Using Remote Sensing Data for Earthquake Damage Assessment in Afghanistan: The Role of the International Charter

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ABSTRACT

Afghanistan is located in a zone of high-seismic activity. Given the rugged and mountainous nature of the country and the location of villages, towns and cities, there is propensity for widespread death and destruction due to landslides whenever an earthquake occurs.

Use of satellite imagery by humanitarian agencies in Afghanistan in preparation for and response to natural and man-made disasters has been very limited, mostly to International organizations such as the United Nations. Earth Observation Satellites (EOS) due to their vantage position have demonstrated their ability to rapidly provide vital information and services in a disaster situation. EOS has been used in emergency situations where the ground resources are often lacking.

The perception amongst humanitarian agencies and civil protection authorities in most developing countries is that the cost of satellite imagery is not cheap. With limited budgets available for purchasing satellite data, they tend to opt for less expensive solutions such as interagency survey teams to assess damages. The rugged and mountainous nature of Afghanistan and the lack of roads in most parts of the country, survey teams are most often hampered, leading to delays in delivery of information from the field to the decision makers.

Recent earthquake in the Hindu Kush of the country in April 2004 witnessed the triggering of the International Charter for free delivery of satellite imagery.

Image analysis and interpretation of both pre and crisis data did not show observable features of damages. The damage assessment maps were used by the humanitarian community for decision-making.

Availability and access to space technology in addressing natural disasters have been the main obstacles facing developing countries particularly those poor countries without their own space programs. This problem has been solved through the introduction of The International Charter for major disasters. However, knowledge about the Charter is not common knowledge in most developing countries; Disaster Management Authorities, the Academic Institutions, humanitarian agencies and the affected communities have very little idea about the availability and access to free satellite imagery. There is need for a massive awareness campaign to educate decision makers about the International Charter and the potentials of using space technology in addressing problems relating to disaster management and the environment. The skills to process satellite imagery and integrate it with other GIS layers are lacking in most developing countries; there is need to embark on a massive capacity building exercise to ensure optimization of the benefits of the technology. The Charter needs to find innovative ways of quickly sending value added information products to disaster management authorities instead of relying on in-country skills in image processing.

This paper elaborates on the experiences gained working with images received from the International Charter, and the immense pressures from the humanitarian community for rapid delivery of information.

1 Introduction

Natural disasters are extreme events within the earth's system that result in death or injury to humans, and damage or loss of valuable goods, such as buildings, communication systems, agricultural land, forest, natural environment etc (Van Westen, 2002). Alexander (1993) distinguished between a disaster from a hazard when the disaster occurs in a populated area, and brings damage, loss or destruction to the socio-economic system.

Afghanistan is located in a zone of high-seismic activity. Given the rugged and mountainous nature of the country and the location of villages, towns and cities, there is always a high propensity for widespread death and destruction whenever an earthquake, landslide, mudslide, avalanche, or flooding occurs.

According to the EM-DAT International Disaster Database (http://www.cred.be/), about 1,919 people have been killed, and a total of

76,550 made homeless due to yearly flooding since 1972. Landslides and avalanches have also made their mark on the lives and properties of Afghans; 1,373 people have been affected with 799 killed. The Red Cross estimates that since the early 1980s, natural disasters in Afghanistan have killed an estimated 19,000 people and displaced 7.5 million people (IFRC/RC, 2002).

Decades of War and civil conflict, as well as environmental degradation, have all contributed to increasing vulnerability of the Afghan people to natural disasters. Several assessments by the humanitarian agencies in Afghanistan have revealed significant shortcomings in the areas of water, sanitation, health, security and natural resource management.

Furthermore, the high level of poverty, lack of livelihood and income generating opportunities, chronic health problems, and poor state of the infrastructure all add to the burden of natural disasters on the people of Afghanistan. The Government of Afghanistan is so weak it relies heavily on the humanitarian community particularly the UN in responding and managing major natural disasters. There is lack of coordination amongst government departments, and clear-cut strategy for disaster management in the country.

