Geospatial Disaster Relief

Jonathan W. Lowe

Geospatial technology and those who know it best are playing key roles in alleviating some of the suffering that results from humanitarian disasters.

Regardless of the natural or political causes for humanitarian disasters, the end results are always grim. If not a victim yourself, it's natural to wonder how you can help the many people in need. In fact, there are quite a few ways that our industry's geospatial technology can and does help victims of humanitarian crises. This column considers some of the problems resulting from large disasters, explains how the application of geospatial technology can help, and describes a recently formed consortium that provides spatial products for disaster relief.

Food, Shelter, Water, Health, and Family

Major humanitarian disasters bring pain, suffering, and death to thousands of people on a large scale. Two recent world events are among the worst such disasters ever seen: the Indonesian tsunami and the political instability in Darfur, Sudan.

In the early morning of December 26, a magnitude-9 earthquake with its epicenter 30 kilometers below sea level caused Tsunami flood waves in the Indian Ocean, which crashed to shore along Sumatra, Thailand, Sri Lanka, and southern India's coastlines. The impact killed more than 160,000 people (with the count still rising when this column went to press in mid-January) and destroyed hundreds of coastal villages.

In Darfur, the past two years of tribal conflicts and clashes between rebels and government forces have killed as many as 50,000 people and displaced more than one million people. The World Health Organization estimates that as many as 10,000 people continue to die each month from disease and malnutrition in the refugee camps. Adding insult to injury, extensive flooding has hamstrung communication and supply links in more remote areas.

In both of these disasters, many people are suddenly deprived of life's necessities. Common problems are where to build shelter or where to find fresh water, food, and fuel for cooking or heat. Mohammed Saleh, a Darfur refugee, characterized this supply problem in his own words: "I work for this butcher under the tree to earn some money for my wife and nine children. Life here is very distressing. It is difficult to get water here — there is little water in the well, and it is not clean."

Richard Saul, project leader of a disaster-response consortium known as Respond, described the challenge of transporting supplies as follows: "Suppose you have to travel 175 miles across dry rivers which have flooded. It can take 10 days to go just that 175 miles due to the barriers such as the flooded rivers — you could walk that far in 10 days! But since they have to transport heavy goods in trucks, walking is not an option. They can use maps to find out where the rivers are, plan when and where to cross them, avoid crossing the same river twice, and so on."

Just finding your way around a recently impacted community can be hard. Temporary camps that spring up overnight to shelter large populations of postdisaster survivors quickly sprawl extensively in a hodgepodge of makeshift tents and paths. Inhabitants may hear that there is medical aid available somewhere in the camp, but have trouble finding it among the maze of tents.

Not necessarily life-threatening, but potentially more painful than physical injury is separation from friends and family. Disaster victims may be desperate to locate lost friends and relatives, but unable even to confirm whether they are alive or dead. Darfur refugee Haloum Cherif Chawa tells this story: "My house was burnt when the army and militia attacked. I set off for the Chadian border with my children. My husband is still in Sudan — I have no idea if he is still alive."

Aid workers trying to help these disaster victims face challenges of their own. They must plan routes for transporting supplies unimpeded from inhospitable or dangerous locations to safer areas. In the short term, they may need to locate airports, schools, and hospitals; conduct site selection for new camps; and identify the main areas of damage. Longer term, they will be assessing whether the crops will fail, which areas are at risk from malaria or other diseases. And always tantamount in aid workers' minds are the questions, "Where are my staff? Are they safe?"

Help from Above

For all of the previously mentioned problems, reliable maps would be a great help. But when the site of a disaster is in a remote or undeveloped location, maps may not be available. Given a lack of existing map data and the urgent needs of the victims, remote sensing technol-

Net Results columnist **Jonathan W. Lowe** covers the role of emerging technologies in the exchange of spatial information. Lowe is the owner of Local Knowledge Consulting (Berkeley, California), where he designs and implements spatial Web sites. He can be contacted at info@gis website.com.

