

# Advanced ICTs for Disaster Management and Threat Detection: Collaborative and Distributed Frameworks

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The objective of this chapter is to present a Systemic Disaster Management System (SDMS) model. The SDMS model is intended to provide a sufficient structure for effective disaster management. It may be argued that it has a fundamentally preventive potentiality in that if all the subsystems (i.e., systems 1-5) and channels of communication are present and working effectively, the probability of failure should be less than otherwise. Moreover, the model is capable of being applied proactively in the case of the design of a new ‘disaster management system’ as well as reactively. In the latter case, a past disaster may be examined using the model as a ‘template’ for comparison. In this way, lessons may be learned from past disasters. It may also be employed as a ‘template’ to examine an existing ‘disaster management system’. It is hoped that this approach will lead to more effective management of natural disasters.

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We live in a world where there are potential sources of disasters with a potential to cause a loss all around us. We could be living close to a coastline that is prone to cyclones or mountainous region vul-

nerable to earthquakes. On the other hand, we might be living in a place where there may be frequent communal tension. Whatever is the area we live in; we need to be aware of our vulnerability to hazardous events. Better awareness about various hazards, proper education, training and preparedness will enhance the community resilience. Information and communication technologies in the form of audio and video (through community radio, village information centres, video awareness programmes through DVDs, etc) play a vital role in creating public awareness, giving education and training to vulnerable communities. This chapter aims to discuss the various ICT initiatives taken in the coastal districts of Tamilnadu, one of the seven coastal states of India.

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The XXI century has brought changes and innovations in educational technology that should be incorporated in the curriculum at all educational levels. Therefore, it is necessary to apply modern technologies in learning processes. This work was based on basic cognitive learning theories and principles, and used software, such as Freehand, Adobe Photoshop, Jigsaw Puzzle Creator, Brainsbraker and Jigsaw Puzzle Lite, to create a multimedia version of the SALTARIESGOS boardgame. The game was applied and validated with students from elementary school of 2nd, 4th, 5th and 6th grades. The results we obtained can be considered satisfactory based on the student’s opinion, and the pedagogical strategy was as an effective tool for achieving our goals. The educational contribution of this interactive version of the game will promote and sensitize school community members at different urban and rural areas, in order to enhance the preventive culture in disaster risk reduction.

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<i>Helena Zemp, University Zurich, Switzerland</i>	

The growing importance of mass media in the ‘information society’, combined with society’s increased dependence on electronic modes of information is important to the perception, regulation and management of risk at a local, national and international level. However, media organisations have their own logic and goals that are not necessarily compatible with the logic and goals of disaster planning and assistance agencies. Using a detailed study of the media coverage of floods in Switzerland from 1910 to 2005, we will illustrate the salient features of disaster reporting and how these relate to issues of risk perception and risk prevention behaviour in the public sphere. The findings are used to discuss the traditional media’s shortcomings for the goal of risk reduction, the public’s information seeking behaviour, and the opportunities and limitations arising from the emergence of digital, internet-based information and communication technologies (ICT) for disaster communication.

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United Arab Emirates: Disaster Management with Regard to Rapid Onset Natural Disasters ..... 65

*David Chester, University of Liverpool, UK*

The United Arab Emirates (UAE) has more exposure to natural hazards than has been previously recognized. In the last 20 years the UAE has been subject to earthquakes, landslides, floods and tropical storms. This chapter examines the structure and procedures for management of natural disasters in the UAE, in particular issues of governance, accountability and communication within states that are part of a federal system. The study involved interviews with officials at both federal and emirate levels and case studies are presented of the impact of recent natural hazard events. Two emirates were selected for more detailed examination, Fujairah the most hazard prone and a rural emirate and Dubai which is a highly urbanized emirate which has undergone rapid development. There is now increasing awareness of natural hazards in the UAR and progress is being made at regional and federal levels. There needs to be a clear delineation between regional and federal roles and an understanding of the need for effective channels of information to relevant agencies.

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From risk identification to emergency response and recovery, information plays vital role and effective use of information is instrumental to reduce the impact of disasters. With the advancement of information and communication technology in the last few decades, lack of information is no more a major issue for disaster risk reduction. The major issue, rather, is managing the information, translating it into a comprehensive knowledge for decision making and disseminating it to the communities at risk for action. The advancement of technology and reach of communication tools at grass-root level have created an opportunity to increase effectiveness of disaster risk management with the optimum use of disaster informatics. This chapter presents an overview of disaster informatics, conceptual framework for information management for disaster risk reduction, review on existing approaches of information dissemination through internet and on use of combined potential of internet with tools which are widely available at grassroots.