The success of disaster management depends largely on availability, dissemination, and effective use of information for decision-making. The information needs will vary depending on the users, and the scale, but generally will include information on weather and climate, all elements at risk, socio-economic and demographic data, and past information on previous disasters depicting their location, characteristics, extent, and impact. Since the overthrow of the Taliban Government in 2001 which, witnessed the return of the United Nations and International Non Governmental organization into the country, disaster management data are being generated by multiple users, stored in different formats and media, making it extremely difficult to bring the data together to support disaster management activities.

Lack of critical and timely information for disaster reduction is typical of developing countries particularly those emerging from decades of war and civil conflict; Afghanistan is not an exception. Reliable information in a timely manner saves lives and properties as actionable decisions are made that lead to fore warning of populations, provision of relief and making communities resilient and knowledge based.

Space technologies have proved to contribute unique and significant solutions in disaster management: disaster mitigation, disaster preparedness, disaster relief and also disaster rehabilitation. Space technology based solutions have become an integral part of disaster management activities in many developed and some developing countries (http://www.oosa.unvienna.org/SAP/stdm/index.html).

In Afghanistan, use of satellite imagery by humanitarian agencies in the country in preparation for and response to natural and manmade disasters has been very limited. The humanitarian community generally assumes that the cost of satellite imagery is not cheap. With limited budgets available for purchasing satellite data, they tend to opt for less expensive solutions such as interagency survey teams to assess damages. The rugged and mountainous nature of the country and the lack of roads in most parts of the country, survey teams are most often hampered, leading to delays in delivery of information from the field to the decision makers.

In March 2002, an earthquake measuring 6 on the Richter scale occurred in the Northeast part of Afghanistan killing about 1000 people (http://earthquake.usgs.gov/activity/past.html). For the first time in Afghanistan, satellite imagery was used to assess damages as over 35,000 people were affected.

Recent earthquake in the Hindu Kush of the country (5th April 2004) witnessed the triggering of the International Charter[1] for free delivery of satellite imagery. AIMS[2] requested a set of satellite imagery through UNOSAT covering both pre and post earthquake periods. Pre disaster imagery was immediately released, but it took over a week before crisis data could be taken and delivered. Problems of availability of cloud free images and too much snow cover delayed delivery of crisis data.

The objectives of the satellite imagery received from the International Charter for Major Disasters were as follows:

1. To provide information on damage assessment as a result of the 6th April 2004 earthquake through the use of satellite imagery,
2. To show the extent and impact of the earthquake on lives and properties,
3. To inform the key players of disaster management in Afghanistan, the Government of the Transitional Islamic Republic of Afghanistan and the humanitarian community of the role of the International Charter,
4. To educate key players of disaster management in Afghanistan, the Government of the Transitional Islamic Republic of Afghanistan and the humanitarian community of the potentials of satellite imagery in damage assessment,
5. Provide a decision support system for Government Authorities and the Humanitarian Agencies in addressing rescue, relief, rehabilitation, reconstruction and mitigation.

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[1] The International Charter for Major Disasters

[2] Afghanistan Information Management Service (AIMS) is a United Nations Development Program (UNDP) project building information management capacity in Government Institutions in Afghanistan.

The methodology used is shown in figure 1.

