GLOBAL DISASTER ALERT AND COORDINATION SYSTEM

MORE EFFECTIVE AND EFFICIENT HUMANITARIAN RESPONSE

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Disaster alerts, Humanitarian aid, GIS, Web technology, Consequence modelling

Abstract

The Global Disaster Alert and Coordination System, jointly developed in 2005 by the European Commission and the United Nations, combines existing web-based disaster information management systems with the aim to alert the international community in case of major sudden-onset disasters and to facilitate the coordination of international response during the relief phase of the disaster. The disaster alerts are based on automatic hazard information retrieval and real-time GIS-based consequence analysis. This paper shows how information systems in general and GDACS in particular can improve efficiency and effectiveness of humanitarian response.

Introduction

All major donors of humanitarian aid agreed in 1995 in the Madrid Declaration[2] that international response to disasters should be independent and impartial or, in other words, needs-driven. In a recent report of the United Nations Office for the Coordination of Humanitarian Affairs (OCHA, 2006) on the effectiveness and efficiency of humanitarian aid, emphasis is put on accurate assessment of the humanitarian needs, partially to be achieved by improving the information exchange between humanitarian responders. The United Nations have organized response in 9 "clusters" (OCHA, 2006). These clusters (Table 1) represent broad categories of needs during a relief operation and can be divided in relief needs for the affected population (e.g. how much emergency shelter is needed) and information needs for responders (e.g. how can we organize logistics in order to get emergency shelter to the affected population).

Table 1. Need clusters used by the United Nations.

Information needs for responders
• Camp Coordination and Camp Management
• Logistics
• Early Recovery
• Emergency Telecommunications

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[2] http://ec.europa.eu/echo/pdf_files/madrid_declaration_en.pdf

Relief needs for affected population
• Emergency Shelter
• Health
• Nutrition
• Protection
• Water, Sanitation and Hygiene

While it is essential to qualify and quantify these needs for each particular disaster in order to target an effective response, there are other information needs that are as important to set up an efficient response. Firstly, the international humanitarian community must be made aware of the disaster through early warning (before the disaster strikes) or alert (immediately after it occurred). Secondly, an understanding of the size and characteristics of the disaster is essential for good response. In particular in a complex and heterogeneous community like the international humanitarian community, efficient response can only be planned if it is coordinated. Coordination of response requires a clear situational awareness by the whole community.

Table 2 shows the list of information needs for an efficient and effective response. Typically, the main sources for such information are:

- The local government, with its local emergency management authority (LEMA): this is the main source for official information on the scale of the disaster.
- The Office for Coordination of Humanitarian Affairs (OCHA): with the mandate to coordinate humanitarian response, OCHA is the central hub for relief and response information. OCHA sends disaster assessment and coordination (UNDAC) teams to the affected area to collect information, sends search and rescue teams (through the INSARAG network) to rescue affected people, sets up an On Site Operations Coordination Centre (OSOCC) and/or humanitarian information centres (HIC) and disseminates all information through a website (ReliefWeb). However, many of these mechanisms are only deployed if needed. This decision requires information from other sources.
- The international media is a rich source of information. However, not all that is reported in the media is true. Automatic collection and analysis of news (e.g. European Media Monitor, Best, Van Der Goot and De Paola, 2005) has the advantage of quantity: many news sources can be processed. Manual collection and analysis of news (e.g. ReliefWeb) has the advantage of quality: resulting information is more reliable.
- Automated consequence analysis is an alternative source of information: after collecting global datasets of sufficient detail on population, vulnerability, key assets and critical infrastructure, transportation lines and populated places, these datasets can be analysed and relevant information can be extracted.
- Early warning and alert systems: timely knowledge about the occurrence of a natural hazard is critical and can be provided by geophysical, meteorological or other measurement systems, optionally combined with a humanitarian impact assessment.

Table 2. Information needs and providers in humanitarian response. X indicates areas where information is available for a particular need. Shaded cells indicate areas that are at least partially covered by GDACS.