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This chapter will emphasize that efficient integration of various Information and Communication Technology (ICT) in disaster management process can help mitigation of impacts of disasters on people

and the environment, minimizing the failures and maximizing the collaboration. It summarizes the nature of information flow and management processes during disasters and the potential of recent ICT at three stages of disaster management. The requirements and problems faced during their deployment at different stages of disaster management process are stated. The solutions for common constraints are discussed as well as the critical factors that should be considered in efficient deployment of ICT in the disaster management process.

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The deployment of Early Warning Systems (EWS) and Alerting Technologies (AT) is one of the best measures for improved disaster prevention and mitigation. With the evolution of Information and Communication Technologies (ICT) we face new opportunities as well as new challenges for improving classical warning processes. This chapter concentrates on the main aspects of existing early warning systems and alerting technologies. Beginning with the definition and classifications in this field, we describe general approaches, representative systems, and interoperability aspects of EWS. Furthermore, we introduce a list of criteria for evaluating and comparing existing systems. It is worth noting that the deployment of an operational EWS is a complex challenge and remains a young field of research. This is due to many reasons, ranging from the political to the technical. The most critical issues regarding efficient alerting are described in this chapter, along with areas for future research.

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The Medical Information System (MedISys) is a fully automatic 24/7 public health surveillance system monitoring human and animal infectious diseases and chemical, biological, radiological and nuclear (CBRN) threats in open-source media. In this article, we explain the technology behind MedISys, describing the processing chain from the definition of news sources, scraping and grabbing articles from the internet, text mining, event extraction with the Pattern-based Understanding and Learning System (PULS, developed by the University of Helsinki), news clustering and alerting, to the display of results. The web interface and service applications are shown from a user's perspective. Users can display world maps in which event locations are highlighted as well as statistics on the reporting about diseases, countries and combinations thereof and can apply filters for language, disease or location or filters with orthogonal categories, e.g. outbreaks, via their browser. Specific entities such as persons, organizations and locations are identified automatically.

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<i>Matina Halkia, European Commission, Joint Research Centre, Italy</i>	

Social media technologies such as blogs, social networking sites, microblogs, instant messaging, wikis, widgets, social bookmarking, image/video sharing, virtual worlds, and internet forums, have been identified to have played a role in crises. This chapter examines how social media technologies interact with formal and informal crises communication and information management. We first review the background and history of social media (Web 2.0) in crisis contexts. We then focus on the use of social media in the recent Gaza humanitarian crisis (12.2008-1.2009) in an effort to detect signs of a paradigm shift in crisis information management. Finally, we point to directions in the future development of collaborative intelligence systems for crisis management.

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The principles of Web 2.0 such as transparency, security, community, usability, and availability are well suited to help effectively manage the effects of a disaster. Many Web 2.0 technologies rely on social collaboration, and as a result these technologies are built with robust communication channels. Utilizing this existing framework will help to create software systems that can efficiently manage disasters. This chapter will examine differing Web 2.0 innovations through the use of Activity Theory, and the benefits and drawbacks of each technology will be analyzed. From this analysis, recommendations and conclusions will be presented to the reader.

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The maturation of incident and disaster management training has led to opportunities for the inclusion of multi-modal learning frameworks. Virtual reality technology, specifically multi-user virtual environments (MUVES) such as virtual worlds (VW), offers the potential, through carefully crafted applications, for increasing collaboration, leadership, and decision making skills of diverse adult learners. This chapter presents a review of ICT appropriate learning theories and a synopsis of the educational benefits and practices. A case study, offered as part of a Master of Healthcare Administration (MHA) course for health care managers, demonstrates the application of a virtual world training scenario hosted in Second Life® and using a Play2Train simulation. Students report a strong positive reaction to virtual learning and demonstrate improved crisis communication skills and decision making competencies. Additional research is recommended to demonstrate the utility of virtual world learning as compared to standard training options such as tabletop exercises.

