

## Radio Frequency Identification Technology application for disaster and rescue: a review

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### ABSTRACT

Radio frequency identification (RFID) always has a significant area of academic research over the last few years. The current paper presents a literature review of academic journal articles that were published on the subject between 2000 and 2017. Several case examples have been analyzed with the particular focus on RFID applications, its potential and future opportunities, particularly during disaster and rescue applications. It is hoped that the review will be a useful resource for researchers interested in RFID research.

**Keywords:** RFID, disaster, rescue operations, review

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### INTRODUCTION

The primary focus of emergency management is the avoidance, control, management, and elimination of inherent losses when disasters occur. With the high number of natural and manmade disasters, researchers have emphasized on all aspect of disaster including preparedness, mitigation rescue, and recovery. Disasters can be very different in their distinctiveness on severity, the impact of homes, businesses, public structures, and human life or any combination of the above [1].

Tracking human beings and objects have been considered as a primary component for researchers and scientists, especially during the disaster and rescue operations. Different Automatic Identification(Auto-ID), Technologies such as Sensors, Barcodes, Smart Cards, Optical character recognition (OCR), Biometric procedures-BP, Pattern analysis, Radio frequency identification (RFID) and Geographical information systems (GIS), have been used for tracking procedures. Detailed study of these technologies shows that they are often more resource demanding and their performance become questionable during the unfavorable conditions such as in emergencies. For instance, to implement GIS in disaster management, each site has to be identified, added to the suitable database and sited on the map. This takes more time and workforce during the development phase, as well as for maintenance phase [2]. The limitation of OCR systems is that they have failed to become globally popular because of their high price and complicated readers they require, in comparison with other ID procedures [3].

RFID can work well for tracking as well as authentication, automation and information management [4-6]. It is a contact-less, cost-effective and reliable technology. Therefore it can be used successfully where contact-less tracking and identification is required. RFID constitutes of a tag made up of a microchip at one end and a reader on the other, whereas

both are connected with antennas. A reader sends out electromagnetic waves such that they are received by a tag antenna [7-9].

## **METHODOLOGY**

This study was an unsystematic review in which the literature search was carried with the help of available literature, journals, books and proceedings and also searches engines available at Google, Google Scholar. We searched and analyzed the keywords such as Radio frequency identification, RFID application, disaster victim identification, disaster rescue and recovery. It was aimed to review the current research and development in the field of RFID application in disaster rescue operations. A taxonomic framework is also compiled to classify literature for quick content analysis and identify future direction of research.

## **FINDING AND ANALYSIS OF REVIEW:**

RFID technology has exploited in the healthcare and hospitality [10], power facilities [11-12], urban planning and construction [13-14], parking and traffic control system [15-19], transportation [20] sectors. This facilitates early identification of potential problems and thus helping in preventing them from escalating into bigger problems. However, the need of planning during a disaster and emergency response has been flagged by various researchers [21-23]. Effective disaster management depends on the information systems and technologies which could play a significant role in making appropriate decisions at any stage of natural disasters and improving information dissemination and communication among of all stakeholders during response and recovery operations [24]. Various information communication technology (ICT) tools, such as geographical information system (GIS), remote sensing, RFID, GPS, building black box, radio communication media, and social media are available for use in disaster recovery [25-28].

Various facets of RFID technologies in disaster and its applications in rescue operations:

The difficulties in identifying Disaster victim identification (DVI) during tsunami catastrophe was discussed by Meyer *et. al.*, 2006 [29]. They suggested that placement of radio frequency identification device (RFID) microchips inside victim bodies provided a practical solution to problems of body tagging and attribution in the DVI setting encountered by the Austrian DVI team in Thailand in early 2005.

Pate [30] in his state of art technology review in Identifying and Tracking Disaster Victims identified the failure of the country to enough track casualties of Hurricane Katrina had been recognized as a noteworthy shortcoming of social and nearby calamity readiness arranges. This gap has urged government and private enterprises to acknowledge that current work-based tracking frameworks are unequipped for overseeing data amid a large-scale catastrophe. In light of this need, endeavors are under the approach to growing new advances including RFID technologies that permit moment access to personality and area data amid crisis circumstances.