Task	Information needs	Hazard alert or early warning	Automated consequence analysis	Media	Operations Coordination Centre	Local Emergency Management Authorities
Early warning and alert	Assess need for international intervention	X		X		X
	Determine affected area	X	X	X		X
Situation awareness	Assess incident	X	X	X	X	X
	Assess affected population		X	X	X	X
	Assess damage		X	X	X	X
	Assess Critical Infrastructure and Key Assets		X		X	X
	Assess indirect or secondary effects		X		X	X
Provide efficient response	Camp Coordination and Camp Management		X		X	
	Logistics		X		X	
	Early Recovery		X		X	
	Emergency Telecommunications					
Provide relief to affected population	Health (death, injured, need for medical care)		X		X	
	Emergency Shelter		X		X	
	Nutrition		X		X	
	Protection				X	
	Water, Sanitation and Hygiene				X	

Information systems play an increasing role in all these information sources. The latter two (automated consequence analysis and early warning and alert) are fully automatic and, therefore, produce information in near-real time. Media analysis can be automated to a certain extent. But also information that traditionally has been exchanged through telephone, telex or fax can now be shared through web-based platforms. OCHA has developed such tools.

This paper shows how information systems can improve efficiency and effectiveness of humanitarian response. The Global Disaster Alert and Coordination System is one such system that has a proven track record and is currently used widely in the humanitarian community.

Theory and Method

Early Warning and Alert for Humanitarian Impact

While the ultimate assessment of needs is done through the local government or through international assessment teams (e.g. UNDAC), geographical information systems (GIS) can contribute to estimate such needs on a near real-time basis. This is possible because consequences of natural hazards are mostly determined by local factors, which can be stored and processed in GIS. For instance, absence of human population and infrastructure will determine if a hazard event is of relevance to the humanitarian community. A typical entry strategy for an international organisation always requires a certain number of casualties or affected people (ECHO, 2004). Therefore, one straightforward way to eliminate irrelevant hazard events is by comparing the affected area with local population density.

When there is population, the disaster will only require international intervention if the local community cannot cope. Coping capacity is an essential element to consider in the context of humanitarian aid. Coping capacity (Schneiderbauer and Ehrlich, 2005) includes local population vulnerability (e.g. quality of housing, income, insurance policies and family structure) but also resilience built in the society (e.g. civil protection authorities, strong and functioning government and presence of Red Cross).

A disaster affects population through direct damage (e.g. destroyed shelter), indirect damage (through secondary effects such as landslides after earthquakes or inundation after tropical cyclones), direct socio-economic losses (loss of family or job) and indirect socio-economic losses. In most cases modelling of damage and losses requires detailed information on census, building stocks and local business and industry which is becoming available on continental scale (for instance in the HAZUS MH system for North America, FEMA, 2006), but not yet on global scale.

However, knowledge of exact consequences of a disaster is not necessary to estimate the overall humanitarian impact. Humanitarian needs for earthquakes – but also for other disasters – are mostly proportional to the population (Gutierrez *et al.*, 2005). The denser the population is, the more shelter and transportation infrastructure there is. Statistical models using the event magnitude, the affected population and the vulnerability of the population are able to predict the level of expected humanitarian needs (De Groeve and Eriksson, 2005; De Groeve *et al.*, 2006).

Table 3. Information related to humanitarian needs provided by GDACS by disaster type. Data is shown in italic, models in plain font. (1) See http://www.gdacs.org/sources.asp for a full list of data sources. (2) Physical flood monitoring based on remote sensing (De Groeve et al., 2007) or an international network of gauging stations (Fekete et al., 1999) is in development, but not available yet on global basis.