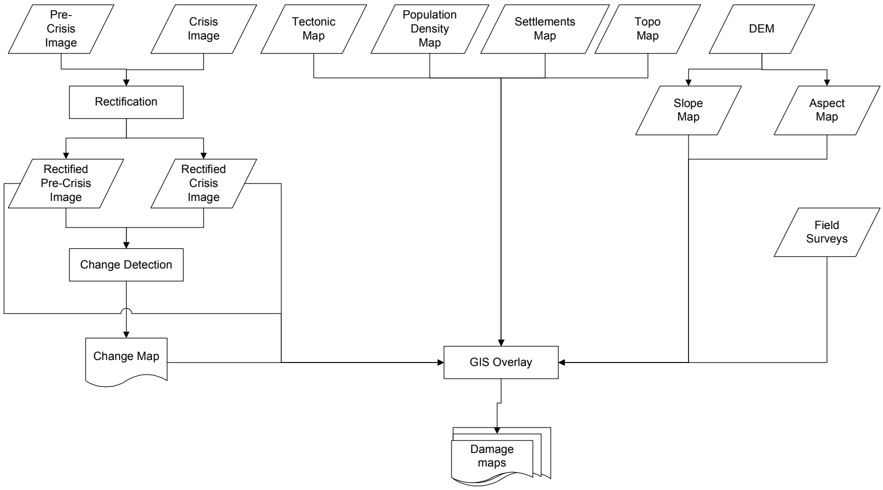

Fig. 1. Schematic representation of the methodology

Using ERDAS IMAGINE 8.4, both pre and post earthquake images (crisis data) were pre-processed, rectified and a change detection map derived. In ArcView GIS 3.2a, the change detection map, and the pre, and post earthquake images were each overlaid with the following GIS layers; major fault lines, population density, settlements, Topographic datasets (1:50K), Slope and Aspect maps to produce damage assessment maps.

2 Results

Table 1 shows that since 2000, about 9 major earthquakes have occurred in Afghanistan, of which 8 occurred in the northeast of the country. The most disastrous earthquake was in March 2002 where about 1000 people were killed and over 35,000 affected.

Table 2 shows the turn around time in the delivery of satellite image following the request for data. Table 2 shows a considerable delay in the delivery of satellite imagery particularly the crisis data after the occurrence of the earthquake (05/04/04) and the request of the imagery from the International Charter. The delay in delivery imagery consequently resulted in the late delivery of processed value added disaster damage maps for decision-making.

Image analysis and interpretation of both pre and crisis data did not show observable features of damages. Change detection performed also did not reveal any structural change. The change maps overlaid with the other GIS layers such as Major Fault Lines (1:6,000,000), Slope and Aspect Maps generated from DEM (90 x 90m), Topographic dataset (1:50,000), Settlements, Population Density, and ground surveys produced a number of value added products.

The damage assessment maps were widely distributed and used by the humanitarian community for decision-making relating to planning of relief assistance.

No.	Date	Scale (Richter)	Killed	Affected	Total Affected	Lat.	Long.
1	19/01/00	6.3				36.2	70.4
2	25/02/01	6.1				36.4	70.9
3	01/06/01	4.9	4	0	270	35.1	69.38
4	03/03/02	7.2	150	3,500	3,500	36.543	70.424
5	25/03/02	6	1,000	35,000	35,200	36.011	69.371
6	12/04/02	5.8	65	6,000	6,150	35.88	69.25
7	29/03/03	5.9	1			35.976	70.585
8	05/04/04	6.6	3			36.512	71.029
9	10/08/04	6				36.456	70.775
	TOTAL		**1,223**	**44,500**	**45,120**		

Table 1. Earthquake Statistics, 2000-2004
Source: (http://earthquake.usgs.gov/activity/past.html)

Disaster damage maps overlaid with major fault lines (Figure 2) and slope maps proved valuable inputs to the development of disaster management plans ranging from national plans to sub-national levels particularly in an earthquake prone country. 50 Km Buffer analyses (Figure 3) showed less densely populated settlements, which according to reports from the limited ground surveys were barely affected by the earthquake. Lack of baseline data makes comparability of damage assessment maps to pre-disaster phase extremely difficult except if local knowledge and ground truthing is used for validation. Change detection analysis (Figures 4 and 5) of images taken in 2003 and those taken few days after the earthquake of 6 April 2004 showed little or no structural changes.

The mountainous and rugged terrain makes most areas inaccessible except by Donkeys, which might take weeks to get there. Due to its vantage position, EOS provided crucial data, which would have taken quite a while due to the inaccessibility of the areas to vehicles.

Data Type	Imagery	Specification	Date Image Taken	Receipt Date by AIMS
Pre-crisis	SPOT	HRG 2 (12000 by 12000) 5m, level 1 A processing	18/10/03	9-Apr-04
Pre-crisis	SAC	MS Image – 120 m Resolution	6/10/01	15/04/04
Pre-crisis	SAC	Pan Image – 35 m Resolution	6/10/01	15/04/04
Pre-crisis	IRS-P6	LISS-3 Medium Resolution MS 24m	26/03/04	15/04/04
Crisis	IRS-P6	LISS-4 High Resolution 5m, PAN	14/04/04	16/04/04
Crisis	IRS-P6	LISS-4 High Resolution 5m, PAN	14/04/04	16/04/04
Crisis	SPOT	HRG 1 PAN (24000 by 24000) 2.5m, level 1 A processing	17/04/04	21/04/04
Crisis	SPOT	HRG 1 MS (Image Corrupt)	17/04/04	21/04/04