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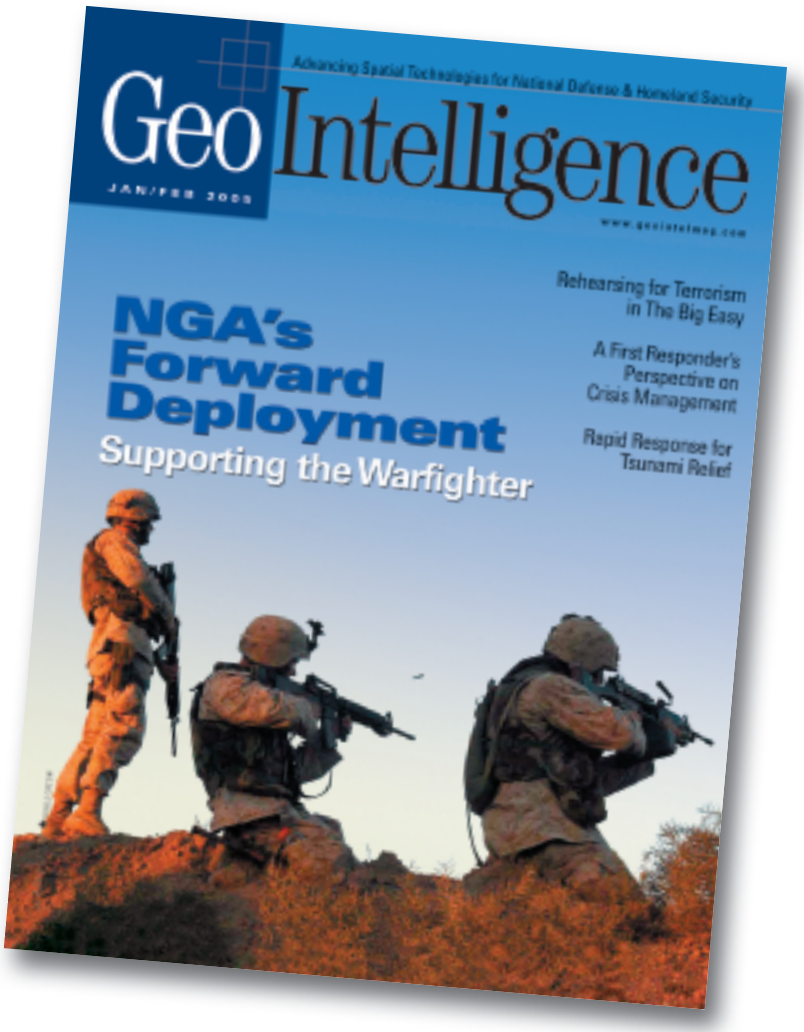

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GeoIntelligence helps military and civil leaders deploy spatial technologies for homeland security and national defense, whether for safeguarding critical infrastructure at home or defending U.S. and allied interests abroad. The magazine is a high-profile and authoritative forum for sharing knowledge about emerging technologies and viewing intelligence through a spatial lens.