The challenges in finding the causalities in seismic tremor in Japan's Niigata Prefecture were noted by M. Daito & N. Tanida [31]. The quake brought about a wired system detachment. The frameworks' breakdown was because of the huge number of clients who were stressed over the security of their relatives. The same circumstance happened amid Hurricane Katrina in the USA. This work gives careful consideration to a fundamental and guaranteed calculation for finding casualties utilizing RFIDs. To begin with, it discloses strategy to affirm the area of casualties. Second, it clarifies a strategy for pinpointing the position of casualties using trilateration. At last, it introduces simulation results.

The urban disaster response and recuperation were discussed by Peña-Mora *et al.*, 2008 [26] through a comprehensive cutting edge survey of different technological advances. This survey was a part of the CP2R venture (Collaboration Framework for Preparedness against, Respond to and Recovery from eXtreme Events (XEs) including necessary physical base) which has concentrated on enhancing the coordinated effort between the major performing artists that ought to be required in various strides of readiness against (*i.e.*, before disaster), reaction (*i.e.* amid calamity) and recuperation (*i.e.*, after disaster). The work presumed that developing Information and Communication Technologies using RFID can assume an essential part in a disaster readiness, reaction, and recuperation forms. Nam, 2009 [32] presented building up an expert system as a GUI project to decode radio

frequency identification codes for modeling and simulation of natural disasters using virtual environment of disasters.

Badpa et al. 2013 [33] emphasized the effect and importance of Knowledge Management System in Disaster Management through RFID Technology Realization. They studied the various disasters, especially quakes in Iran. This work recommended Radio Frequency Identification System can be utilized in disaster victim identification and framing disaster management strategies in coordination with Oracle as Data Base Management System with a devoted system framework.

The exploration work of Beruvides, 2014 [1] emphasized on potential uses for the RFID innovation in emergency management. The paper was focused on crisis administration (man-made or natural) and found that emergency management includes the avoidance, services, control, and disposal of intrinsic misfortunes when disasters happen. Vijtech et. al. 2016 [34] studied on Ultra High-Frequency Radio Frequency Identification device tag design for disaster management. The Ultra High Frequency (UHF) Radio Frequency Identification device (RFID) label plan as a piece of RFID confinement framework principally assigned for mass disasters. The configuration of RFID label considers numerous setbacks in a range of hundreds square meters, human body impedance, battery lifetime, maximal yield power, safe epitome and so forth. Results demonstrate the composed RFID label model is reasonable for application in a disaster management.

Healthcare and disaster supply chain have becoming a more critical and popular research issues recently. The current issues both healthcare and disaster supply chain, especially in natural disaster case, was studied by Syahrir, I., & Vanany, I. (2015) [35]. Research that integrates both healthcare and disaster supply chain is a relevant issue to develop a model framework in order to have the capability in handling humanitarian relief operations during natural disasters including focused on inventory management and controls for medical needs in the event of a natural disaster (eg earthquakes, floods, epidemic disease outbreaks, landslides, etc.). Use information technology such as RFID was highlighted more widely in the healthcare and disaster supply chain system in responding to the problem of interference supply chain at the time of the disaster.

Daito, M., & Tanida, N. (2008) [31] in their study on Agent-based simulation approach for disaster rescue using active RFID found that after the 2004 earthquake in Japan's *Niigata* Prefecture, there were many difficulties finding the victims. The earthquake caused a wired network disconnection. Also, fixed-phone and cell-phone service systems crashed due to the rapid increase in the volume of communications. The systems' collapse was due to a large number of users who were worried about the safety of their relatives. The same situation happened during Hurricane Katrina in the USA. Reflecting on these situations, the Japanese Ministry of Internal Affairs and Communications is trying to adopt several methods to correct these communications problems. Authors recommended that a predominant goal of one of the methods is most likely to find victims using RFIDs (Radio Frequency Identification) with computer sensors. They suggested that the RFID process would have to be incorporated in the following ways: 1) by scattering sensor devices from helicopters when a large-scale disaster such as an earthquake occurs, 2) by making RFIDs self-organized into a network, and 3) by making the self-organized network pinpoint the position of victims. The researchers pay specific attention to a simple and assured algorithm for discovering victims using RFIDs by the method to confirm the location of victims then pinpointing the position of victims using trilateration and simulation results.

