Chapter 16
Integration of Multiple Technologies in Web Environment for Developing an Efficient Framework for Emergency Management

V. Bhanumurthy and Vinod Kumar Sharma

Abstract Emergency management is a multi-disciplinary endeavor of applying science, technology, planning, and management to deal with extreme events. Effective emergency management demands availability of right data in right format at right time to enable disaster managers for taking efficient decisions at the time of crisis. Technologies and tools including remote sensing, geographical information system (GIS), web services and communication technologies have tremendous potential to support decision making process at the time of emergency. Integration of the available technologies and tool at a common platform for addressing emergency management is a challenge. Different technologies and tools have their own communication protocols and different data standards. To overcome this limitation in integrating all relevant multidisciplinary technologies, a comprehensive framework is proposed with the capabilities of database organization, integration, and decision making tools. This framework is a chain of action for dealing with all phases of emergency management life cycle. It facilitates the necessary components such as preparing for and recovering from a disaster or emergency situation. The integrated system yields as disaster dashboard services, multi-scale geospatial database, decision making tools, set of mobile applications for relief management. To test the capabilities of the framework in real time, it has been translated into a comprehensive emergency information system for National Disaster Response Force (NDRF) as a proof of concept in the form of geo portal. It is an end to end solution fulfilling all the requirements of the NDRF at ground starting from initiating an event to successful completion of the event.

Keywords Emergency management · GIS · Emergency management life cycle NDRF

V. Bhanumurthy · V. K. Sharma (✉)
National Remote Sensing Centre, Hyderabad, India
e-mail: vinod_sharma@nrsc.gov.in

V. Bhanumurthy
e-mail: bhanumurthy_v@nrsc.gov.in

P. J. Rao et al. (eds.), *Proceedings of International Conference on Remote Sensing for Disaster Management*, Springer Series in Geomechanics and Geoengineering,
https://doi.org/10.1007/978-3-319-77276-9_16

1 Introduction

Emergency management is the discipline dealing with risk and risk avoidance [1]. Emergency situation can arise due to a disaster, caused by a technology or natural process. Emergencies or disasters are no respecters of national borders and may not occur at convenient times. It can happen at any time, at any place. Emergency response demands rapid decisions in short time. In emergency conditions, the decision makers may commit mistake due to pressure. To minimize the manual mistake, it is very important to have emergency plans in place. WHO [2] recommends launching of a coordinated response mechanism for comprehensive emergency management. Response to deal with emergency situation relies on execution of one or more response plans. Command and control centre are responsible for proper execution of response plans on ground. The command and control center gives directions to the team on the field based on current situation. A commander on field coordinate and executes the relief activities with the help of support staff on ground, which has been monitored by the control center. New information about the emergency situation have been updated from the ground to the control center which has been analyzed and appropriate decisions have been transferred to on field team for execution. The activities during a disaster or an emergency incident are mostly tiresome and have to be carried out under severe pressure [3]. Selection of emergency plan for execution on the ground depends on the type of emergency or disaster event. Some time it become difficult to execute the emergency plans on ground due to adverse conditions, which includes bad weather, non-accessibility of the site, non-availability of equipments and many more. Hence, a set of optional plans has to be made for implementing most appropriate or suitable one. Real-time monitoring and control of response activities have been considered as integral parts of effective emergency response where the technologies play an important role. The ultimate objective of emergency management is to bring down the extent of disaster impact on the lives or property Therefore, emergency management means to identify challenges and be prepared for possibilities and threats through competence and comprehensive insight in activities and operations [4].

Emergency manager need rapid sharing of the database or information to analyse the situation. It requires the disaster-specific data for data interpretation, analysis and for the rescue and relief operations. Further, detailed spatial information at the larger scale, high resolution satellite data complementing the vector database and detailed spatial attributes with proper linking of secondary information, etc. in addition the above-mentioned database is essential. The most critical and difficult part is to immediately capture the information accurately following a disaster in terms of extent and impact of the event. Such information is important and essential requirement for effective response and decisions making. Unfortunately, the environmental and adverse situations prevailing after a disaster event prevent the timely acquisition of such information through conventional collection methods, such as ground surveys or telephonic reports. During such situations technologies such as Remote Sensing (RS), Global Positioning System (GPS), mobile devices,

communication satellites etc. are of immense use. Image Processing (IP) techniques, Geographic Information Systems (GIS) help in analysing the data received by various means in decision making. The technological advancements in the field of computer science, Information Technology (IT) and Open Geospatial Consortium (OGC) standards have significantly changed the GIS, allowing users to take advantage of new distributed mechanism. Internet GIS has become an important back bone for disseminating spatial database for emergency managers. Therefore, the emergency information systems with robust communication networks with the background of well-structured database, Location Based Services (LBS), decision support tools, etc. need to be integrated into a platform or a portal to assist the people responding to crisis, disasters and calamities.