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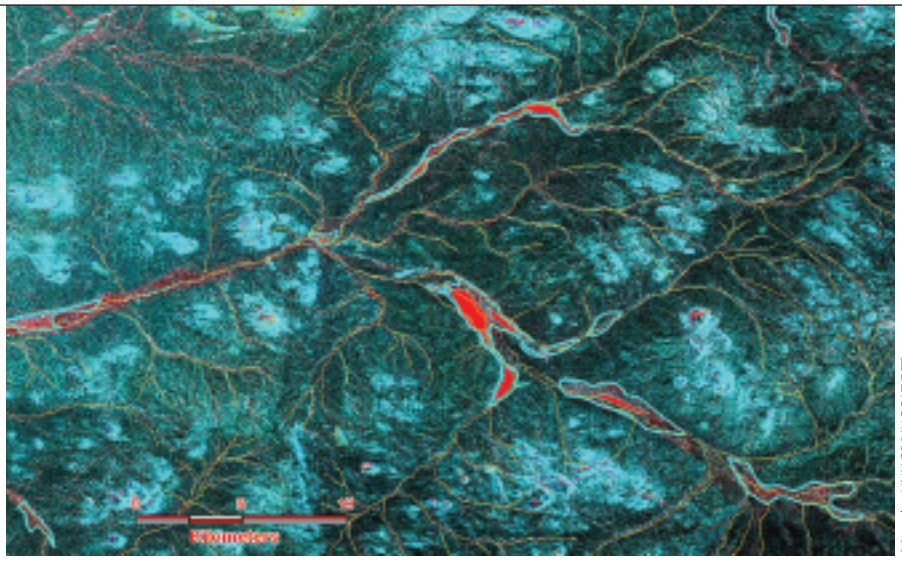
ogies often are the best candidates for quickly collecting disaster-zone data. Different sensors are particularly well-suited to different geospatial disaster-response purposes.

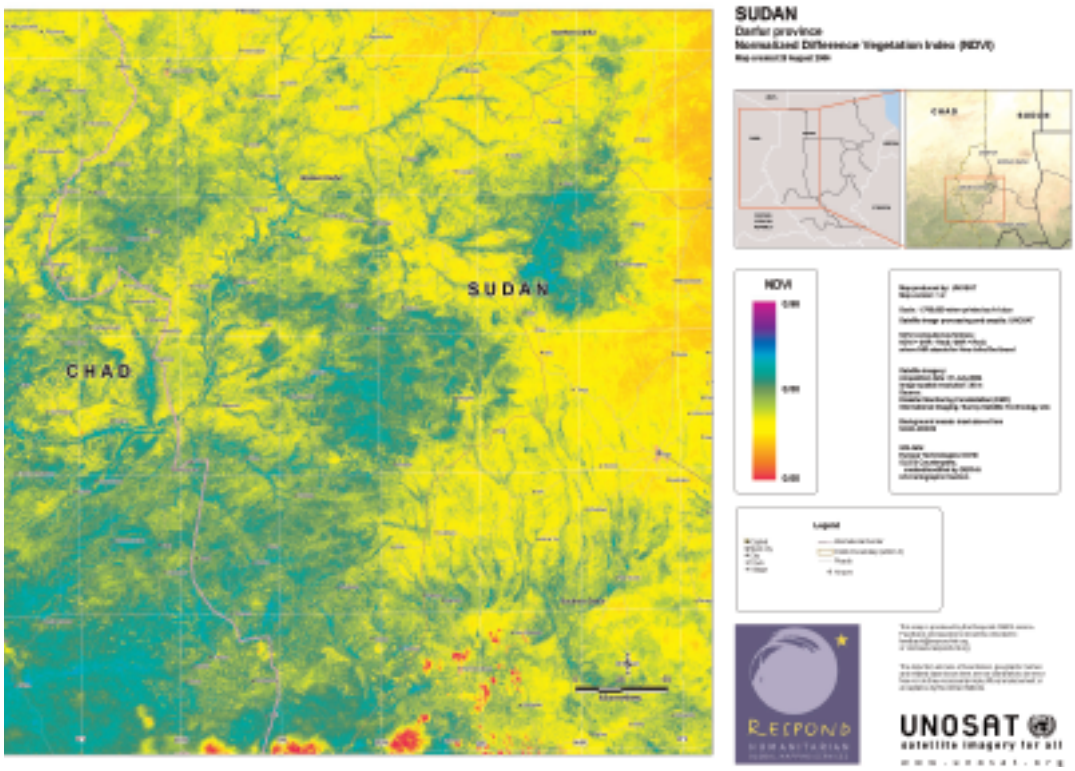
For instance, remote sensing technologies, such as ERS and JERS-1 radar in combination, can detect areas with available subsurface water as well as dry areas, supporting well-drilling decisions and helping aid workers deliver water to camps with the worst access to water. When selecting sites for new camps, this same satellite data identifies areas on truly dry ground, but with nearby access to water and roads (see Figure 1).