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#### Next Generation Approaches and Distributed Frameworks for Disaster Management

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Immediately after the catastrophes that affected Venezuela at the end of 1999, especially the flood of the State of Vargas, a group of investigators of a consultancy company and of a private university of Caracas Venezuela, started working in decisions support systems (DSS) that could be useful in the moment of a catastrophe, helping to minimize the impact of its three principal stages: Pre-catastrophe, Impact and Post-catastrophe. Clearly, for the development of these DSS, it was indispensable to construct mathematical models to support them. The objective of this chapter is to disclose this experience by presenting some of these mathematical models and its conversion in DSS that supports decision making in the case of catastrophes.

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Integrating Scenario-Based Reasoning into a Multi-Criteria Decision Support System for  
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Multi-criteria decision analysis (MCDA) is a technique for decision making among multiple alternatives for action providing transparent and coherent decision support for complex situations with conflicting objectives. Managing longer term decisions for environmental incidents is an application domain in which MCDA has proved useful. Yet a difficulty in applying MCDA is when uncertainties abound. Contrarily, scenario-based reasoning is a method allowing for the assessment of multiple possible future developments of the situation. In this way, the use of scenarios is a transparent and easily understandable way to integrate uncertainties into the reasoning process. We propose a mechanism to integrate scenarios. Our theoretical framework can be operationalised by decision support systems relying on both automated systems and human experts. These facilitate the assessment of consequences within a scenario, and may propose new scenarios. We illustrate this mechanism taking the decision making in emergency management after a train crash with potential release of chlorine as an example.

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*Michael Lehning, WSL Institute for Snow and Avalanche Research SLF, Switzerland*

In the developed world, an ever better and finer understanding of the processes leading to natural hazards is expected. This is in part achieved using the invaluable tool of numerical modeling that offers the possibility of applying scenarios to a given situation. This in turn leads to a dramatic increase in the complexity of the processes that the scientific community wants to simulate. A numerical model is becoming more and more like a galaxy of various sub-process models, each with their own numerical characteristics. The traditional approach to High Performance Computing (HPC) can hardly face this challenge without rethinking its paradigms. A possible evolution would be to move away from the Single Program, Multi Data (SPMD) approach and towards an approach that leverages the well known Object Oriented approach. This evolution is at the foundation of the POP parallel programming model that is presented here, as well as its C++ implementation, POP-C++.

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*Dimitrios V. Manatakis, University of Athens, Greece*

*Elias S. Manolakos, University of Athens, Greece*

*Stathes Hadjiefthymiades, University of Athens, Greece*

The SCIER platform is an integrated system of networked sensors and distributed computing facilities, aiming to detect and monitor a hazard predict its evolution and assist the authorities in crisis management for hazards occurring at Wildlife Urban Interface (WUI) areas. The goal of SCIER is to make the vulnerable WUI zone safer for the citizens and protect their lives and property from environmental risks. To achieve its objective, SCIER adopts and combines technologies such as: (1) wireless sensor networks for the detection and monitoring of disastrous natural hazards, (2) advanced sensor data fusion and management for accurately monitoring the dynamics of multiple interrelated risks, (3) environmental risk models for simulating and predicting the evolution of hazardous phenomena using advanced computing (e.g., Grid-computing). In this chapter we focus on the key software components of the SCIER architecture, namely the sensor data fusion component and the predictive modeling and simulation component.

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A Personalized Forest Fire Evacuation Data Grid Push Service: The FFED-GPS Approach ..... 279

Much work is under way in disaster reduction and emergency management towards the utilization of information and communication technologies (ICT) and the design of relevant services associated with risk management towards sustainable development and livelihood. Recent forest fires occurred in Southern Europe, caused environmental destruction and a number of fatalities. The effective and efficient production of forest fire evacuation plans requires decisions based on integrated data from heterogeneous and distributed sources that change over time very quickly. Recent ICT advances suggest the need for further work in the advanced evacuation systems area. We are particularly interested of how to automatically inform potential victims about the most relevant evacuation routes in the most-timely fashion so they can escape a forest fire safely. With this in mind, this chapter describes the concepts, architecture and implementation of the Personalized Forest Fire Evacuation Data Grid Push Service using data push and next generation grid technologies.

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## Foreword

During the past decades, the international public opinion is communed and concerned, with an increasing frequency, about disasters triggered by natural phenomena and technological accidents. Consecutive floods and extreme weather phenomena, climatic changes, earthquakes, tsunamis, landslides and other phenomena manifested around the planet with intense geotectonic effects, give the impression of a gradually accelerating procedure of changes on the earths' surface.