	Earthquake	Cyclone	Volcano	Tsunami	Flood
Hazard occurrence	*Seismological networks (1)*	*World Meteorological Organization Regional Specialized Meteorological Centres (1)*	*Media monitoring; volcano observatories (1)*	Earthquakes of magnitude 7 and higher occurring under water	*Media monitoring (1) (2)*

Determine affected area	Fixed radius of 100km around epicentre Alternative: intensity modelling (e.g. Wald *et al.*, 1999)	Fixed radius of 200km around track points Alternative: satellite measurements (NOAA), wind field modelling (e.g. Holland, 1980)	Fixed radius around volcano Alternative: Eruption modelling	Wave propagation and height modelling (Annunziato, 2006)	*Media monitoring* *Satellite observations (interpretation of near real-time MODIS images)*
Determine affected population	*Global population dataset* (Bhaduri *et al.*, 2002)	*Global population dataset* (Bhaduri *et al.*, 2002)	*Global population dataset* (Bhaduri *et al.*, 2002)	Urban population of affected coastal cities	*Media monitoring*
Determine vulnerability of population	*Sub-national vulnerability index* (Vernaccini *et al.*, 2006)				
Determine need for intervention (De Groeve *et al.*, 2006)	Function of magnitude, depth, population and vulnerability	Function of cyclone wind speed and population	Function of volcano eruption status and population	Function of earthquake magnitude	Function of flood magnitude and population affected

Table 3 shows an overview of the data and models used currently in the Global Disaster Alert and Coordination System. The principle of GDACS is to use the best open source information that is available on global scale and apply models to create missing information. The models used in GDACS are currently humanitarian impact models (for all disasters) and a tsunami wave propagation and height model (Annunziato, 2006). The impact models for earthquakes, tropical cyclones and volcanoes have been calibrated with historical disaster impact data (De Groeve *et al.*, 2006).

When GDACS detects a new event with potential humanitarian impact, the system generates email, SMS and fax alerts to inform humanitarian responders about the disaster and, simultaneously, starts consequence analysis routines and other information processing tasks described below.

Consequence analysis and secondary effects

With the currently available global datasets, it is not possible to have a detailed and accurate assessment of disaster consequences and humanitarian needs, as it is possible on national scale in certain countries (FEMA, 2006). However, global geographical databases are becoming available at increasingly larger scale, provided by research organisations, government organisations or international organisations. With every new global dataset, new aspects of consequence models can be implemented.

In spite of this strong data dependence, relevant information can be extracted from the currently available global datasets (Peduzzi *et al.*, 2005). Even if information on potential consequences can have low confidence (such as the probability of a dam burst after an earthquake), information on the absence of consequences can have high confidence (no dam burst because there are no dams in the affected area). Knowledge about potential factors that can complicate intervention is very relevant for planning response.

Table 4. Consequence analysis in GDACS.

	Earthquake	Cyclone	Volcano, Tsunami, Flood
Assess Critical Infrastructure and Key Assets	Neighbourhood analysis of global datasets *Datasets available on nuclear plants, hydro-dams, airports, ports, etc.*		
Assess indirect and secondary effects	Tsunamis (see tsunami) Landslides: report on slopes in affected area (from *digital elevation models*, e.g. SRTM, Werner, 2001)	Damage to agriculture by flooding: report on land use in affected area (from *global land cover*, e.g. GLC2000, Bartholomé *et al.*, 2005)	–
Provide information for logistics	Neighbourhood analysis of transport related global datasets *Datasets available on roads, airports, ports*		

Table 4 shows the current consequence analyses provided by GDACS. A geographical analysis of the affected area (which is either obtained from a data source or modelled) can offer valuable information for (1) evaluating potential damage to critical infrastructure and key assets and (2) logistics through the transportation network.

Moreover, the likelihood of disaster specific secondary effects can be assessed based on the presence or absence of critical conditions. For instance, landslides cannot occur without slopes and tsunamis cannot occur above water. Indirect socio-economic effects of the disaster can also be estimated to a certain extent through a geographical analysis: for example, floods can only cause crop loss in areas with significant agricultural area.

It must be clear that the information that can be provided by automated consequence analysis will rapidly gain in importance in the coming years. New technology (such as new satellite sensors) and software (such as Google Earth) allow the collection of more and more detailed datasets either through direct measurement or as a community effort (e.g. Open Street Map[3]).

