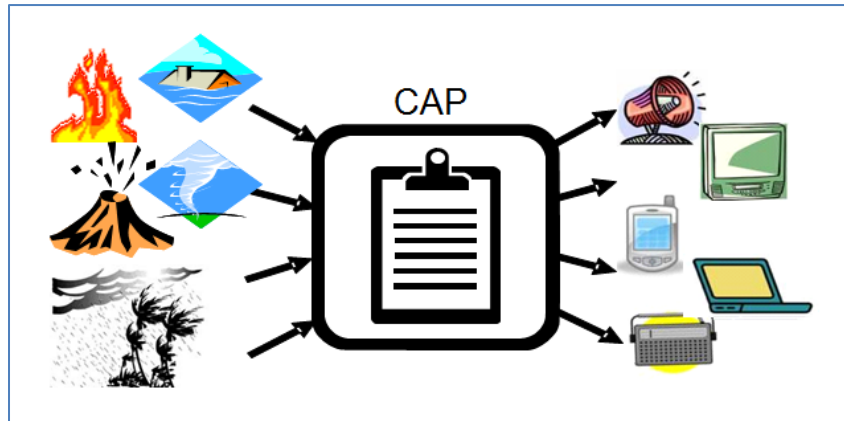


Fig.2. CAP integration methods

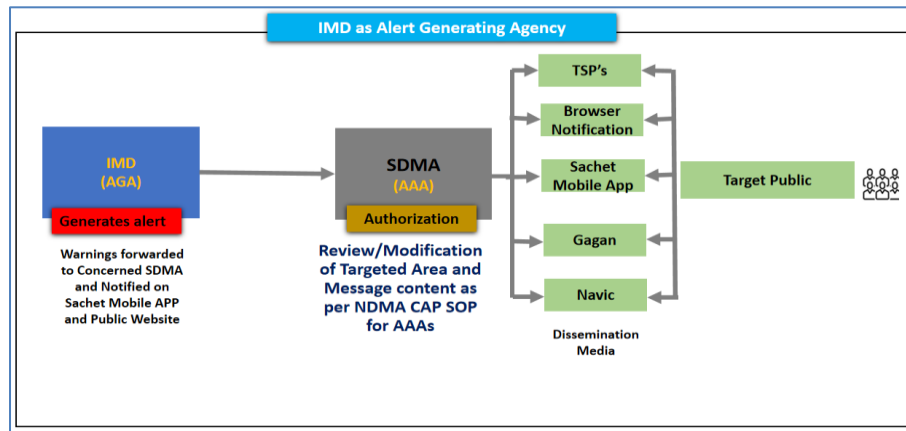


Fig. 3. Dissemination of CAP Alert to end user

- (i) Nowcast Warnings - Lead time/validity up to 3 hours.
- (ii) Current Day Warning - Lead time/validity up to 24 hours.
- (iii) Cyclone Warning in 4 Stages (Pre Cyclone Watch, Yellow, Orange and then Red Alert)
- (iv) Fisherman Warning through satellite media (Gagan and NAVIC)

Step 4: For issuing a Nowcast warning (let's say), select Nowcast from the given options

Step 5: It shows four ways to add a nowcast warning area

- (i) Select District(s)
- (ii) Draw a polygon on Map
- (iii) Select a pre-saved area from templates
- (iv) Upload GeoJSON

Step 6: To use the polygon approach (let's say), select Draw polygon on Map from the given options. The map opens for the respective user; for example, the IMD Lucknow user will generate an alert in Uttar Pradesh, so the Lucknow user will view the map for Uttar Pradesh.

Step 7: Use your mouse to click and draw the polygon over the impact area. On finalizing the Area of interest, name the Area and click on Fill Warning Details

Step 8: Fill event details – Event, Date Time of Issue, Date Time of Expiry, Warning Type, Probability, Message to SDMA and click SUBMIT

3. Results and discussion: The pilot project for the NDMA CAP Project implementation at a smaller scale with limited SMS functionality started in Tamil Nadu in January 2020. The India Meteorological Department (IMD), Regional Meteorological Centre (RMC) Chennai and Tamil Nadu State Disaster Management Authority (TNSDMA) used the CAP Pilot System during Cyclone Nivar and Cyclone Burevi, Tamil Nadu Heavy Rains and Flood warning dissemination.