The paper on emerging technologies to support urban resilience and disaster recovery by Peña-Mora et al., 2008 [26] presented a comprehensive state-of-the-art review of various emerging technologies to support urban disaster response and retrieval. The review was undertaken as a part of the CP2R project (Collaboration Framework for Preparedness against, Respond to and Recovery from eXtreme Events (XEs) involving critical physical infrastructure) which has focused on improving the collaboration between the main actors that should be involved in different steps of preparedness against (i.e., before disaster), response (i.e. during disaster) and recovery (i.e., after disasters). Technologies reviewed include the application of Radio Frequency Identification (RFID) based techniques for formative assessment, field responders mobility and disaster site data collection, Geospatial Information System (GIS) for optimal resource optimization from disaster site were discussed. The paper concluded that emerging ICTs (Information and Communication

Technologies) can play a pivotal role in disaster preparedness, response and recovery processes. The need for further exploitation of convergence and synergy between various technologies and their application to support existing disaster response processes is also discussed.

Dorasamy *et al.*, 2013 [36] in their review of Knowledge management systems in support of disasters management highlighted that the successful management of emergency situations requires proper planning, guided response, and well-coordinated efforts across the emergency management life cycle. It was suggested that emergency management efforts benefit from well-integrated knowledge-based emergency management information systems (EMIS). It was found that only limited work has been done in three EMIS-knowledge management system (KMS) subdomains: (i) definition, (ii) use, and (iii) methods. Second, only limited research has been done in embedding roles in KM systems.

Ganz *et al.*, 2015 [37] introduced the DIORAMA based system that provides situational awareness for urban search and rescue operations in both indoor and outdoor settings, significantly improving the operations' efficiency. Using a Smartphone, DIORAMA enables the responders to triage patients with active RFID tags and to mark the locations of trapped patients and points of interest (e.g. fire, chemical spill, collapse buildings). Also, the tagged patients' location will be automatically tracked and updated on the interface. The incident commander can also interact with the responders on-site using the DIORAMA interface either on a Smartphone or a tablet. The DIORAMA system uses active RFID technology as well as visual analytics tools.

Hasanzadeh, S., & Sarkari, M. (2014) [38] argued that RFID can be useful technology that can be used in emergency situations. In the model offered by Badpa and his colleagues this technology had a major role in coordination, which can be done in an emergency situation. Dorasamy and his colleagues' research showed that if some recommendations offered by them is considered in KMS designing, it can be more useful in support of emergency situations. And finally, Li and his colleagues' research show that establishing broad connection between different parts of a community including various organizations and peoples can make a useful database that its' knowledge and resources can be used when a disaster occurs.

Nam, 2009 [39] in his paper presented an expert system as a user interface program to decode radio frequency identification codes for simulation and modeling of natural disasters. The entire developed environment for the expert system is intended to integrate all subtasks as a standard user interface program to simulate and report the damages due to the catastrophic disasters. To perform the simulation as a part of the entire system, the expert system reads in RFID codes to provide the desired information about the damages due to the catastrophic disasters based upon the available fields.

Ingrassia *et al.*, [40] demonstrated the applicability and the reliability of a radio frequency identification (RFID) system to collect data during a live exercise. In their study, a rooftop collapse of a crowded building was simulated. Fifty-three volunteers were trained to perform as smart victims, simulating clinical conditions, using dynamic data cards, and capturing delay times and triage codes. Every victim was also equipped with a RFID tag. RFID antenna was placed at the entrance of the advanced medical post (AMP) and emergency department (ED) and recorded casualties entering the hospital. Results showed 100% accuracy in tag reading or data transfers.

Ahmed, A., & Sugianto, L. [41] in their papers addresses the impacts of RFID (radio frequency identification) adoption on the performance of emergency management organizations. They studied that what are the effects of RFID adoption on the performance of emergency management operations? They found that the impacts of using RFID technologies reduced response time, efficient tagging and tracking, compatibility, reduced labor cost, and robustness. The empirical findings in these studies indicated that five key factors influencing the decision to adopt privacy, compatibility, standardization, implementation, and locatability.

