Near Real-Time Forensic Disaster Analysis

Friedemann Wenzel
Karlsruhe Institute of Technology / Center for Disaster Management and Risk Reduction Technology (CEDIM)
friedemann.wenzel@kit.edu

Jochen Zschau
Helmholtz-Centre Potsdam – German Research Centre for Geosciences / CEDIM
jochen.zschau@gfz-potsdam.de

Michael Kunz
Karlsruhe Institute of Technology / CEDIM
kunz@kit.edu

James E. Daniell
General Sir Monash Foundation / Karlsruhe Institute of Technology / CEDIM
j.e.daniell@gmail.com

Bijan Khazai
Karlsruhe Institute of Technology / CEDIM
bijan.khazai@kit.edu

Tina Kunz-Plapp
Karlsruhe Institute of Technology / CEDIM
tina.kunz-plapp@kit.edu

ABSTRACT

We introduce the approach of near-real-time Forensic Disaster Analysis (FDA) as a methodology to reveal key features of ongoing disasters using modern communication and information tools and the methods of loss analysis. The scientific background, the objectives and results from first pilot examples are discussed.

Keywords

Natural disasters, loss analysis, risk reduction.

INTRODUCTION

Recent technology developments opened unprecedented opportunities for earthquake loss assessment. The internet usually provides information by various sources less than an hour after a large event somewhere on the globe; modern crowd sourcing allows to quickly assess initial information on events; remote sensing data of high quality are commonly available on the order of 1 to 3 days after an event. Methods have been developed for earthquakes but also for other natural disasters, which allow estimation of potential damages once the hazard and impact parameters have been roughly estimated. In addition to this, several services are accessible with highly relevant information; among them is the Joint Research Center (JRC) with its GDACS service (www.gdacs.org/) but also the EQEDAT (www.eqecat.com/) information from the private sector.

Forensic disaster analysis has been coined as a research target by the Integrated Research on Disaster Risk (IRDR, www.irdrinternational.org; Burton, 2010), an ICSU (International Council for Science, www.icsu.org) initiative located in Beijing. The aim of the forensic investigation of disasters (FORIN) program is to study natural hazards with the aim to uncover the root causes of disasters through in depth investigations that go beyond the typical reports after disasters: "Thoroughly analyzing cases, including both success stories and failures, will help build an understanding of how natural hazards do – or do not – become disasters." (www.irdrinternational.org). With the aim of generating a comprehensive portrait of disasters that allows to learn not only specific aspects but fundamental lessons, the FORIN program essentially includes the investigation of the circumstances, causes and consequences of losses in disasters, the conditions that have limited or prevented loss as well as the context of scientific research development and the level of disaster risk reduction.

The Center for Risk Management and Disaster Reduction Technology (CEDIM, www.cedim.de) adopts this

comprehensive understanding of disasters and develops the methodology of near real-time Forensic Disaster Analysis FDA (Wenzel, Daniell, Khazai, Kunz-Plapp, 2012; Wenzel, Daniell, Khazai, Mühr, Kunz-Plapp, Markus, Vervaeck, 2012), as a complementing component of the FORIN program of IRDR.

CEDIM FORENSIC DISASTER ANALYSIS – PRINCIPLES AND OBJECTIVES

In the methodological approach of CEDIM Forensic Disaster Analysis (FDA), the term forensic is used in the sense of scrutinizing disasters closely by using the high potential of the modern empirical and analytical methodologies available in science, engineering, remote sensing and crowd sourcing to estimate potential impacts. The outputs given by these different modeling techniques have to be combined, updated and compared against information coming from the ground. The interpretation of this information is the starting point for comprehensive science-based assessments and judgments of events in near real-time. The science-based assessments are compiled based on multi- and interdisciplinary expertise and include the critical evaluation, the assessment, the validation, appraisal and quantification of an event. The near real-time approach is justified by the following considerations:

- Time criticality is important as many pieces of information emerge within the first days.
- Interaction with the many actors is most intensive and open during these days.
- Potential user interest (emergency services, tourism industry, insurance industry, economic cooperation agencies, relief agencies, etc.) is also at peak at this initial stage.
- Initial hypotheses (with little information after the first days) on loss evolution and implications can be tested in the following days.
- It can significantly speed up our understanding of natural disasters within their respective socio-economic contexts.

The analysis of data available from various sources is complemented by own models for near-real time loss estimates that are currently developed in CEDIM. These cover methods, models and tools for rapid information extraction from social media (twitter), for rapid impact assessments of atmospheric events and floods, but also for rapid assessments of socio-economic impacts, direct and indirect economic losses and effects of transportation interruption to supply chains. Currently CEDIM is developing models for three types of hazards: geophysical, meteorological and hydrological. The objectives of the forensic approach is to build up the capability to rapidly

- generate a portrait of the disaster, with the aim of revealing the main characteristics, causes of loss and potential loss estimates;
- reveal the short and long-term impacts on regional and national scale;
- track the evolution of disasters;
- and to develop a framework for loss and future risk reduction.