Table 2. Data turn around time

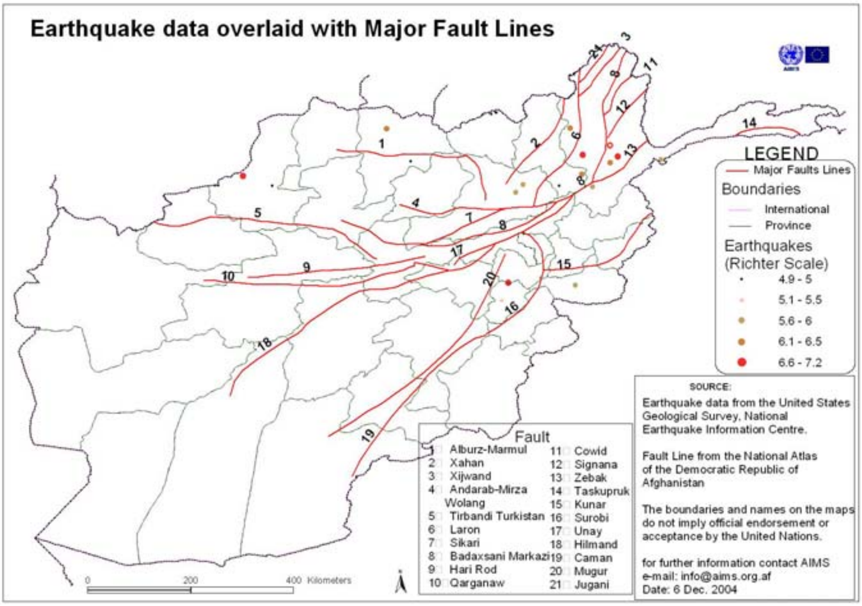

Fig. 2. Major Fault Lines overlaid with USGS Earthquake Data

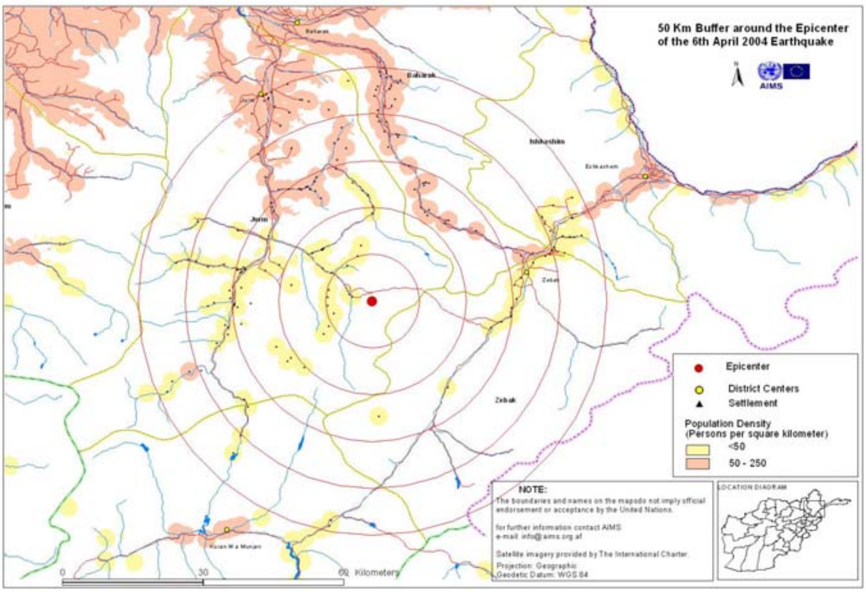

Fig. 3. Settlements within 50 Km Buffer around the Epicenter of the 6 April 2004 Earthquake