TABLE 2

Use of CAP dissemination during Cyclone

Area Description	Message	Generated By, Date Time
North & Middle Andaman, South Andaman districts of Andaman and Nicobar Islands	Due to the formation of tropical cyclone Mocha over southeast Bay of Bengal, Squally weather accompanied with Heavy to very heavy rainfall and winds 50 to 60 kmph gusting to 70 Kmph is likely to prevail at one or two places from 11 to 12 May 2023.	IMD Kolkata, Thu May 11 18:00:00 IST 2023
Haora, Hugli, Kolkata, Murshidabad, Nadia, North 24 Parganas, Purba Medinipur, South 24 Parganas districts of West Bengal	Due to formation of severe cyclone REMAL and forward movement, Very heavy (12-20 cm) to extremely heavy (>20 cm) rainfall accompanied with very strong wind is very likely to affect North and South 24 Parganas, Kolkata, East Midnapore, Howrah, Hooghly, Nadia and Murshidabad districts during 26-27th May,2024.	IMD Kolkata, Sun May 26 13:30:00 IST 2024
All districts of Andhra Pradesh	The CYCLONIC STORM MICHAUNG with maximum wind speed of 65-75 gusting to 85 Kmph lays centred at 2030 IST of 03.12.23 near latitude 12.4N and longitude 81.9E, 310 Km southeast of Nellore, Andhra Pradesh. Cyclone Warning for all districts of Andhra Pradesh.	IMD Visakhapatnam, Sun Dec 03 23:30:00 IST 2023
Devbhoomi Dwarka, Jamnagar, Kachchh districts of Gujarat	Heavy to very heavy rains very likely at isolated places with isolated extremely heavy falls in the district of Dwarka. Heavy to very heavy rains very likely at isolated places in the districts namely Kutch and Jamnagar. Total suspension of fishing operations over adjoining North Arabian Sea.	IMD Ahmedabad, Wed Jun 14 14:30:00 IST 2023

Now, with the PAN India implementation started in August 2021, all the offices of IMD have collectively issued more than 3200 crores of disaster alert messages in about 33 thousand alerts on the CAP-based Integrated Alert System till Dec 2024 as seen from IMD CAP dashboard. (<https://sachetdashboard.ndma.gov.in>) The NDMA CAP SACHET platform's mobile application and public website display alerts from IMD and other Alert Generating Agencies. The WMO Alert Hub at <https://alert-hub.org> automatically aggregates IMD's CAP feeds.

Dissemination Methods Integrated with the CAP SACHET system are

- (i) Short Message Service (SMS)
- (ii) Mobile App & Browser Notification
- (iii) Public Website, RSS Feeds
- (iv) Satellite GAGAN and NAVIC

Dissemination Methods Tested with CAP SACHET and pending integration are

- (i) Television
- (ii) Radio
- (iii) Cell Broadcast
- (iv) Indian Railways

Case Studies of Cyclone

CAP dissemination methodology has also proven useful during cyclone disturbances since its inception. The references of CAP during cyclone are referred in Table 2.

Similar CAP alerts are also issued and sent to the general public via SMS and Internet Media during other cyclones. For POC purposes in live cyclone, CAP alerts were also issued through Cell Broadcast during Cyclone Mandaous and Television during Cyclone Biparjpy. This was purposed as a test in live environment in a manual way as advised by NDMA. CAP alert reception in Cell Broadcast and Television has been recorded for next phase full-fledged roll out across PAN India. The legacy SMS technology still faces challenges with SMS delivery timelines.

Improvement in CAP dissemination System: An insight into Cell Broadcast

The CAP dissemination to the public is active with SMS services to date. However, in disaster situations, LEAD TIME is an essential factor where Cell Broadcast is the most proven immediate alerting technology worldwide.

Cell broadcast (CB) is a mobile technology that sends messages simultaneously to multiple mobile users in a specific geographic area without knowing individual phone numbers. It is especially effective for emergency communication because it works even when mobile networks are congested.