One critical condition for near-real time forensic analysis is the availability of data bases which can be consulted in case of an event. For earthquakes, CATDAT is the most comprehensive data base that is globally available (Daniell, Khazai, Wenzel, Vervaeck, 2011). It includes 12,400 damaging earthquakes from which 7,100 occurred after the year 1900. It refers overall to 21,000 different sources in 60 languages, all of them have been translated to English. It also includes socio-economic analysis data and tools that use more than 100 socio-economic parameters. Each event in the data base is validated to the extent possible. Other data bases in use are the Weather hazard – early warning web service of CEDIM, and for regional studies the CEDIM risk explorer. Another tool allows the automatic internet search for relevant information in case of a disaster (EQUATOR). For earthquakes we, in addition, refer to the real-time multi-source reporting web site on all worldwide earthquakes EarthQuake-Report (http://earthquake-report.com/).

EXAMPLES OF CEDIM FDA ANALYSIS

The first forensic disaster analysis activities are documented on the CEDIM webpage. They include a number of geological and hydro-meteorological disasters. The Van earthquake in 2011 was the first test case to implement and test the near-real time approach. The main results of our FDA research activities in the 10 days after the earthquake are summarized in the next section. So far, CEDIM covered the following disasters to prepare, to test and to further develop the near-real time FDA approach:

The March 11, 2011 Tohoku earthquake in Japan was analyzed for weeks in terms of the evolving direct and indirect economic losses (Daniell, Wenzel, Vervaeck, 2011; Khazai, Daniell, Wenzel, 2011) but was also

meteorologically monitored regarding the direction and velocity of a possible radioactive cloud. The October 23, 2011 Van earthquake will be discussed in more detail below. The November 2011 Thailand flood was monitored with view on the supply chain crisis that emerged for computer parts (hard discs) and seriously affected the global market of those goods and several major electronic and car manufacturing companies.

The Ferrara (Northern Italy) earthquake sequence between May, 20 and 29, 2012 caused 'only' 24 fatalities but 15,000 homeless people, more than a billion € direct economic loss (0.6% of Emilia-Romagna's GDP), significant heritage losses as well as large industry and residential losses. Around 500 million € damage to the cheese, ham and other agricultural industries in the region are estimated.

Two FDA reports were issued on the 2012 Western US summer drought that emerged after a record-breaking hot spring. The heat persisted in the U.S. and North America through summer 2012. July 2012 was the hottest July on record in the U.S. with the summer (June to August) ranking 3rd since 1895. Analysis focused on a social vulnerability index for droughts to assess the aggravated impact by social conditions.

From October 22 until October 29, 2012, Hurricane Sandy made its way from the Caribbean Sea into the Atlantic Ocean and finally entered the United States on the morning of October 30, not far from New York. According to the Saffir-Simpson Hurricane Wind Scale with a 1 to 5 rating, Sandy was a category 2 Hurricane (154-177 km/h). Along its path Sandy caused many fatalities on Jamaica, Haiti and Cuba and left many people homeless. The interaction between Sandy and an extra-tropical weather system created a huge storm that made landfall in the U.S. and affected large areas; it was associated with high impact weather as far as the Great Lakes and even beyond in southern and southeastern Canada. Due to the huge spatial extension and intensity, Sandy caused massive damage and losses in the densely populated East Coast states. Analysis focused on fatalities, casualties, shelter needs but also power loss, business interruption and social vulnerability.

PILOT STUDY ON THE VAN EARTHQUAKE OF OCTOBER 23, 2011

The Van earthquake in 2011 hit at 10:41 GMT (13:41 Local) on Sunday, October 23rd, 2011. It was a Mw 7.2-7.3 event located at a depth of around 10 km with the epicenter located directly between Ercis (population: 75,000) and Van (population: 370,000). The province of Van has around 1.035 million inhabitants at the last census. The Van province is one of the poorest in Turkey and has much inequality between the rural and urban centers with an average HDI (Human Development Index) around that of Bhutan or Congo. The earthquake is estimated to have caused around 700-1000 casualties (601 as of 2nd November 2011; mostly due to falling debris and house collapse), and around 1 billion TRY to 4 billion TRY (approx. 555 million USD – 2.2 billion USD) in total economic losses. This would represent around 17 to 66% of the provincial GDP of Van.