For enabling the data/information and tools for decision making, an appropriate framework has to be developed with well-defined component for storing static database, ways and means to obtain field data in real/near-real time, integration of data obtained from multiple sources, communication channel/connectivity for exchange of information, dissemination of information to disaster managers and public. Sometimes, appropriate information is required at right time (preferably near-real time) for situation assessment during response. Therefore development of a suitable framework for emergency management has been proposed through integration of multiple technologies for effective management of emergency event.

2 Design Objectives and Multi-disciplinary Technologies for Emergency Management

Emergency management is a key challenge and priority issue for any country. It involves multi-disciplinary fields for real-time decision making. Sometimes, appropriate information is required at right time for situation assessment during response. Various technologies including Remote Sensing, Geographic, Mobile Technology and Global Positioning System and Web Technology have got potential role to play in managing emergency situations. Therefore, it is proposed to develop a suitable framework for emergency management through integration of various multi-disciplinary technologies. This framework results effective exchange of information for decision making, communication among response teams and disaster managers besides information on the situation prevailing at disaster site in real/near real-time.

2.1 Design Objective

The objective of the research is to develop a suitable framework for addressing emergency management through integration of multidisciplinary technologies for effective decision making.

The framework is intended to demonstrate and utilise on pilot basis for National Disaster Response Force (NDRF), a premier organisation of Ministry of Home Affairs, Government of India for carrying out relief and rescue operations.

2.2 *Multi-disciplinary Technologies for Emergency Management*

Today a host of technologies and tools such as Remote Sensing (RS), Geographical Information System (GIS), Global Positioning Systems (GPS), Internet, Web services, Database systems, Information Technology (IT), Communications etc. are widely used in various fields contributing to the geographic mapping and analysis of the Earth and human societies. Availability of these technologies in Free and Open Source Software (FOSS) has open up many new avenues for implementation of emergency management framework. Integration of these diverse technologies into a seamless environment provides an effective and easy to use solution for implementation of geoplatform for decision making process for emergency situations. Some potential technologies are discussed in the following sections.

2.2.1 Remote Sensing

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object. Remote sensing makes it possible to collect data from inaccessible areas. Remote Sensing has a growing relevance in the modern information society. Furthermore, remote sensing exceedingly influences everyday life, ranging from weather forecasts to reports on climate change or natural disasters [5]. The Earth observation satellites covering large areas at various spatial and temporal scales in real-time have become valuable sources of information related to atmosphere and earth surface. Polar orbiting satellites have the advantage of providing much higher resolution imageries, even though at low temporal frequency, which could be used for detailed monitoring, damage assessment and long-term relief management. Geo-stationary satellites provide continuous and synoptic observations over large areas on weather including cyclone monitoring [6].

Satellite images acquired prior and after disaster event show the areas affected thereby assists the disaster managers in assessing the damages.

2.2.2 Geographic Information System

Geographic Information System (GIS) is a computer based information system used to digitally represent and analyse the geographic features present on the earth'

surface and the events that taking place on it. GIS technology plays an important role in the emergency management activities. The important phases of emergency management require variety of database from various sources. This data is typically a spatial data along with attributes and live information as an important input for development of emergency management systems. By utilising the capabilities of GIS, one can share the information through databases on computer generated maps for visualisation. Most of the data requirements for emergency management is of spatial nature and need spatial support for visualisation and decision making. The capabilities of GIS make very large impact on the planning, mitigation, preparedness and response phases through database integration, organisation, and interfacing with high level programming languages for implementation of geoportals [7].