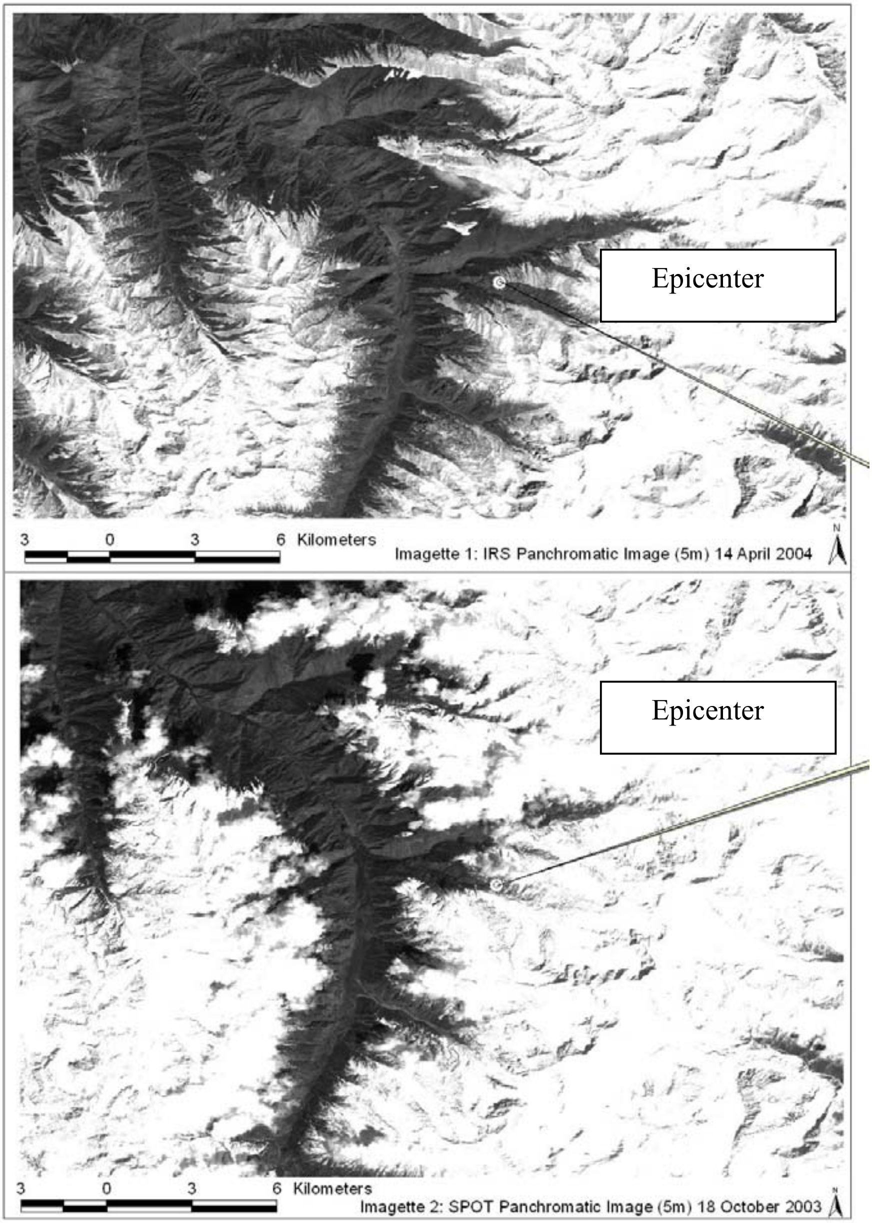

Fig. 4. Change detection between SPOT image taken in 2003 and IRS image taken on 14 April 2004

