Accelerating the use of mobile phone capabilities to maximise the effectiveness of public emergency alerts in South Africa

Tsumbedzo Mukange
Council for Scientific and Industrial Research
South Africa
tmukange@csir.co.za

Bayanda Mokoto
Council for Scientific and Industrial Research
South Africa
bmokoto@csir.co.za

Tumelo B Moipolai
Council for Scientific and Industrial Research
South Africa
tmoipolai@csir.co.za

Zimasa Ndamase
Council for Scientific and Industrial Research
South Africa
zndamase@csir.co.za

Abstract

An emergency alert system (EAS) enables government authorities, its agencies, and community authorities at various levels to use communication platforms to inform people in threatened areas of imminent disaster. Disseminating emergency alerts to the public is crucial to ensure effective and efficient disaster management. The purpose of disseminating emergency alerts is to provide important and life-saving information to the public so they can take the necessary actions to ensure their safety. EAS uses various communication channels to disseminate alerts and warnings, including TV and radio, sirens and long-range acoustic devices, message signage and public address systems, the Internet, fixed phones, and mobile phones through cell broadcast services (CBS), SMS and mobile apps. The United Nations launched the Early Warning for All initiative that promotes the use of geo-located mobile-based early warning services, such as CBS and location-based SMS (LB SMS), to disseminate emergency alerts to all by 2027. The accessibility of mobile phones has accelerated the use of mobile phone capabilities to disseminate emergency alerts. In South Africa, using CBS and LB SMS capabilities to disseminate emergency information to targeted geographical areas by authorities is still an area of improvement. The study aims to accelerate the adoption and use of cell broadcast and location-based SMS to maximize the effectiveness of public emergency alerts in South Africa. The study forms a basis to accelerate the adoption and use of CBS and LB SMS to disseminate public emergency alerts. Partial results show emergency alert message crafting and appropriate communication approaches are vital in influencing the public to comply with the alert. In addition, South Africa had implemented some components of emergency alert systems, but in isolation and focusing on specific types of emergency alerts.

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1 Introduction

The rise in disaster risks has necessitated the strengthening of the Disaster Management function in government which focuses on disaster risks reduction, disaster management measures, sustainable development and humanity. Communicating and disseminating safety information and warnings to the public is crucial to ensure effective and efficient disaster management [1]. It is the government's responsibility to set up structures that deal with disaster management. Governments create Acts and policies that guide Disaster Management to act within the law. The South African government has implemented the Disaster Management Act, of 2002 (Act no 57 of 2002), as well as the accompanying Disaster Management Framework Policy [2]. This Act provides for a unified & organized disaster management policy that focuses on preventing or reducing the risk of disasters, mitigating the severity of disasters, emergency preparedness, rapid & effective response to disasters, and post-disaster recovery and rehabilitation. These promote an integrated and coordinated disaster management system with an emphasis on prevention and mitigation. The cornerstone of successful and effective disaster management is unifying and organizing all the role-players and their activities into a holistic system aimed at disaster risk reduction. It is also a good investment in technology to aid the efficiency and effectiveness of some functions in the disaster management ecosystem.

A reliable emergency alert system (EAS) saves lives and protects properties and the environment in a disaster emergency [3]. EAS enables the government, its agencies, and community authorities at various levels to use communication platforms to inform people of imminent disasters in threatened areas [4]. EAS uses multiple communication channels for disseminating alerts and warnings, such

as TV and radio, sirens and long-range acoustic devices, message signage, the Internet, fixed phones, and mobile phones [5].

The accessibility of mobile phones has accelerated the use of mobile phone capabilities to disseminate emergency alerts [1]. Mobile phones are used in various ways to disseminate emergency alerts to the public through mobile applications (mobile apps), cell broadcast services (CBS), and location-based SMS (LB SMS). Mobile apps enable the sharing of more information, including pictures, links, and maps [6]. Cell Broadcast Service (CBS) allows mobile network providers to push critical and time-sensitive messages to all active mobile devices within a specified geographical area [1]. Location-based SMS (LB SMS) technology allows mobile network operators to send SMS notifications to mobile phone users in a specific geographical area [5].