Figure 1 provides a sketch of the type of information that was available shortly after the earthquake in this particular case and that we therefore used for our Forensic Disaster Analysis. Scrutinizing the information from seismological services (USGS, EMSC, and GEOFON) which showed a high variability of epicentral location (variations of 25 km) we decided that an immediate estimate of potential losses was not possible as the shifted locations would easily change the estimates by orders of magnitude. The USGS PAGER service estimated initially 12,000 fatalities, more than 13 billion USD loss and reduced this estimates after 1.5 days to 1,000 deaths and 2.9 billion USD. The QLARM (WAPMERR) service provided an initial estimate of 8,000 to 20,000 fatalities and 20,000 to 60,000 injured persons. Using the CATDAT (EQLIPSE) service we found that no reliable estimate of fatalities was possible and the economic loss would probably be between 0.5 and 1.25 billion USD, again with large uncertainties.

The historic data base (CATDAT) provided the information on previous earthquakes within the past 35 years as shown in Figure 2. This information was made available with the fourth CEDIM report on the Van earthquake of 02.11.2012.

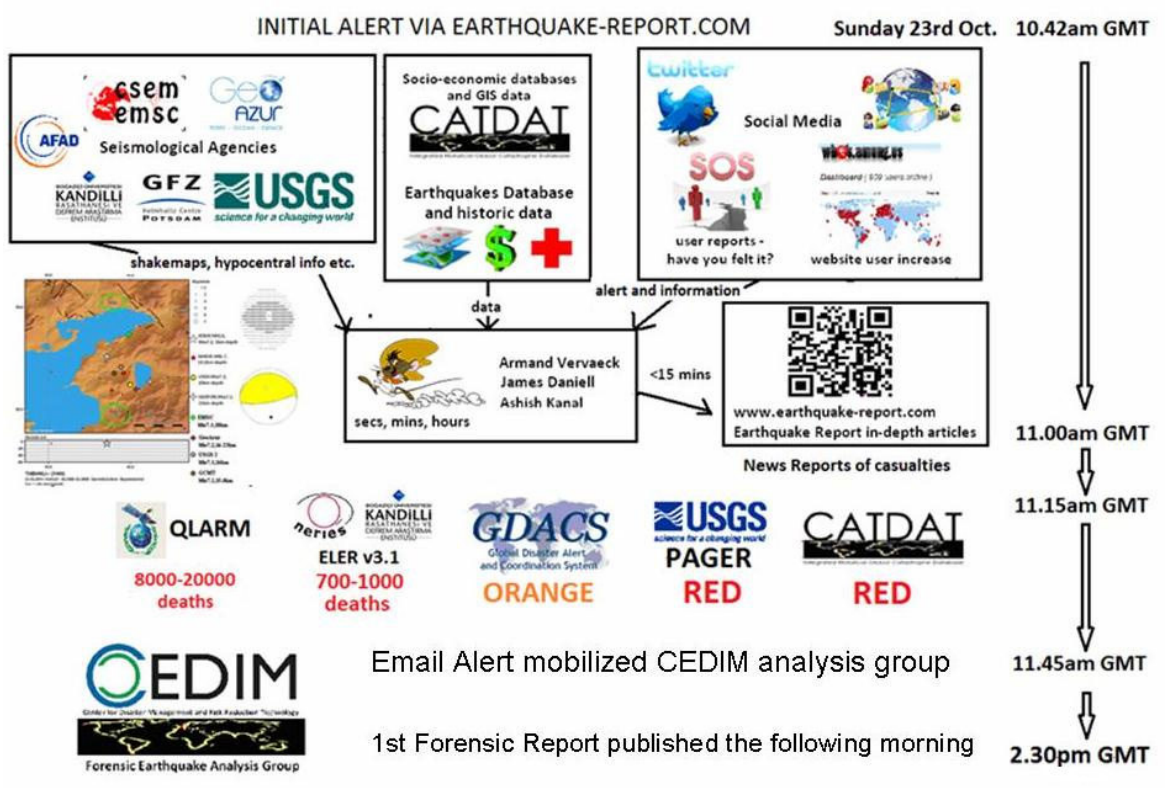

Figure 1. Available information shortly after the Van earthquake of 23 Oct 2011 from various sources; the timeline at the right side of the figure indicates how this information was used by CEDIM in the pilot study to test the CEDIM FDA approach after the Van earthquake.