2.2.3 Mobile Technology and Global Positioning System

Use of mobile and GPS technologies in disaster management should be seen as a new era to aid better management of disaster relief operations. The use of mobile applications in disaster management and emergencies has greatly improved due to the leading advances in telecommunication and remote sensing techniques. Mobile technology has its wide application in area of disaster management. The technology is helpful in tracking people in disaster prone areas. Users can be tracked with the help of GPS in mobile phones. As the technology is advancing, the area of mobile usage has greatly expanded due to 3G, social networking, video, android, etc which has led to enormous growth in communication and enhanced channels of communication [8]. Use of smart phones has greatly come over all the technologies due to reduced cost and improved capability. Use of latest technologies enabled in android mobiles help in providing location using GPS, quick internet access and in some mobile devices pre-disaster warning. The users have the capability to receive updates about the disaster events and also pass the messages to others who could be affected.

2.2.4 Web Technologies

The World Wide Web (WWW) is the universe of network-accessible information, an embodiment of human knowledge. Web browsers on the client side for rendering data presentation coded in HTML, a web server program that generates data presentation, an application server program that computes business logic, and a database server program that provides data persistency. The three types of server programs may run on the same or different server machines. Web browsers such as Internet Explorer, Google Chrome etc., can run on most operating systems with limited hardware or software requirement. Adobe Flex is another technology often used in Web 2.0 applications. Compared to JavaScript libraries like jQuery, Flex makes it easier for programmers to populate large data grids, charts, and other heavy user interactions. HTML5 offers many new technologies that allow content to

be delivered to users in a more streamlined and personalized manner. Web 2.0 sites have recently started using Javascript/Ajax framework. There had been a rapid development in field of web. It has its impact in almost every area such as education, research, technology, commerce, marketing etc. So the future of web is almost unpredictable.

All the above mentioned technologies have been integrated together on a platform, resulting in a framework to manage the emergency situations.

3 Methodology

Implementation of proposed framework for addressing emergency management, involves seamless integration of multiple technologies such as Remote Sensing (RS), Geographic Information Systems (GIS), Global Positioning Systems (GPS), Database Management Systems (DBMS), Web GIS, Location Based Services (LBS), Information Technology (IT), Communication Technologies etc.

The multi-disciplinary technologies has been integrated and connected together (Shown in Fig. 1) in the proposed framework to manage emergency situations. The framework have been implemented on a geo-web platform to address the real time emergency situation. The possible emergency phases including Relief Management, Medical services, Contingency plan and Evacuation have been incorporated as a module in a web based spatial decision support system (SDSS). The web based SDSS have been implemented using 3 components:

1. Organisation of database
2. Availability of organized data as an service coupled with web interface
3. Customization of spatial DSS tools, disaster dashboard and communication protocols

The detailed workflow of developed emergency management information system is shown in Fig. 2.

The first major step is to collect and organize the heterogeneous spatial and non-spatial database. Database schema and automatic procedures have developed to arrange and organize the data layers collected from different resources in a seamless way.

The organised data have been coupled with a web based interface developed using open source web technologies to execute data driven web interface. OSGEO open source standards have been followed in development of the web portal. DSS tools have been developed to perform complex GIS operations on to the data for generating the relief and rescue plans. Further the portal is organized, depending on the type of natural disasters. Individual disaster specific modules helps the decision makers to view, analyze and interpret the disaster specific data in an efficient manner. An end to end solution for addressing the emergency situation have been developed to manage the emergency situation. To test the capability of the