At the same time, technological disasters occur with an increasing frequency during the last years, triggered by human activities and inappropriate management of technological elements, such as transportation accidents, waste and toxic substances contaminations, explosions, biological pollution, urban and forest fires etc.

Taking into account that in the immediate future, the above mentioned disasters will represent the primary concern of countries and administrative authorities, many scientists have been orientated towards the systematic research of the phenomena with impressive results. However, at the same time it is observed that the "know-how" is accumulating in research centers rather than being distributed to the statutory authorities or to the broader social groups. As a result, the response is not as effective as it should be and the consequences unfortunately are increasing.

The content of the present book aims to cover the gaps that exist in a series of disaster management topics. The information techniques for the new pioneer practices of natural and technological disaster management through novel management models and actions have the primary role.

For the information of the authorities and groups of population, the use of modern internet technologies that can transfer directly new scientific knowledge and information on potential natural hazards that may trigger disasters and emergencies, is determinant.

An important sector that is presented in this book, is that of the distant education ability of broader groups of population that can be trained in a variety of subjects easily, quickly and with low cost.

I am certain that this book investigates an interesting field of natural and technological disaster management and contributes to the reduction of the consequences caused by disasters in a global scale.

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## Preface

During the last decades the number of losses caused by natural and man-made disasters has increased. Evidently, humans are not always capable of avoiding extreme natural phenomena, technological accidents, or terrorist attacks. There is a need to prepare and plan in advance actions in response to these events in order to support sustainable livelihood by protecting lives, property and the environment. In turn, various disaster management bodies (FEMA, EMA, European Civil Protection, etc) involving authorities at a local, national and international level have been formed to mitigate, prepare for, respond to and recover from such disasters. There are also collaborative research institutes, scientific laboratories and other non-profit organizations studying natural phenomena yet most importantly, the response processes as to advance the disaster management discipline, its practice and application as a whole.

Disaster management is a dynamic and fluid area, which requires the involvement of expertise from different authorities and organizations. It mainly consists of expert individuals and teams from the civil protection, police, fire and rescue services, health and ambulance services, engineering sector, utility companies, local authorities, central government, relief bodies armed forces, monitoring, research and observatory centers. Bringing in expertise from different parties is essential and critical, as these will assist in managing emergency situations in a more informed and holistic approach. Apparently, this type of collaboration bring together the intellectual and physical resources so as to enable the conceptualization, production, utilization and application of disaster management strategies including critical infrastructures, relevant ICT resources, response plans, policies, risk management techniques, recovery and contingency plans.

ICT developments over the last four decades have facilitated organizations with numerous collaborative tools to support various levels of enquiries within the field of application. In particular, the use of advanced distributed technologies has evolved over the years such as to accommodate and advance collaborative endeavors between interested parties (including disaster management stakeholders) scattered across the world. Such utilization of distributed data and resources related to ICT developments – including but not limited to early warning systems and alerting technologies, data mining and advanced decision support systems, data visualization techniques, data and system integration frameworks, next generation collaborative technologies and Web 2.0, service oriented approaches, and grid technologies – should be further aligned for the purpose of augmenting the effectiveness and efficiency of disaster management and risk reduction approaches towards sustainable developments and livelihood.

## **THE PURPOSE OF THE BOOK**

The primary goal of this book is to demonstrate how strategies and state-of-the-art ICT have and/or could be applied so as to serve as a vehicle to advance disaster management approaches, decisions and practices. The achievement of such a goal implies the contribution from various practitioners, scholars in the area and researchers from other disciplines who are willing to offer their expertise and skills in advancing disaster management discipline both as theory and practice.

It aims to provide both conceptual and practical guidance to disaster management stakeholders including ICT and senior managers from relevant organizations. It will help assist in identifying and developing effective and efficient approaches, mechanisms, and systems using emerging technologies to support their effective operation. Specifically, the book aims to build a network of excellence in effectively and efficiently managing advanced strategies and next generation distributed and collaborative ICT for disaster management stakeholders to advance their current practices and approaches. This is achieved by introducing both technical and non-technical details of strategies and ICT demonstrating their application and their potential utilization to the disaster management sector. It also prompts revisiting current approaches and further develops the area for best practice so as to cope with emerging and unforeseen threats.