The role of the RFID technology in an earthquake to rescue victims was studied by Akbari, B., & Ajami (2015) [42]. They found in their review that organizational resources and technical structures such as hardware and software are essential requirements in the redesign of electronic projects, especially in disaster response. The RFID makes the prevention of the human error of Medicine, easy, and fast access to medical staff,

equipment, medicine. It is cost effectiveness. All of these factors cause to increase the quality and quantity of care in the healthcare sector. The study also helps define the concept of “Tracking victims via RFID” (regarding both advantages and barriers) as the new technology in the present age.

Chatfield *et al.*, 2010 [43] studied the E-Government Challenge in Disaster Evacuation Response and emphasized on the role of RFID Technology in Building Safe and Secure Local Communities. The potential high impact and strategic value of integrating RFID into e-government development and government’s comprehensive natural disaster management policy for improved preparedness, response, recovery, and mitigation, very little has been written in the e-government literature regarding the adoption, use, and impact of RFID in building safe and secure local communities for citizens and businesses.

The role of the RFID technology in an earthquake to rescue victims was studied by Akbari, B., & Ajami, S. (2015) [42]. They found that organizational resources and technical structures such as hardware and software are essential requirements in the redesign of electronic projects. The RFID makes the prevention about the human error of Medicine, easy, and fast access to medical staff, equipment, medicine. The advantages of RFID cited by researchers includes reduce time; cost, error, facilitate medical and supportive data recording by using RFID in the process of victims tracking. The significant barriers highlighted in this study by Akbari, B., & Ajami[42] was the inability to read wet Tags; Tags and reader interaction, safety & security concern, the high initial cost for tag and hardware, ethical and moral dimension to tagging human.

Daito, M., & Tanida, N. (2008) [31] revealed that RFID could play a predominant role to find victims with computer sensors. They suggested that the RFID method would have to be incorporated in the following ways: 1) by scattering sensor devices from helicopters when a large-scale disaster such as an earthquake occurs, 2) by making RFIDs self-organized into a network, and 3) by making the self-organized network pinpoint the position of victims. They also highlighted the importance of field-testing as a necessity to confirm the effects. The summary of the review is presented in table 1.

Table: Summary of RFID review

<b>Particulars related to RFID</b>	<b>Major area of RFID application</b>	<b>Abstract</b>	<b>Reference</b>
The adoption of RFID technology in the retail supply chain	Recent improvements with respect to selection of RFID innovation in retail inventory network.	This innovation to retailers are plot as opposed to Bar Coding	[44]
Implantation of radio frequency identification device (RFID) microchip in disaster victim identification (DVI)	Practical solution to problem of body tagging.	The position of RFID microchips inside casualty bodies gave a down to earth answer for issues of body labeling and attribution in the DVI	[45]
VIRE: Active RFID-based localization using virtual reference elimination	RFID for indoor area detection.	The proposed methodology can defeat the above downsides without extra cost	[46]
A framework for disaster management system and WSN protocol for rescue operation	Information collection framework for disaster mitigation and rescue operation.	This proposed structure and contrast the execution of the convention and that of SENDROM framework convention.	[47]
Identifying and Tracking Disaster Victims: State-of-the-Art Technology Review	Identification and tracking of disaster victims.	Proposed approach to grow new advances that permit moment access to personality and area data amid crisis circumstances.	[30]