<u>Media and open source monitoring</u>

A third source of information in the immediate aftermath of a disaster is the international media. This can be seen in the large sense including any information that is published relevant to the disaster, including scientific data and expert reports. Information systems, such as GDACS, can be automatically configured to collect such information from the Internet.

When a new disaster is detected by GDACS, the system starts a targeted collection of media report using a direct interface with the European Media Monitor (Best *et al.*, 2005), an on-line newspaper scanning system developed at JRC. This information is dynamically published in on the GDACS website and in GDACS reports. In addition, GDACS collects specialized

[3] http://wiki.openstreetmap.org

humanitarian information sources from partner organisations, including ReliefWeb news and situation reports and UNOSAT maps.

Depending on the disaster type, different organisations provide scientific data or expert information that is of use for response planning. Automated collection of this information and dissemination through a single website increases the efficiency response. Examples of such information collected by the GDACS system includes earthquake intensity maps (ShakeMaps) from the United States Geological Survey, near-real time flood extent maps from the Dartmouth Flood Observatory, earthquake mortality estimates from the World Agency for Planetary Monitoring and Earthquake Risk Reduction.

In particular for scientific information and expert reports it is important to present only information that is relevant to a given disaster. Even if the definition of "disaster" various widely in different professional disciplines, there is currently a de facto standard for identification of disasters that is used in GDACS and by GDACS partners to relate information. This standard is the GLIDE number, a globally common Unique ID code for disasters (Tschoegl *et al.*, 2006).

<u>Operations Coordination Centre</u>

Computer systems cannot predict the detailed consequences of a disaster. The most important information on the situation must come from observations on the affected area. Since OCHA has the mandate to coordinate international relief, it is the information hub between the many organisations involved in a response (including aid donors, international NGOs, local relief workers and the local emergency management authorities). In response to a growing need for structured information exchange between first responders in an international humanitarian disaster, OCHA developed the Virtual On-Site Operations Coordination Centre (Virtual OSOCC). The Virtual OSOCC is an on-line information exchange and coordination tool for disaster managers and international response organisations. It is used by responders during major disasters to exchange information in order to facilitate their decision-making for international assistance. Since 2006, the Virtual OSOCC has been integrated in the Global Disaster Alert and Coordination System.

By combining both automatically collected and modelled information (available before or immediately after a disaster strikes) with field-based information from responders (typically available hours after the disaster), GDACS is able to fill the critical information gap at the onset of the disaster before an On-Site Operations Coordination Centre (OSOCC) has been set up in the affected area.

However, also after the establishment of an OSOCC, the professional response community continues to use GDACS as a private platform to exchange unofficial information, making it an excellent source of information for needs assessment and response planning. Ultimately, though, other OCHA tools become the main source of information, including ReliefWeb (dissemination OCHA Situation Reports) or, for large disasters, a Humanitarian Information Centre in the affected area.

<u>Local emergency management authorities</u>

Last but not least there are the local emergency management authorities (LEMA). Unless the disaster has disrupted the local chain of information, the LEMA has the means to obtain the most reliable information on disaster consequences and relief needs. Thanks to a targeted promotion and training by OCHA, LEMA are increasingly being included in GDACS. This is extremely important for an efficient and effective response from the international community. Not only can LEMA provide critical information to the international community, but they can also be aware of what relief is available and is being deployed.

Results

A scientific evaluation of a change in effectiveness and efficiency of humanitarian response due to the use of information systems such as GDACS is hardly feasible. Even if, in a review of humanitarian response (OCHA, 2005), the United Nations recommended the establishment of benchmarks to measure progress, such benchmarks are unlikely to be sensitive enough to detect the contribution of a single factor (i.e. use of information systems) to the overall improvement of humanitarian response. Moreover, it is unlikely that information systems alone would improve response a lot: changes in effectiveness and efficiency cannot be seen separately from the general changing culture of accountability in humanitarian aid.