The book has collected together the vast experience of many leaders demonstrating past and current methods, tools and practices employed for disaster management purposes. As such, the book claims to be a definitive state-of-the-art collection and to prompt the future direction for disaster managers to identify applicable theories and practices in order to mitigate, prepare for, respond to and recover from various foreseen and/or unforeseen disasters.

## **WHO SHOULD READ THE BOOK?**

The content of the book reflects the interests of a broad audience as it offers state-of-the-art information and references for work undertaken in the challenging area of utilizing cutting edge distributed and collaborative ICT to advance disaster management as a discipline to cope with current and future unforeseen threats.

The projected audience ranges from those currently engaged to those interested in joining collaborative work in the field of disaster management utilizing applicable ICT. In particular, audiences currently working in or are interested in joining interdisciplinary, multidisciplinary and transdisciplinary collaborative disaster management related advancements are the primary focus in this book. Specifically, audiences who are: (1) researchers in the areas of disaster management, emerging technologies and collaborative ICT; (2) managers and practitioners in the local authorities, research institutes and scientific centers and the industry; (3) academics, instructors, researchers and students in colleges and universities.

The book can be used as a source for leading edge literature review in the area of emerging and applicable ICT and disaster management, documenting the latest developments in the academia, government and business sectors. It serves as a guide between relevant bodies from different countries providing lessons learnt and paradigms of good practices worldwide. It can also be used as a library reference. Most importantly, specialist training providers, colleges and universities (having relevant courses) could use it as a course supplement. Finally, the book serves as a source of reference material and as a source of

ideas for further research and development activities for academics and researchers in the field. Similarly, it serves as a valuable source for researchers willing to join in relevant collaborative works.

The potential impact of this book is to educate, sustain or even enable the formation of communities and teams (like research teams, charities, voluntary bodies, etc) as to support interdisciplinary and collaborative multidisciplinary research and practices towards an effective and efficient protection of human lives, property and the environment.

## ORGANIZATION OF THE BOOK

Seventeen self-contained chapters, each authored by experts in the field, are included in this book. The book is organized into three sections according to the thematic topic of each chapter. Thus, it is quite possible that a paper in one section may also address issues covered in other sections. However, the following three sections reflect most of the topics sought in the initial call for chapters.

The first section, Section 1: Current Approaches in Disaster Management includes six chapters. This section introduces concepts and principles of disaster management and ICT, such as systemic approaches to managing disasters, rapid onset natural disasters and disaster informatics. These cover past and recent methods and techniques for ICT based decision-making in disaster management. In addition, some chapters present scenarios and approaches related to the role of education, training and media in disaster reduction. As such, they underpin future development and implementation of relevant approaches.

The second section, Section 2: Advanced Collaborative Technologies for Disaster Management includes six chapters. This section is concerned with the use of various collaborative Information and Communication Technologies (ICT), such as Early Warning Systems, Alerting Technologies, Web 2.0 innovations, Second Life® and simulation, which aim to advance disaster management processes and risk reduction.

The last section, Section 3: Next Generation Approaches and Distributed Frameworks for Disaster Management includes five chapters. This section goes beyond and builds upon current theory and practice, providing visionary and applicable directions on how next generation technologies – based on current state-of-the-art service oriented and grid computing frameworks – could be used in the future to the benefit threat detection, disaster management and risk reduction.

A brief introduction to each of the chapters follows.

In Chapter 1, *A Systemic Approach to Managing Natural Disasters*, J. Santos-Reyes, and A. N. Beard present a Systemic Disaster Management System, that is able to be used proactively, as well as reactively, as a means to manage disasters in a more effective manner.

In Chapter 2, *ICT Approaches in Disaster Management: Public Awareness, Education and Training, Community Resilience in India*, S. Kuppaswamy discusses the important role that ICT plays in the public awareness, education, training and preparedness for disasters. This takes place via the presentation of various ICT approaches and initiatives taken in the coastal districts of Tamilnadu.

In Chapter 3, *Multimedia Educational Application for Risk Reduction*, A. Iztúriz, Y. Barrientos, M. A. González, L. Rivas, M. V. de Bezada and S. Ruíz focus on the application of modern ICT in the learning process, in order to enhance a preventive culture in disaster risk reduction. In particular, they use cognitive learning theories and existing software to create a multimedia version of a boardgame promoting and sensitizing school community members to different urban and rural areas.