Maps by UNHCR/UNOSAT/RTF

Figure 1. An image processed to reveal the best-candidate locations for finding water. Campsite planners would use this map to locate dry ground near water and roads.

The ERS radar captures surface topography and near-surface geologic features, such as earthquake faults or buried drainage channels called *wadis*. The JERS-1 radar's longer-signal wavelength penetrates deeper (reportedly as deep as 2 meters in arid regions), yielding additional clues about potential water sources. Multitemporal radar imagery provides yet another indicator by revealing underground humidity anomalies. A French company, Radar Technologies France, reports being capable of delineating prime locations for water prospecting by interpreting ERS, JERS-1, and multitemporal radar imagery with algorithms originally designed for oil, gas, and mineral exploration.



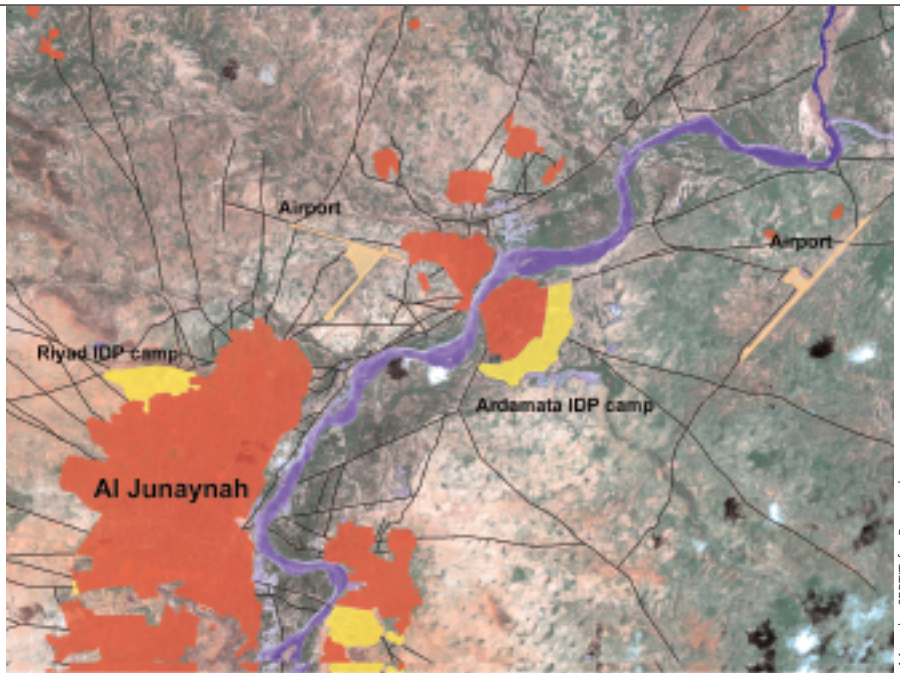
Map by UNOSAT and Respond

Figure 2. Vegetative fuel-distribution maps, such as this view of a region in Sudan, help aid workers distribute fuel supplies to communities with the worst access to naturally occuring firewood.

Sensors such as SPOT, IKONOS, QuickBird, and Landsat can map vegetative-fuel distribution, identifying where woody shrubs or trees are growing to support fuel rationing and distribution decisions that supply fuel to camps with the worst access to naturally occurring firewood (see Figure 2). Synthetic aperture radar (SAR) sensors can capture the location of roads, rivers, and wadis in support of transit and supply-chain planning (see Figure 3).

Satellites such as IKONOS, capable of high-resolution image capture, can provide 1:4,000- and 1:2,000-scale maps of refugee camps with enough detail to identify medical tents (see Figures 4a and 4b). With the addition of a keyed grid overlay linked to a Red Cross camp census, such images help survivors navigate their camps and locate lost relatives (see Figure 5 on page 36).