South Africa is challenged by increasing levels of disaster risk. It has experienced weather hazards, including drought, fire, tropical cyclones, and severe weather hazards, resulting in losses of life and livelihoods and significant infrastructure damages [7]. There are several South African initiatives focused on disseminating crucial information and warnings, such as the South African Weather Service (SAWS) WeatherSmart App [8], the South African Police Service (SAPS) AMBER initiative in partnership with Facebook and MySAPS [9], and the National Department of Health (NDoH) COVID Alert SA app [10]. South Africa relies heavily on TV, radio, websites, mobile apps, and social media platforms to disseminate public emergency alerts. The efforts on these initiatives are unintegrated; there is no integrated EAS. Each authority has its systems and mechanisms to alert the public. Furthermore, the use of LB SMS relies on the registered addresses of users subscribing to each authority mobile app and third-party apps. Using Cell Broadcast Service (CBS) and LB SMS without users registering their addresses will ensure the alert reaches every citizen and tourist in the country.

In South Africa, using CBS and LB SMS capabilities to disseminate emergency information to targeted geographical areas by authorities is still an area of improvement. Additionally, there is a need to centralize the efforts of disseminating public disaster emergency alerts through National and Provincial Disaster Management Centres. Therefore, there is a need to explore and accelerate the use of mobile phone capabilities to maximize the effectiveness of public alerts in South Africa. The research questions are as follows: (1) What are the building blocks of EAS that contribute to the effectiveness of using mobile phone capabilities in EAS? (2) What is the state of the art of research on utilizing mobile phone capabilities for public emergency alerts in South Africa?

The study focuses on the adoption and use of mobile phone capabilities to maximize the effectiveness of the EAS in disseminating public emergency alerts. The study is organized as follows: The next section provides a literature review on Emergency Alert Systems focusing on mobile phone capabilities, followed by the methodology. Then, the preliminary findings and discussion are presented, followed by the conclusion section, which summarizes the study and outlines future work.

2 Literature Review

According to [3], a reliable emergency alert system (EAS) is crucial for saving lives and protecting properties and the environment. [1] urged that multiple communication channels increase the effectiveness of emergency alerts by complementing each other's limitations. This section provides the concepts of emergency alert systems (EAS), mobile phone capabilities for public emergency alerts, mobile phone capabilities-focused implemented EAS from various countries, and the state of EAS in South Africa.

2.1 Emergency Alert System

EAS is sometimes called a public warning system (PWS), and these two terminologies are used interchangeably. An early warning system (EWS) is sometimes called EAS. According to [11], these systems consist of protocols, policies, and information technologies assembled to disseminate timely disaster alerts to the public. In addition, [11] identified four main components of EAS, namely a) awareness of the risks; b) tracking, review, and risk forecasting; c) communication or dissemination of alerts and warnings; and d) people's reaction to received warnings. According to [5], the following are the most used channels for disseminating alerts and warnings: namely TV and radio, sirens and long-range acoustic devices, message signage and public address systems, the Internet, fixed phones, and mobile phones through cell broadcast, SMS, instant messaging services, email, push IP (Internet Protocol) to smartphones, and mobile apps. However, [12] they argued that sirens, radio, and TV are no longer sufficient for emergency alerts. Global satellite navigation is another alternative channel to disseminate real-time location-based emergency alerts due to its resilience to network infrastructure failures during disasters [1].

In general, EAS comprises alerting authorities, alert gateway, alert distributors, and the public. Alerting authorities can be government departments, officials, and agencies that disseminate alerts to the public [4]. The alert gateway is the central system that receives alerts from authorities, validates them, and formats them to acceptable formats by different alert distributors. Alert distributors distribute alerts to the public, who is responsible for following the alert instructions. Mobile phone capabilities have been used to complement other dissemination channels in EAS. Figure 1 is a general high-level mobile-based EAS architecture focusing on mobile phone capabilities.

2.2 Mobile Phone Capabilities for EAS

The accessibility of mobile phones has accelerated the use of mobile phone capabilities to disseminate emergency alerts and collate information for situation awareness [14]. The United Nations advocated the use of geo-located mobile-based early warning services, such as CBS and location-based SMS (LB SMS), to disseminate emergency alerts to all by 2027 [15]. Authorities can notify people of an imminent disaster in and around their area using mobile applications, social media platforms, CBS, and SMS capabilities in collaboration with mobile network providers.