Agent-based simulation approach for disaster rescue using active RFID	Strategy to affirm the area of causalities.	This work gives careful consideration to a basic and guaranteed calculation for finding utilizing RFIDs	[36]
Review of Emerging Technologies to Support Urban Resilience and Disaster Recovery	Radio communication and social media for use in disaster recovery.	The work presumes that developing ICTs can assume a urgent part in a disaster readiness, reaction and recuperation forms.	[26]
Lightweight cryptography in radio frequency identification (RFID) systems	Lightweight cryptographic arrangements in RFID	Study investigates of the best in class distinguishes the requirement for lightweight cryptographic arrangements reasonable for these extremely obliged gadgets	[48]
Development of an Expert System as a User Interface for an RFID Application	Expert system as a user interface program.	Proposed master framework peruses in RFID codes considering the end goal to give the sought data about the harms.	[40]
Implementable Privacy for RFID Systems	RFID innovation to track development of items.	A configuration strategy for building private frameworks from these building blocks	[49]
What benefits can be brought forward by adopting RFID in emergency management	Impacts of RFID adoption on the performance of emergency management.	This work will help the crisis administration associations to better manage the crisis operations	[41]
E-government challenge in disaster evacuation response: the role of RFID technology in building safe and secure local communities	Role of RFID in building safe and secure local communities.	This work presents an audit of the review and a field contextual investigation	[43]
A relationship investigation was performed between the two techniques plotting the matched RFID and manual times	Data collection in a live mass casualty through RFID and manual system.	Data collection in a live mass casualty incident simulation: automated RFID technology versus manually recorded system	[50]
Findings show that 5 key variables affecting the choice to receive are security, standardization, compatibility, implementation and locatability.	Significance of RFID in Emergency management.	Potential of RFID in Emergency Management: Task-Technology Fit Perspective	[41]
This study proposes	Inventory	An RFID-based inventory	[51]

an structure for the improvement of a philanthropic crisis stock administration	management framework for emergency relief operations.	management framework for efficient emergency relief operations	
The proposed model means to concentrate on learning, human and innovation related issues of Emergency Coordination Center	Effect and importance of Knowledge Management System in Disaster management through RFID.	Effects of knowledge management system in disaster management through RFID technology realization	[33]
This study had performed examination of Flood Prediction procedures taking into account GIS utilizing Ad hoc remote Sensor Network Architecture	Flood prediction and disaster risk analysis.	Flood Prediction and Disaster Risk Analysis using GIS based Wireless Sensor Networks, A Review	[52]
This study exhibits two decade's audit of works relating to the use of learning driven frameworks in backing of crisis administration	Knowledge management system in support of disasters management.	Knowledge management systems in support of disasters management: A two decade review	[37]
It show a novel separation hopping convention in light of diagrams that is amazingly low-asset expending	Innovative separation hopping.	Privacy in RFID and mobile object	[53]
This work, subsequent to calamity administration, asses learn about the calculated model of the KMS application in a disaster administration.	KMS application in disaster management.	Evaluation of Knowledge Management Systems application in Disaster Management	[39]
This work presents past examination and applications that show new potential uses for the RFID innovation in emergency management	Primary focus of emergency management.	An Analysis of the Potential and Actual Utilization of the RFID Technology in Emergency Management	[1]
Proposed work is to counteract cloning and falsifying of tags in view of RF Fingerprinting	RFID based signal acquisition.	RFID Signal Acquisition and Identification	[54]
The composed RFID label model is	Disaster management centric	UHF RFID tag design for disaster management	[35]

reasonable for application in a disaster management	RFID tag designs.		
This work is a preparatory report of an examination on medicinal services and calamity store network	Healthcare and disaster supply chain.	Healthcare and Disaster Supply Chain: Literature Review and Future Research	[36]
The labeled patients' area will be naturally followed and overhauled on the interface	Smartphone and RFID tag based rescue.	Urban Search and Rescue Situational Awareness using DIORAMA Disaster Management System	[38]
This literature survey characterizes the idea of "tracking casualties by means of RFID" as the new innovation in the present age	Role of RFID in earthquake to rescue victims	Radio frequency identification and rescue victims in earthquake	[42]

## CONCLUSION

The adoption of RFID technology hailed as one of twenty-first century's greatest contributions in the retail supply chain, healthcare and hospitality, power facilities, urban planning and construction, parking and traffic control system, transportation sectors is significant. Recently Radio frequency identification (RFID) gains an important area of academic research with focus on disaster preparedness and rescue operations. However, from the above literature review, it can be concluded that standardization of hardware, software, network protocols and reading devices of RFID can play vital role during disaster and rescue applications including disaster victim identification.

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