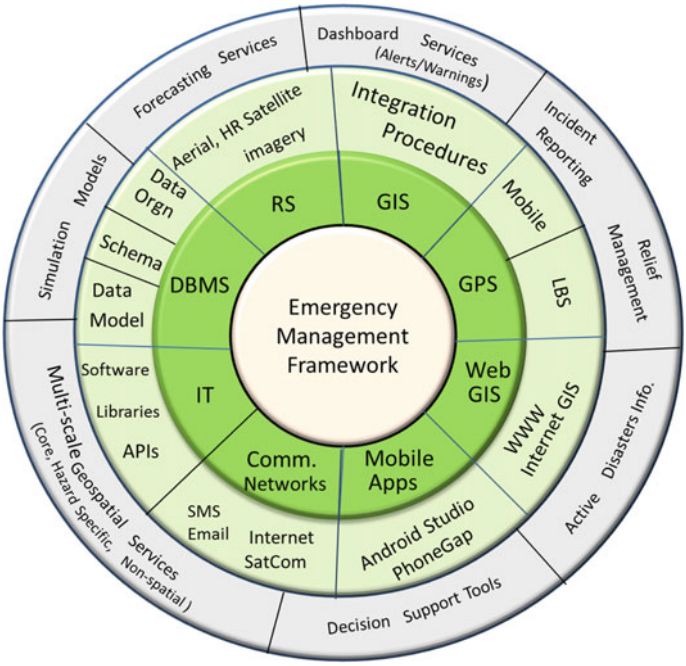

Fig. 1 Multi-disciplinary technologies for emergency management

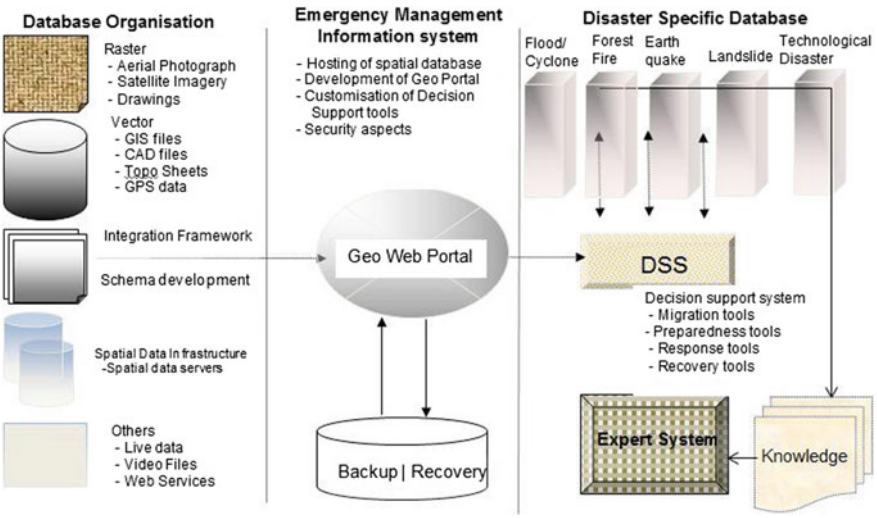

Fig. 2 Workflow for EMIS

developed system in real time, the framework have been customized as per the needs of Natural Disaster Response Force (NDRF) for carrying out relief and rescue operations.

4 Application Case Study

To test the framework capabilities in disaster situation, a dummy disaster situation cum mock drill has been organized by the NDRF officials. The Graduate level officials has been fully trained to use the system developed in web environment, before the mock drills. The framework customized for NDRF has been categorized into 5 modules namely:

1. Situation assessment—Alerts, warnings, live news from disaster dashboard.
2. Map Viewer—Battalion wise/Head Quarter map interface for visualization of multi-scale data services with standard GIS tools.
3. Disaster incident reporting—Incident reporting from the field and subsequent approval from the HQ.
4. Decision support tools—Customized decision support tools for relief and rescue operations.
5. Communication—One to one/many communications means through text messages, live audio video chat, mail etc.

Detailed working of each modules is explained below.

4.1 Situation Assessment Module

A web based disaster dashboard integrating the information about alerts and warning from different nodal departments along with disaster news has developed as shown in Fig. 3.

Live feeds from different nodal departments as an service has been integrated into the dashboards. In addition, heterogeneous data from different resources has been transformed and organized for visualization, analysis and alert generation.

4.2 Spatial Online Map Viewer

An open source spatial web viewer is developed (Fig. 4) facilitating, visualization of multi-scale data services with standard GIS tools to NDRF officials. They can select the datasets to view and analyze, from data driven options provided in spatial web viewer.