Mobile apps enable the sharing of more information, including pictures, links, and maps, but using a mobile app requires users to download it and rely on internet services [6]. Cell Broadcast Service (CBS) allows mobile network providers to push critical and time-sensitive messages to all active mobile devices within a specified geographical area [1]. The technology does not require mobile phone users to register; all active CBS-capable mobile phones are

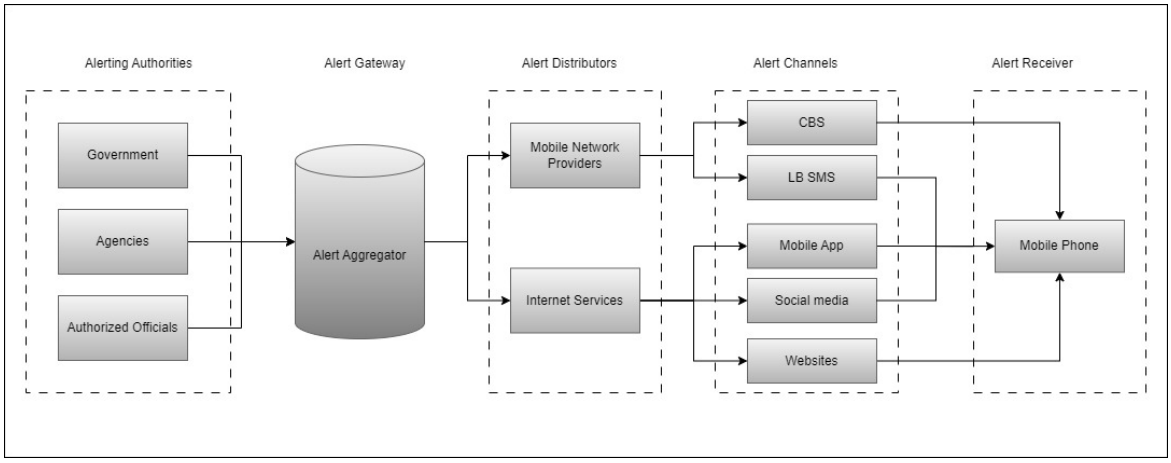

Figure 1: High-level mobile phone capabilities-based EAS architecture [13]

Table 1: Mobile phone capabilities for EAS

Characteristics	Mobile App	CBS	LB SMS
Alert Details	More information, including links and maps, can be presented.	Limited characters	Limited characters but can include links.
Precise Location	Rely on GSM/GPS and internet services	Its precise location depends on Cell tower coverage	It has more potential for location precision based on the last known or user-registered location.
Reception	Received once the mobile phone is switched on and the app is active (can be background running)	No reception if the mobile phone is switched on after broadcasting	Received once the mobile phone is switched on
Deliver Confirmation	Delivery confirmation is supported	No confirmation of delivery	Delivery confirmation is supported
Sensitivity to Network Conditions	Network congestion can affect alert delivery speed	Continue to function during network congestion	Network congestion can affect SMS delivery speed
Configuration and settings	Requires users to download the app Register personal information such as location address.	There is no need for the user to register. Some mobile phones might need to be configured.	No user registration Everyone is familiar with an SMS text message.
Examples	KATWARN in Germany WeatherSmart in South Africa	WEA in the USA NL-Alert in the Netherlands	Emergency Alert in Australia BE-Alert in Belgium

automatically opted in when they connect to a mobile network but have limitations on message characters and rely on cell towers for coverage [16]. Location-based SMS (LB SMS) technology allows mobile network operators to send SMS notifications to mobile phone users in a specific geographical area [5]. LB SMS combines cell-based location with traditional SMS to send SMS alerts to mobile phones in a targeted area. Table 1 summarizes mobile phone capabilities for EAS by comparing them and giving examples of each capability.

2.3 Existing EAS

Countries use complex EWS to predict the likelihood of disasters happening early, alert people of the harmful effects of various disasters, and share life-saving instructions. In 2007, Japan implemented J-Alert, an emergency broadcast system that alerts the public via satellite and an array of equipment set up nationwide [17]. In 2009, Australia launched the Emergency Alert that sends warning messages based on people's registered address or last known location of a mobile phone [5]. In 2012, the United States of America (USA) launched Wireless Emergency Alert (WEA), which notified citizens about emergencies by sending alerts to mobile phones [13].

In 2018, The Emergency Telecommunications Committee standardized PWS across European countries [12]. EU-Alert is a generic

term for the European public warning services based on CBS technology. EU countries can configure PWS to meet their specific requirements while promoting pan-European interoperability [12]. When implemented, each country replaces the letters EU with letters identifying the country, e.g., NL-Alert for the Netherlands. Some EU countries, such as Belgium and Sweden, use LB SMS and do not comply with EU-Alert standards and regulations [5].