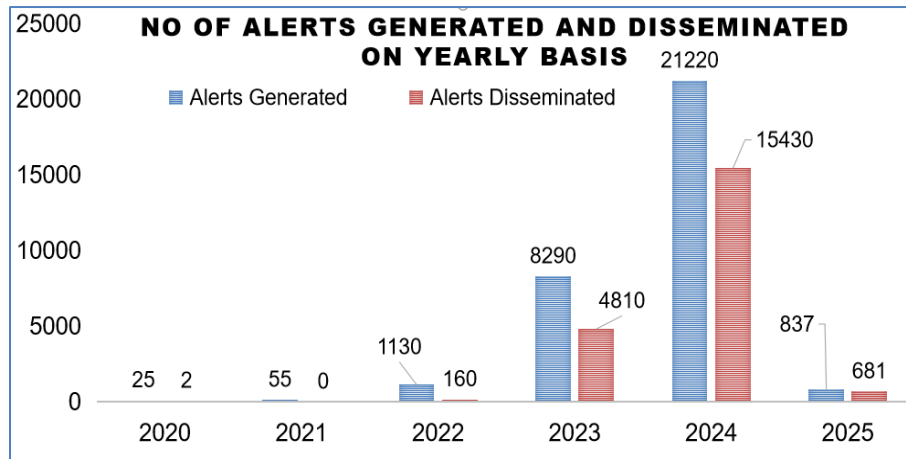


Fig. 3. Number of warnings generated by IMD and disseminated by States

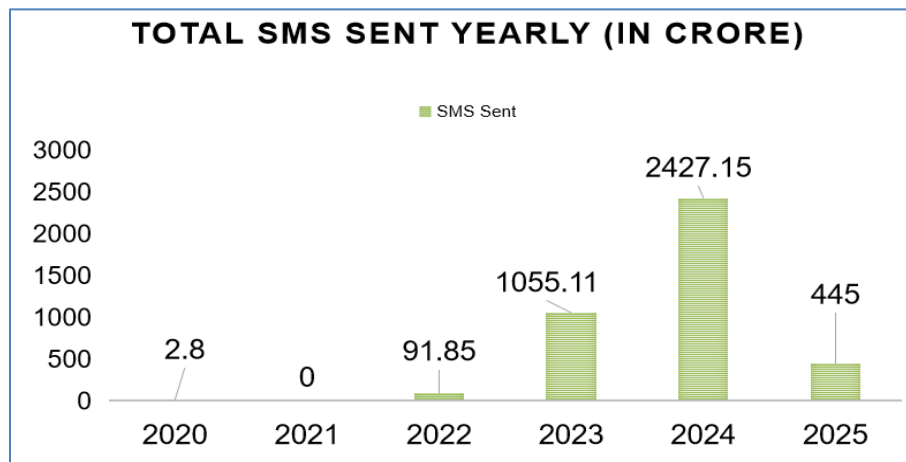


Fig. 4. Number of SMS alerts sent to citizens (updated 31 Apr 2025)

Key features of cell broadcast

- (i) Geo-targeted: Messages can be sent to all users in a specific area.
- (ii) Immediate: Messages are delivered almost instantly.
- (iii) Device-independent: Works on all mobile phones that support CB.
- (iv) Non-intrusive: Messages appear like pop-up notifications or alerts.
- (v) Reliable during network overload: CB does not suffer congestion issues like SMS or calls.

Also, SMS Alerts have technology limitations. If authorities disseminate alerts over a vast area (more than 500 km) or repeatedly disseminate them over the same location in a short duration, the alerts get delayed. The TSPs have improved the quality of service in minimizing the dissemination time. Still, the legacy SMS technology

has specific limits for improvement and cannot compete with modern technologies like Cell Broadcast.

With the severity pattern of different weather alerts, the NDMA Standard Operating Procedures (SOP) defines the selection of appropriate dissemination media for different severities of alerts sent through the CAP-based Early Warning System to avoid flooding of SMS to the common public, resulting in missing out important alerts due to ignorance.

The growth in the number of alert messages as shown in Fig. 3 and the SMS issued to citizens as per Fig. 4 has increased, making this CAP-compliant early warning system, SACHET by NDMA, a helpful and reliable approach.

The alerts generated by IMD offices in the CAP-based SACHET system are directly received on the Internet Media for the common public and forwarded to the State Disaster Management Authorities for dissemination on

other media. SEOC (State Emergency Operations Centre), being a user in the CAP platform, takes necessary action on the warnings, forwarding them on SMS media if deemed necessary as per the SOP, hence the alert reaches end users on SMS.

4. *Conclusions:* This paper examines recent advancements in the dissemination services of the India Meteorological Department (IMD). The CAP offers an open, non-proprietary digital format for delivering various types of alerts and notifications. IMD has fully integrated CAP into its daily forecasting operations, extending its implementation to sub-offices across the country.

With the CAP-based Early Warning System, IMD alerts are reaching the targeted end users for quick and timely action. The disaster response forces are in action, and with the CAP-based Early Warning System, the coordination between disaster managers is improved to the next level as it has become digital and quick. All the top-end monitoring on warnings issued, the number of SMS alerts sent, and notifications sent over mobile & web browsers are available on the dashboard, making it easier for authorities to act upon.

Future Work: With the PAN India rollout of CAP, it was clear that SMS alerts are not enough; hence, technologies of immediate alerting through Cell Broadcast have to come into effect for more effective management in disaster situations.

An essential aspect of CAP immediate alerting is localizing the area and a compelling message content for intended users to react and act promptly. The message content should be precise and contain all the relevant information needed to act upon, which becomes a scope of work for the future and

A Decision Support System (DSS) provides a map-based view of weather observations, visually representing relevant parameters in the user interface. By integrating DSS with CAP, the polygon-based approach for generating CAP alerts can significantly improve the accuracy and efficiency of alert dissemination. This integration enables users to directly identify the affected areas from the DSS, allowing more precise targeting of alerts and reducing the time required to issue a CAP alert.

Data Availability: The CAP statistical data supporting the findings of this study are available in IMD Dashboard user of NDMA CAP Integrated Alert System.

Conflicts of Interest

The authors declare no conflict of interest.

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Authors' Contributions

Prashant Bansal: Performed writing-original draft and conceptualization, derived charts, prepared flow diagram. Dr. Sankar Nath: Performed review and editing.

Disclaimer: The contents and views presented in this research article/paper are the views of the authors and do not necessarily reflect the views of the organizations they belong to.

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