And in the case of the Indonesian tsunami, where damage is so over-



Maps by SERTIT for Respond

Figure 3. Route planners transporting supplies between villages need to avoid natural barriers, such as flooded rivers or muddy wadis that will bog down their vehicles. This map used SAR sensors to capture roads, rivers, and wadis.

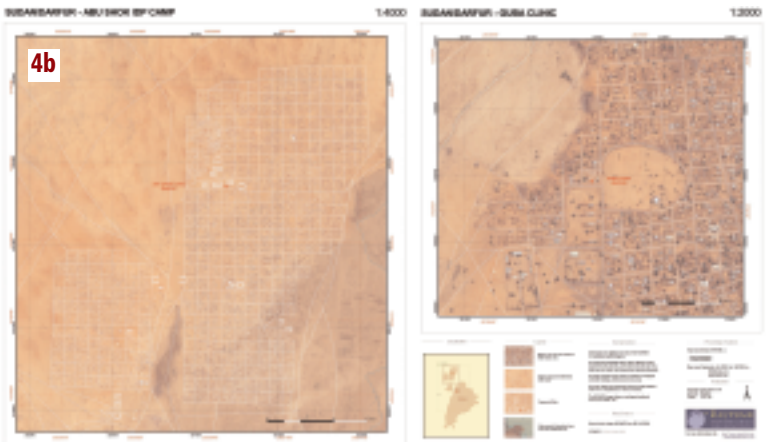
whelmingly extensive, simply cataloging the extent of the impacted areas is an important first step that then guides future relief deployment (see Figures 6a and 6b on page 37).

Problem, Meet Solution

Given the aforementioned technologies' clear benefit to disaster victims and aid workers, what more than technical aptitude is needed to deploy them? Perhaps the most necessary and difficult requirement is cooperation. Because there is a complex supply chain between satellite sensors and disaster victims, many different participants must cooperate to ensure that useful geospatial products actually reach those who need them. For instance, the journey begins when aid agencies identify the general location of a severe disaster. Satellite-imagery providers must then arrange for their devices to capture imagery of impacted areas. Mapping companies then must process and interpret that imagery as map products. Next, distributors, such as news agencies, must prepare the map products for distribution to a large network of newspapers or other media channels, so that the public can finally get their hands on the needed maps.

Cooperation between these participants on an ongoing basis requires some sort of organizational structure, particularly for the chance to reapply successful working relationships to future disaster-relief projects. Noteworthy in their ongoing support for a variety of world disasters is a consortium called Respond (www.respond-int.org), composed primarily of European companies — such as its prime contractor, Infoterra — but providing support via map products for any international disaster. Compared with the mapping sites that have appeared as a direct consequence of the Indonesian tsunami, Respond seems aimed instead at many world disasters — and for the long term.

Respond describes itself as "an alliance of European and International organisations working with the humanitarian community to improve access to maps, satellite imagery, and geographic information." Respond defines its capabilities to include support for all crisis stages in which geographic information is useful, including slow-onset crises (such as famine) as well as "fast" disasters (such as earthquakes or floods). Respond's services include not only map products, but also such services as training, in-field support, or forecasting and alert services.



Maps by Keyobs for Respond

Figures 4a and 4b. Even at the scale of a tent, remotely sensed imagery can help. This image identifies medical tents in a Sudanese refugee camp.

The CEO of Infoterra, Dave Fox, commented that Respond's proven reliability stemmed largely from the involvement of enough skills and capacity (namely, many cooperative vendors and agencies) to build a guaranteed service.

"The effort is underpinned by a high-profile European Space Agency initiative," he explained, "which gives Respond valuable political credibility. Participants can count on long-term viability, staged initially over five years." Fox also stressed that no single participant is solely responsible for Respond's success to date, saying, "It is very much a group effort."