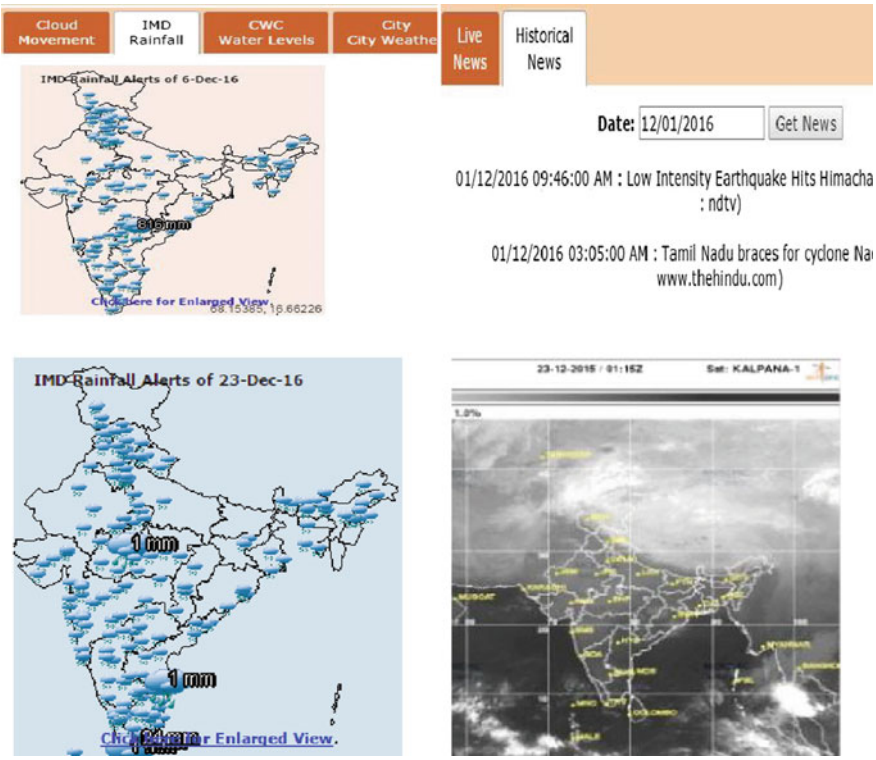

Fig. 3 Live data integrated into disaster dashboard

4.3 Disaster Incident Reporting

Android based mobile application has been developed to report the disaster incidents to the central server from the field in near real time using GPRS. Below mentioned android based mobile applications (Fig. 5) has developed and given to NDRF officials to test the same on ground:

1. Relief management
2. Geo-Spatial data collection
3. Geo-Tagging of emergency facilities

The incident reported using the mobile application from field can be visualized on to the portal and appropriate decisions can be communicated back to the field in near real time. A sample incident reported by the NDRF officials during the mock is shown in Fig. 6.

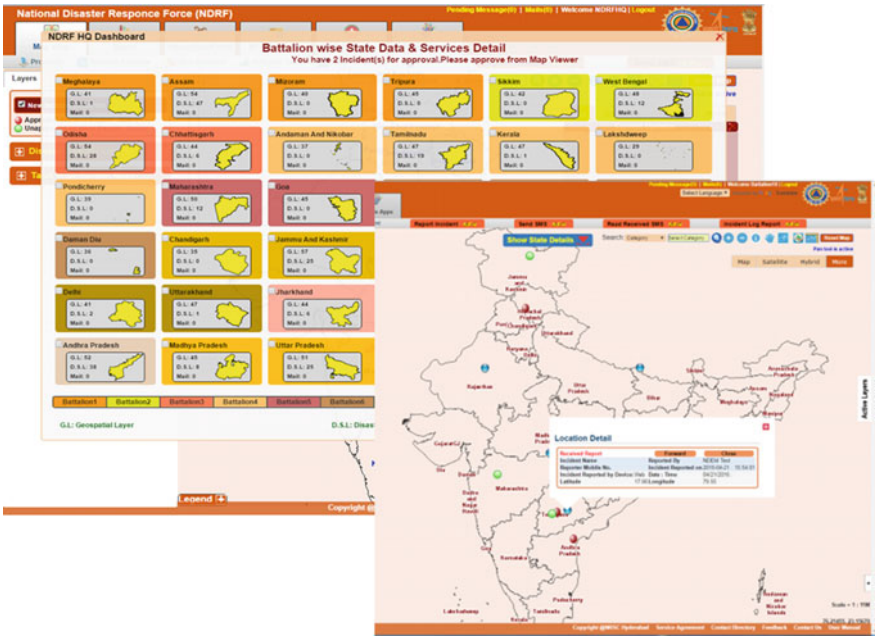

Fig. 4 Spatial web viewer for data visualisation

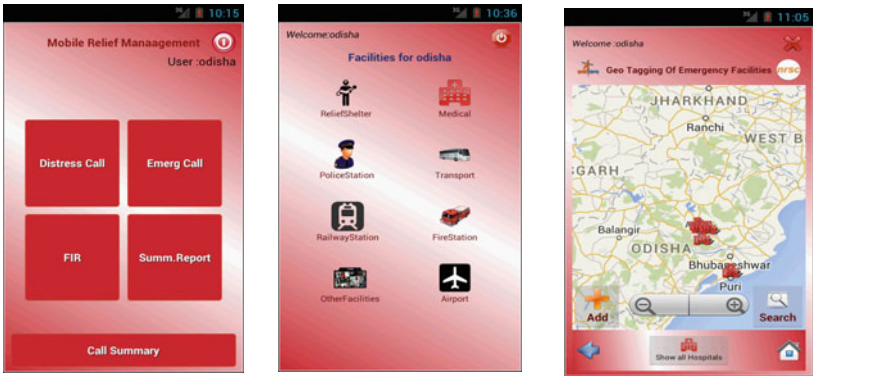

Fig. 5 Android based mobile application

4.4 Decision Support Tools

Decision makers for taking decisions on the reported events needs certain complex tools, which can help them in analyzing the situations. Complex tools like shortest