However, there are indirect ways to assess the impact of information systems on effectiveness and efficiency of response. Firstly, a historical analysis of the accuracy of GDACS alerts and consequence analysis information can determine how trustworthy the information is. Users are likely to use trustworthy information, while they will quickly abandon systems that provide more false information than correct information. Secondly, an analysis of the use of GDACS can show if the objectives are met.

<u>Needs assessment: alerts and consequence analysis</u>

An analysis of the accuracy of GDACS earthquake alerts has been published before (De Groeve *et al.*, 2005). However, that analysis was based on the assumption that the number of casualties was representative for humanitarian needs. This assumption does not always hold (Eriksson, 2006). A better measure for humanitarian needs is the monetary value of humanitarian response.

Table 5 shows the accuracy of GDACS alerts compared to humanitarian response in the past 2 years. For earthquakes, tsunamis, tropical cyclones and volcanoes, very few disasters were missed, and only because of particular circumstances. Of those, only Hurricane Stan – or more precisely, the landslides caused by the heavy rain accompanying hurricane Stan – required significant humanitarian aid (3 million US$). There are slightly more false alerts, in particular for tsunamis and volcanoes: more work is needed to improve results.

Table 5. GDACS alerts compared to humanitarian response. Financial data is from OCHA's Financial Tracking System (FTS) and ECHO's HOPE database.

<table>
<tr><td>Period of observation: January 2005 to November 2006</td><td>Number of events</td><td>Correctly alerted</td><td>False alert</td><td>Missed alert</td></tr>
<tr><td rowspan="2">Earthquakes (magnitude > 5) and tsunamis (magnitude > 7)</td><td>2141</td><td>7</td><td>8</td><td>2</td></tr>
<tr><td colspan="4">Total funds: 1.2 billion US$
Total funds for missed alerts: 275,000US$
False alerts: 6 where false tsunami alerts; 1 caused 200 deaths but did not trigger international response
Missed alerts: 1 in sparsely populated area, 1 was a series of low magnitude events.</td></tr>
<tr><td>Tropical Cyclones</td><td>141</td><td>12</td><td>3</td><td>2</td></tr>
</table>

	Total funds: 5.8 million US$ Total funds for missed alerts: 3 million US$ Missed alerts: Gamma (Honduras, 2005) never reached hurricane strength; Stan (Mexico and Guatemala, 2005): most damage because of landslides and heavy rain. False alerts: Shanshan (China, 2006), Saomai (China, 2006), Nabi (Japan, 2005); it is possible that humanitarian response was provided for Shanshan and Saomai, without this being reflected in the FTS.			
Volcanoes	35	8	27	0
	Total funds: 22.3 million US$			

Use of GDACS in the humanitarian community

Another measure of success is in the use of the GDACS system. The assumption is that if the GDACS information does not contribute to more efficient and effective response, the system would not be used. The number of users of the GDACS system (the combination of the alert system, the consequence analysis system and the Virtual OSOCC) reaches 4000.

Most GDACS users are from the international response community, the search and rescue (including UNDAC) teams, international and national NGO's, including the Red Cross and Red Crescent organisations. Together, this group – which is the primary focus of the system – represent 65% of users. However, GDACS is being promoted in disaster prone countries. This is done through annual stakeholder conferences and by including GDACS in the regular and established OCHA training and simulation exercise sessions organised by OCHA/FCSS in disaster prone countries. As a result, already 90 users from local emergency management agencies (representing 5% of users) are registered in the GDACS system. In addition, individual people from disaster prone regions are subscribing and represent 6% of the users.

Discussion

With ever increasing availability of global geospatial information and real-time measurements of natural hazards, information systems can play a significant role in making humanitarian aid more effective and efficient. While currently only simple consequence analyses can be performed due to data restrictions, such analyses will become more detailed and complex, ultimately producing very detailed forecasts or now-casts of the disaster situation and humanitarian needs as is the case now in countries like the United States.

The Global Disaster Alert and Coordination System is one of the first multi-hazard information systems to provide such functionality. It not only produces alerts and consequence analysis reports, but it also collects open source information in a targeted way and provides a closed forum for professional responders to coordinate their response.

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Author Biography

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