YEAR	Event	Deaths	Injured	Homeless	Affected	Buildings Destroyed/ Uninhabitable	Buildings Damaged	Tents**	Temporary Housing**
2011	**Van-Ercis**	**601***	**4201***	**150000***	**700000+***	**14156***	**17923***	**45000***	**16500**
1966	Varto	2517	1420	108000	217000	20007	n/a	n/a	11140
1971	Bingol	995	1900	45000	88665	5617	6726	9035	tbc
1975	Lice	2385	4500	5000++	53372	8149	8453	4144	5805
1976	Muradiye	3840	15000	51000	216000	9552	10175	5000	10000
1983	Narman-Horasan	1400	1137	25000	130000	3241	7092	5473	3000+
1992	Erzincan	652	3850	95000	322000	4783	13385	27250	16000
2003	Bingöl	177	530	45000	245000	5367	12073	14000	tbc

***data still being updated – refer to earthquake-report.com for latest updates,** size of temporary housing and tents differs, and also includes temporary housing and prefab housing in many cases built.**

Figure 2. Table published in 4th CEDIM Van earthquake report on human impact data for seven additional historic earthquakes of Eastern Turkey (source: CEDIM Forensic Earthquake Analysis Group, 2011)

The main conclusions of our analysis 10 days after the earthquake were:

Weather conditions were critical for shelters (tents), as on the high altitude of the Van area freezing temperatures were expected already in October. This is one of many cases where weather is not critical for direct loss of an earthquake but important for rescue and relief. The historical analysis conducted on sheltering of displaced populations following cold weather conditions after the 1976 Muradiye earthquake – an event which occurred in the coldest winter in 40 years in eastern Turkey – proved helpful to bring forward lessons learned and project a worst case trajectory for Van. Many buildings were destroyed in rural areas and – focusing

on the cities – little initial attention was given to this although life stock losses were important as they had been in previous eastern Turkey earthquakes. The building damage assessment varied significantly between the various relief agencies involved due to different characterizations of buildings and occupation classes. Little damage occurred to schools, hospitals, and infrastructure. Several favorable circumstances kept the number of fatalities small: On Sunday afternoon many people were not at home; the seismic energy was released fairly slow and the epicenter was closer to Erciş than to Van. The Turkish relief organizations acted swiftly and efficient and provided reliable and rapid information to the public.

SUMMARY AND CONCLUSIONS

We have tested our new methodology "CEDIM near real-time Forensic Disaster Analysis" in several cases. Based on the comprehensive example of the Van earthquake, we show in this paper that near real-time forensic disaster analysis can provide very rapid information with high potential for users such as emergency services, tourism industry, insurance, economic cooperation agencies, relief agencies, and other. The example of the Van Earthquake of 2011 and also the near real-time analysis of Hurricane Sandy in October 2012 show that near-real time information must be re-visited, validated and scrutinized after the event, once more consolidated knowledge becomes available.

In addition it is necessary to document case histories in a more systematic way, using modern tools of knowledge management. We currently focus on the methodology of Case Based Reasoning – CBR (Aamodt and Plaza, 1994), which allows comparing different events via attributes that have to be specified in a quantitative way for various aspects of the disaster.

REFERENCES

1. Aamodt, A. and Plaza, E. (1994) Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches, *AICom - Artificial Intelligence Communications*, IOS Press, 7, 1, 39-59.
2. Burton, I. (2010) Forensic disaster investigations in depth: A new case study model. *Environment*, 52, 5, 36-41.
3. CEDIM Forensic Earthquake Analysis Group (2011) Report No. 4 Comparing the current impact of the Van earthquake to past earthquakes in Turkey, Nov 2 2011, online available: www.cedim.de\downloads\CEDIMForensicEQAGTurkeyVanEQ_Report4.pdf
4. Daniell, J.E., Khazai, B., Wenzel, F. and Vervaeck, A. (2011) The CATDAT damaging earthquakes database, *Nat. Hazards Earth Syst. Sci.*, 11, 2235-2251, doi:10.5194/nhess-11-2235-2011.
5. Daniell, J.E., Wenzel, F. and Vervaeck, A. (2011) The Socio-economic effects of the 2011 Tohoku earthquake, *Geophysical Research Abstracts*, 13, EGU2011-14270.
6. Khazai, B., Daniell, J.E. and Wenzel, F. (2011) The March 2011 Japan Earthquake - Analysis of losses, impacts, and implications for the understanding of risks posed by extreme events, *Technikfolgenabschätzung - Theorie und Praxis*, 20, 3, 22-33.
7. Khazai, B., Vangelsten, B., Duzgun, S., Braun, J. and Daniell, J. (2011) Social Impacts of Emergency Shelter Provision in the aftermath of Earthquakes: Integrating Social Vulnerability in Systemic Seismic Vulnerability Analysis, *Geophysical Research Abstracts*, 13, EGU2011-7374.
8. Wenzel, F., Daniell, J.E., Khazai, B., Kunz-Plapp, T. (2012) The CEDIM Forensic Earthquake Analysis Group and the test case of the 2011 Van earthquake, *15th World Conference on Earthquake Engineering WCEE*, Paper 3557.
9. Wenzel, F., Daniell, J.E., Khazai, B., Mühr, B., Kunz-Plapp, T., Markus, M. and Vervaeck, A. (2012) Real-time forensic disaster analysis, *Geophysical Research Abstracts*, 14, EGU2012-1328.