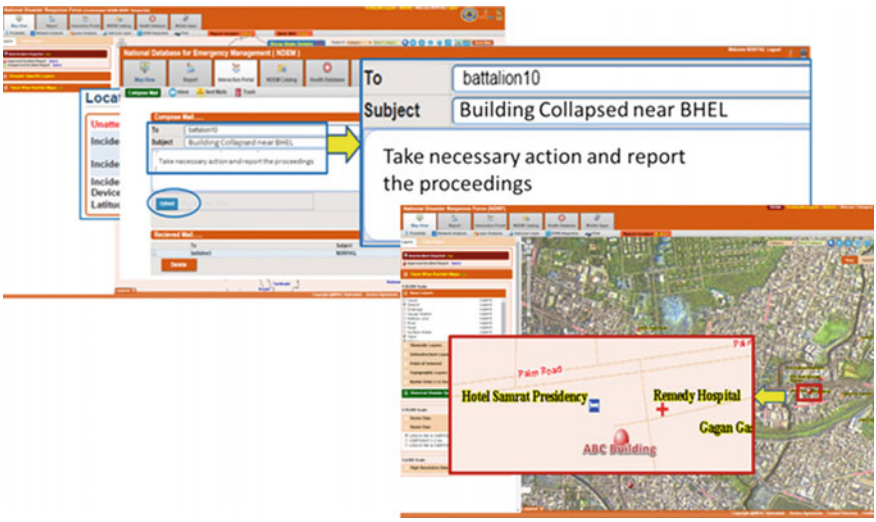

Fig. 6 Disaster incident reporting and decision making

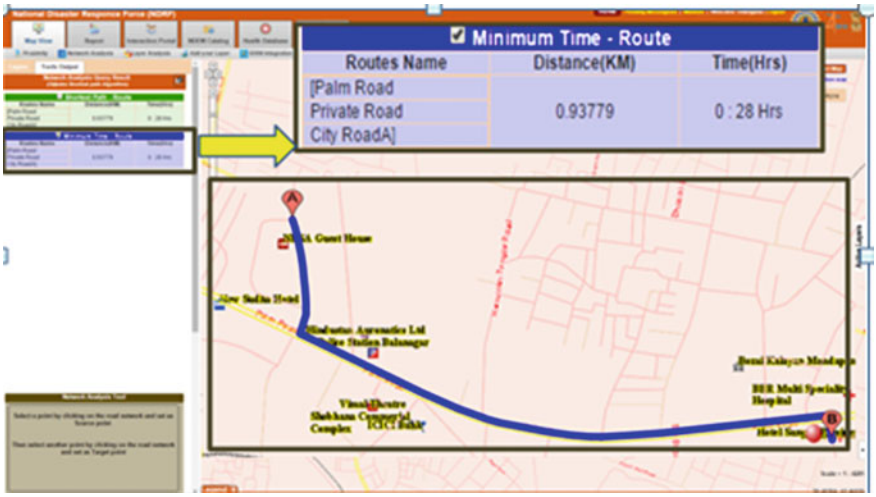

Fig. 7 Executing shortest path

path and proximity analysis can help decision makers to know which are the hospitals near the incident location and which is the shortest path to follow to reach the hospital in less time. To facilitate this, proximity analysis and shortest path tools are integrated and executed on spatial DSS as shown in Figs. 7 and 8.

Fig. 8 Executing proximity analysis

4.5 Communication Module

An audio/video chat with live stream transfer communication shown in Fig. 9 has been implemented in web environment. Using this module more than 2 people can interact with each other by sending text, audio and video. It facilitates live reporting and communicating the decisions from control room to field.

The above explained modules clearly indicated the capability of the framework developed by integrating the multiple technologies to manage the emergency situation. The framework inform of a geo web portal available at http://ndrf.nrsc.gov.in/central/ in internet domain, for NDRF is helping them in managing the emergency situation in real time.