In Kenya, the Trilogy Emergency Relief Application (TERA) system was launched in 2015, followed by M-Salama in 2018, and both platforms disseminate alerts and updates in disaster areas to AirTel Kenya and Safaricom subscribers, respectively [18] [19]. In 2023, Tunisia developed an SMS-based EWS to notify citizens of imminent natural disasters [20]. Later in the same year, the Republic of Mauritius implemented a location-based PWS across all government and law enforcement agencies to immediately warn the public in the event of an emergency [21].

Countries have been using CBS to disseminate emergency alerts nationwide, mainly due to its reliability and coverage compared to other communication channels. In Europe, countries standardize the naming and implementation of EAS to promote cross-country interoperability and data sharing. In Africa, the adoption of CBS and LB SMS is still an area for improvement.

2.4 EAS in South Africa

South Africa is not exempt from disasters, and timely information dissemination is essential in saving lives in areas threatened or affected by disasters. In their paper, [22] revealed that between 1959 and 2019, South Africa faced several major floods, resulting in losses of life and livelihoods and significant infrastructure damages. Post 2019, South Africa experienced heavy rainfall that led to floods and landslides [23]. A runway bush fire threatened nature and residential properties along the Western Cape coastal line [7]. Earthquakes and hailstorms in Midrand [24]In 2014, the Council for Scientific and Industrial Research (CSIR) highlighted that disseminating warnings to all levels of society remains challenging, and a lack of awareness in communities leads to poor participation in disaster management.

According to [25], the SAWS is the central-mandated government entity responsible for monitoring weather and climate patterns for decision-making. SAWS issues forecasts to relevant government authorities, who then generate and disseminate alerts to the public to minimize potential impacts [8]. SAWS uses its website, social media platforms, print media (newspapers), televisions, radio stations across the country, and mobile apps to alert the public [8]. In addition, SAWS provides Application Programming Interfaces (APIs) for system-to-system access to weather warnings [8]. Other EAS include the South African Police Service (SAPS) AMBER initiative in partnership with Facebook [9], the MySAPS app [26], and the National Department of Health (NdoH) COVID Alert SA app [10].

Constitutionally, the South African government assumes a primary role in disaster management. The Disaster Management Act 57 of 2002 (DMA) is the primary legislation focusing on disaster management in South Africa. DMA provides a unified and organized disaster management policy focusing on prevention, mitigation, emergency preparedness, rapid and effective response, and post-disaster recovery [2]. DMA established the National Disaster Management Centre (NDMC) to encourage a unified and organized approach to managing disasters, focusing on prevention and mitigation by authorities in disaster management and communities [2]. NDMC has an early warnings registration page that enables citizens to register to receive early warnings targeting areas of their interest.

3 Methodology

A systematic literature review was followed to answer the research questions. The following selection criteria were used: peer-reviewed and journal papers written in English focusing on EAS and the use of mobile phone capabilities. The study included peer-reviewed and journal papers published from 2014 to 2024. The publications search was conducted on Google Scholar, ACM Digital Library, SpringerLink, ScienceDirect, IEEE Xplore Digital Library, Scopus, and CSIR Library. The search string was designed to capture relevant papers across several fundamental concepts. 606 papers were identified across the selected databases, and after deduplication of entries and applied exclusion and inclusion criteria, the total number of papers was further reduced to 30. Academic papers on emergency alerts are scarce in the South African context. We expanded our systematic review methodology to include grey literature. [27] demonstrated the practical application of grey literature in a systematic review.

Each paper was screened for quality to ensure the validity and reliability of the findings. The extraction process focused on patterns and trends emerging from the literature that align with the fundamental concepts of EAS. The study categorizes the findings under themes, facilitating a structured analysis of the existing literature.

While the methodology used in this systematic review was rigorous, there are limitations. The reliance on specific databases may have excluded relevant papers that were not indexed in these sources. The focus on English-language papers may have led to the omission of valuable research published in other languages.

4 Preliminary Findings and Discussion

The study is still undergoing data analysis, and a few findings have emerged. Various themes emerged and were grouped into seven categories: emergency alert messages, disaster information management, technology and infrastructure, situational awareness and communication, stakeholders and roles, user experience and perception, and regulations and policy. However, as the analysis is ongoing, these themes are not yet exhaustive or finalized. For this working paper, a discussion has focused on insights gathered around four of seven categories.