Given earlier explanations of the value of map products during disasters, what general operating procedures maximize the effectiveness of an organization such as Respond? Infoterra reports that all detailed basemapping, imagery, and thematic mapping become part of an online archive, available on an ongoing basis. But disaster victims are unlikely to directly access such a repository — rare indeed is the starving disaster survivor who is equipped with a fully connected laptop! So Respond also uses existing, current, "popular" delivery mechanisms to get maps to those in need.

For example, a participating member of the consortium is the Reuters Foundation and its AlertNet distribution system for transmitting JPEG images to news publishers. Other in-sector providers capable of channeling geographic information to the humanitarian community are the European Commission Directorate–General Joint Research Centre, UNOSAT (an organization dedicated to supplying "Satellite Imagery for All"), and Deutsches Zentrum fur Luft-und Raumfahrt (DLR). In addition to Infoterra, participating commercial producers of geographic information are currently Metria, Keyobs, and MapAction. Participating systems engineers and consultants are Kayser-Threde, SciSys, Controlware, ESYS Consulting, and Surrey Satellite Technology Ltd.

Filling out the consortium are the recipients of Respond's disaster-mitigation map products — called *core users* — who supply feedback and evaluate Respond's efforts. There are currently five core users. One, the Mission of the Office for the Coordination of Humanitarian Affairs (OCHA), has a directive that is representative of all five core users and explains why they are involved in the first place. OCHA exists "to mobilize and coordinate effective and principled humanitarian action in partnership with national and international actors in order to alleviate human suffering and disasters in emergencies,

Figure 5. To navigate a refugee camp with thousands of tents, or to find a particular person in the camp, a gridded map and keyed census are indispensable.

advocate for the rights of people in need, promote preparedness and prevention, and facilitate sustainable solutions." The other four core users are Deutsches Rotes Kreuz (the German arm of the Red Cross), Technisches Hilfswerk (the governmental disaster relief organization of the Federal Republic of Germany), International Strategy for Disaster Reduction, and the United Nations Office for Project Services. Some members of the core users also chair a strategy group that refines Respond's service offerings over time.