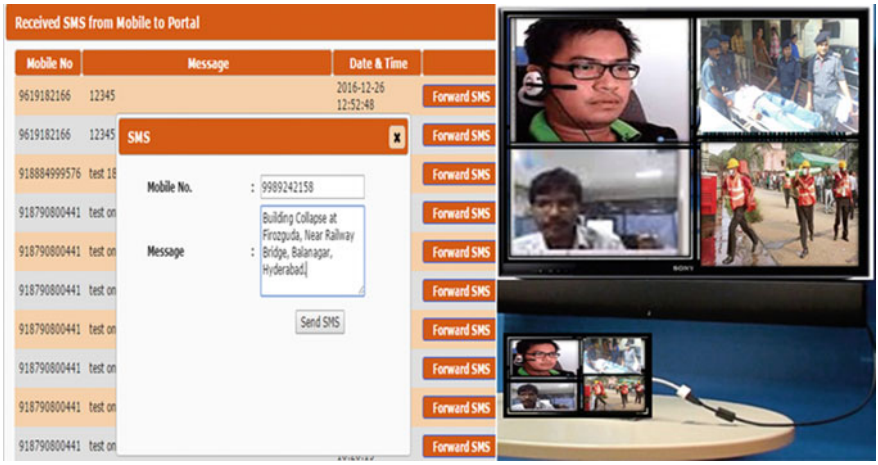

Fig. 9 Communication module showing text/audio/video chat

5 Conclusion

Emergency management involves multi-disciplinary effort, requiring various kinds of data available for emergency managers in right format for effective decision making. No single tool or technology available cannot manage the emergency situation efficiently. There is a need to utilize the services, expertise and availability of different software modules/technologies in an integrated manner, seamlessly. Complexity and nature of available technologies, restricts the direct integration with each other. To overcome this an effective and robust framework is proposed, developed and successfully tested in real time for managing the emergency situation. The developed framework is robust, secure and interoperable in nature. It facilitates relief and rescue organisation with a facility of incident reporting from field using mobile application, which further helps in triggering the response by the responding agencies, in addition of integrating various warning and alerts provided by different nodal agencies. Its ability to organize the multiple, huge heterogeneous data make it an efficient data repository with complex spatial analysis tools, managing important databases like emergency facilities including hospital information. It is an end to end solution for the decision makers by the technological experts.

Acknowledgements We thank Dr. Y. V. N. Krishna Murthy (Director NRSC) for providing the continues guidance throughout the process. We are grateful to colleagues at the National Database for Emergency Management, Disaster Management Support Group & National Disaster Response Force for support and cooperation.

References

1. George, H., Jane, B., Damon, P.C.: Introduction to Emergency Management, 5th edn. Elsevier, Burlington (2013). ISBN 13: 978-1856179591
2. World Health Organization: Risk reduction and emergency preparedness. WHO six-year strategy for the health sector and community capacity development (2007). ISBN 978 92 4 159589 6
3. Mendonça, D., Beroggi, G.E.G., Wallace, W.A.: Decision support for improvisation during emergency response operations. Int. J. Emergency Manage. **1**(1), 30–38 (2001)
4. Karina, A., Torstein, T.: Learning in emergency organisations: trial without error. Int. J. Emergency Manage. **1**(4), 410–421 (2003)
5. Van Westen, C.J., Rengers, N., Terlien, M.T.J., Soeters, R.: Prediction of the occurrence of slope instability phenomenal through GIS-based hazard zonation. Geol. Rundsch. **86**(2), 404–414 (1997)
6. Jayaraman, V., Chandrasekhar, M.G., Rao, U.R.: Managing the natural disasters from space technology inputs. Acta Astronaut. **40**(2–8), 291–325 (1997)
7. Bhanumurthy, V., Jai Shankar, G., Ram Mohan Rao, K., Nagamani, P.V.: Defining a framework for integration of geospatial technologies for emergency management. Geocarto Int. **30**(9), 963–983 (2015). https://doi.org/10.1080/10106049.2015.1004132
8. Lachner, J., Hellwagner, H., Roland Kop, K., Steinberger, C., Günther, C.F.: Information and communication systems for mobile emergency response. In: Information Systems and e-Business Technologies: 2nd International United Information Systems Conference UNISCON 2008 Klagenfurt, Austria, 22–25 Apr 2008 Proceedings. http://dx.doi.org/10.1007/978-3-540-78942 (2008)