4.1 Emergency Alert Message

According to [28], the content of an alert message has an influence on how the receiver understands an alert. Therefore, investing in crafting alert messages for each disaster is vital to increase the effectiveness of EAS alerts [29]. Consistency in alert messages over multiple communication channels is noted, and international schemes and formats were recommended to facilitate interoperability across different systems and countries [30]. The accuracy of the location of a disaster and guidance on what to do were emphasized,

and the use of clear and short, simple words was recommended, as the effectiveness of EAS depends on the receiver's understanding of the message [14]. The validity and credibility of alert messages play a significant role in the effectiveness of EAS alerts. Therefore, it is essential to consider the authenticity of an alert message.

The study did not find literature evidence related to EAS alert messages in South Africa. Five aspects of crafting effective alert messages must be considered to assess and deduce the effectiveness of emergency alert messages in South Africa in communicating accurate and relevant information so people can take appropriate action to save their lives.

4.2 Communication and Awareness

According to [16], EAS relies heavily on the clear, timely dissemination of information and actionable guidance to the public. These factors significantly influence risk perception and the urgency of response [31]. Providing accurate and timely information across multiple communication channels, as recommended by [16] and [31], are the contributing factors for enhancing public trust in the alerts and increasing the likelihood of prompt, appropriate action. Utilizing multiple communication channels ensures that information reaches a broad audience. Moreover, a pre-incident public information campaign about the emergency alert system is essential to build confidence in the system's credibility. According to [31] and [32], alerts should be used sparingly to avoid desensitization, and when they are issued, they must be accompanied by clear, actionable instructions.

The study did not find direct evidence specific to the South African context. However, the effectiveness of emergency alert systems in South Africa could be challenged by the country's linguistic diversity and varying levels of technological access across provinces. To address these challenges, a multi-lingual alert system that can deliver messages in the most widely spoken languages of each province is required [33].

4.3 Stakeholder Roles and Responsibilities

Effective EAS requires strong partnerships between government authorities, mobile network providers, technology companies, and the public [3]. Collaboration between these stakeholders is essential for ensuring that public emergency alerts via cell broadcast reach all citizens. The public is often viewed merely as information recipients during disasters, and [33] recommended a more inclusive approach to disaster management, where the public should be recognized as multi-role stakeholders capable of acting as site sensors, volunteers, or even initiators of alerts. Additionally, initiatives such as the partnership between the South African Police Service (SAPS) and Facebook on the AMBER alert system demonstrate the potential of leveraging social media and digital platforms to enhance the reach and effectiveness of emergency communications [9].

4.4 Regulations and Policy

In South Africa, the Disaster Management Act 57 of 2002 provides a unified, organized disaster management policy focusing on prevention, mitigation, emergency preparedness, rapid and effective response, and post-disaster recovery. A policy, through authorized awareness programs that are compliant with legal requirements, can reduce community resilience in the event of a disaster [2]. Even if an emergency alert could save lives, people in some nations, like Japan, may choose not to act on it if it breaches the law [34].

The Protection of Personal Information Act (POPI Act) must also be considered in South Africa. The National Disaster Management Framework, 2005, calls for creating awareness, promoting a culture of risk avoidance, and establishing good media relations. [35] found that policies support multi-channel alert dissemination to reach the public. The National Disaster Management Framework, 2005, calls for creating awareness, promoting a culture of risk avoidance, and establishing good media relations. While legislative frameworks are essential, effective implementation remains the paramount challenge.

5 Conclusion

Disaster risk reduction is not an abstract or theoretical idea; instead, it needs to be implemented at all levels of government through focused, realistic initiatives (local, provincial, and national). To minimize the risks associated with disasters, we must optimize the application of the legislation and take necessary steps. Benchmarking with international practices is necessary since countries that have implemented EASs and faced catastrophic disasters have advanced in this area.

Mobile-based public emergency alerts have been emphasized as effective in informing people in threatened areas of imminent disaster. The paper preliminarily identified the building blocks of EAS: regulations and policies, disaster information management, technology infrastructure, situation awareness, communication approaches, alert message design, user experience and perception, and collaboration of stakeholders. South Africa has implemented some components of EAS, but in isolation and focusing on specific types of emergency alerts; additionally, there is a need to centralize the efforts of disseminating public disaster emergency alerts through National and Provincial Disaster Management Centres.

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