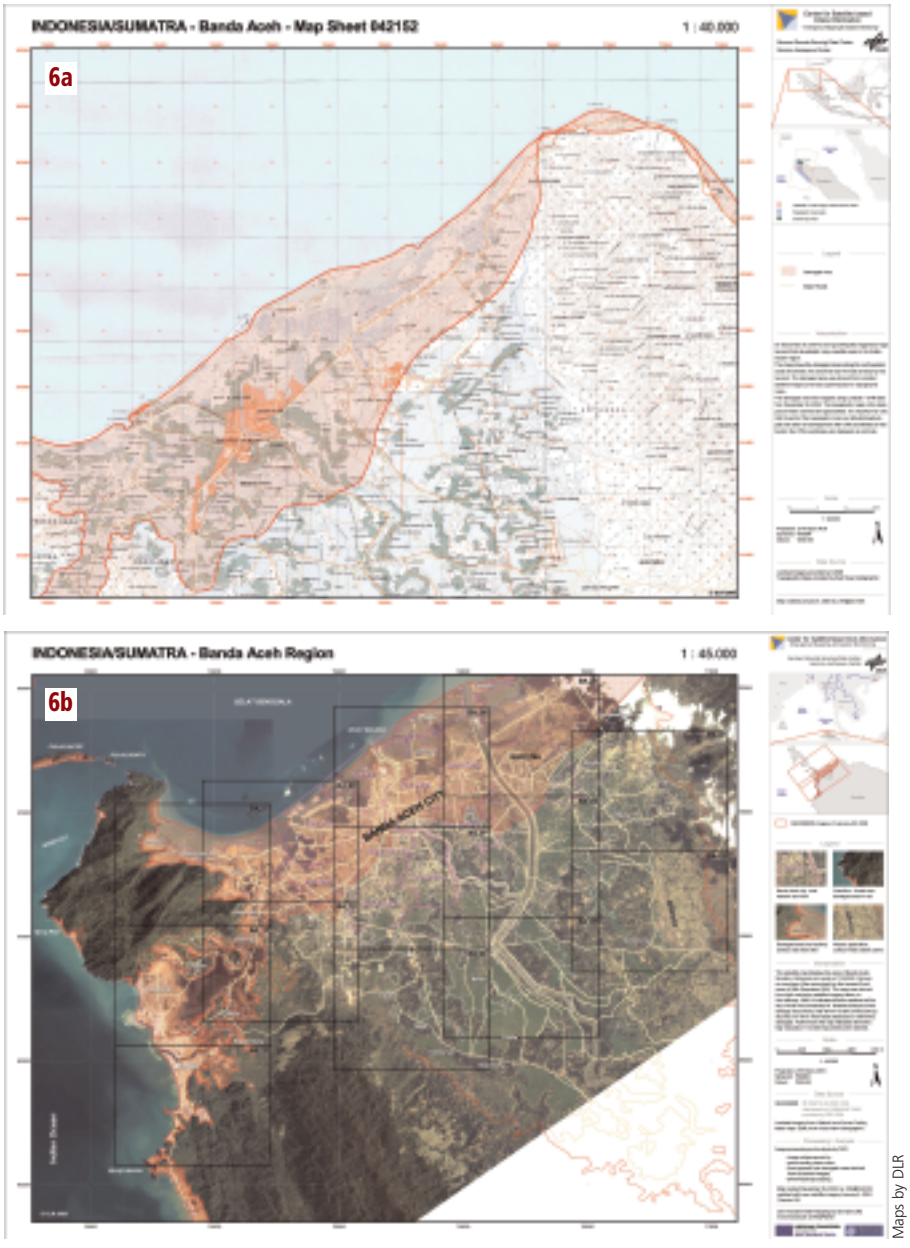
Funded Altruism

Whether disasters are natural or human-generated, we humans struggle to understand why we are victims. Darfur refugee Yacoub Youssouf is no exception in wondering what he could possibly have done to deserve his fate: "It took me 40 days to reach the Chadian border from my village. In the daytime I hid with my wife and four children in caves and then at night we walked. Our village was bombed from the air and then attacked by ground troops. I am just a farmer. I don't know why they attacked us."

No matter how bad the news gets, though, our human capacity to empathize with others never seems exhausted. We contribute money and time to people in need with no anticipated benefit to ourselves, even if those we help are strangers living halfway around the world.

Unthinkably, however, even after people have suffered as terribly as Youssouf has, there are those who will still try to capitalize on disasters. As a journalist, it's tempting to wonder why organizations such as Respond come into existence. For instance, are Respond's members acting purely altruistically, or instead, with intent to earn public-relations kudos?

Infoterra's Fox speculated that a combination of mature sensor and geospatial software technology on the one hand, combined with a unified multinational desire to participate internationally, was the specific driver for Respond. He explained that the European Space Agency and European Commission have established a joint initiative called Global Monitoring for Environment and Security (GMES, www.gmes.info) intended to "bring together the needs of society associated with the issue of environment and security with the advanced technical and operational capability offered by terrestrial and spaceborne observation systems." Respond is one of a dozen GMES proposals for achieving that goal, and is thus funded by GMES.



Figures 6a and 6b. Maps delineating the extent of coastal damage following the Indonesian tsunami guide relief deployment.

So, while Respond is not acting purely altruistically, the consortium's efforts do reflect a formalized European desire to soothe world suffering with humanitarian action — and over an initial five-year period. I would argue that today in Indonesia and Sudan and tomorrow who-knows-where or why, unfortunate disaster victims will continue to need both the ad-hoc goodwill of millions of world citizens and the organized and long-term vision provided by initiatives such as GMES and consortia such as Respond.