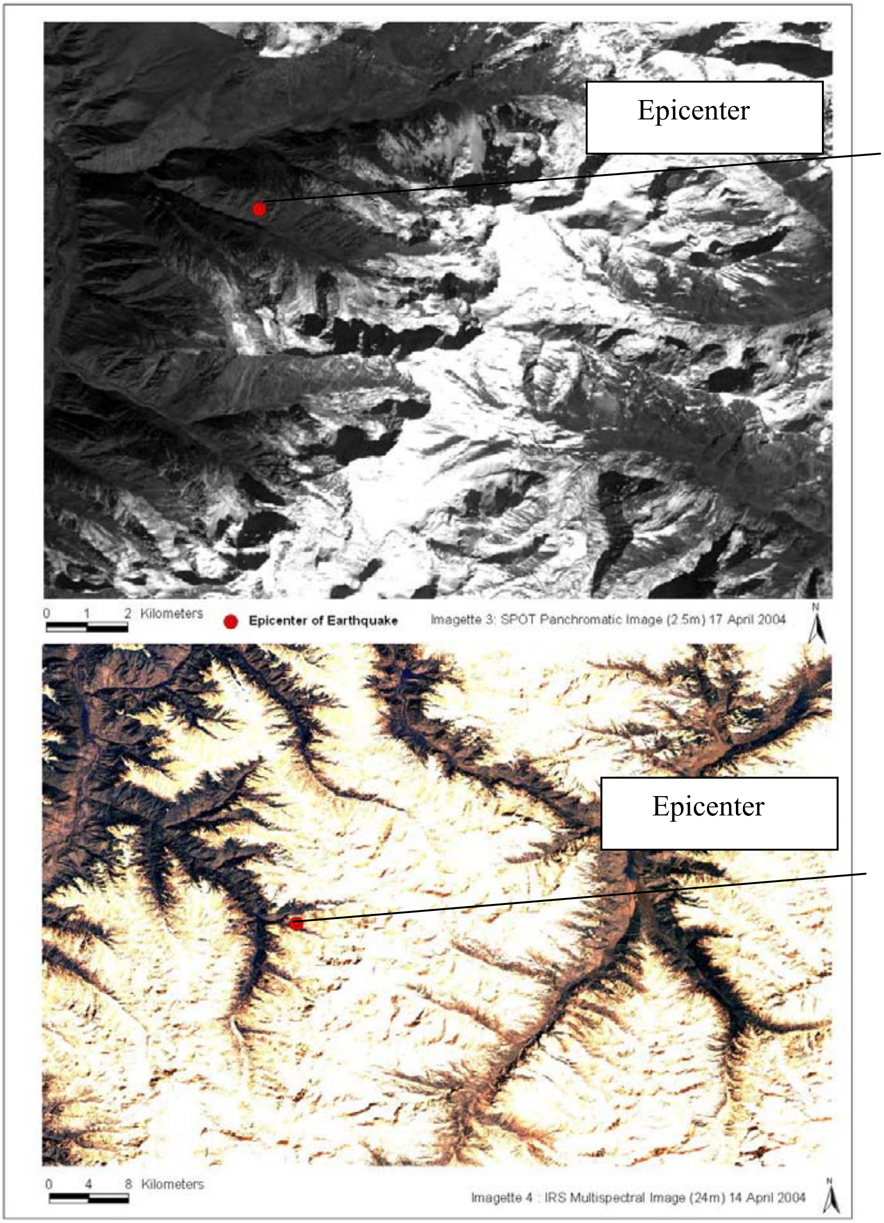

Fig. 5. Spatial variability between SPOT Pan and IRS Multispectral

3 Conclusion

Though there has been a remarkable improvement in the turn around time in delivery of space data, there are still notable delays in image data acquisition and delivery particularly due to problems of availability of cloud free images and too much snow cover. Most disaster management authorities in developing countries lack the infrastructure to access, process and deliver operational products. Lack of near real time data to monitor, assess and map the extent and impact of natural disasters has also hampered disaster management authorities in responding in a timely manner. The spatial and temporal resolution of the imagery provided by the Charter makes it difficult to monitor and assess the damage if the earthquake occurred in a built-up area with high population density.

Availability and access to space technology in addressing natural disasters has been the main obstacles facing developing countries particularly those poor countries without their own space programs. This problem has been solved through the introduction of The International Charter. Knowledge about the Charter is not common knowledge in most developing countries; there is need for a massive awareness campaign to educate decision makers about the Charter and the potentials of using space technology in addressing problems relating to disaster management. The skills to process satellite imagery and integrate it with GIS are lacking in most developing countries; there is need to embark on a massive capacity building exercise to ensure optimization of the benefits of the technology. The needs of the users are varied, and most often the users themselves do not know what they want. Data and information providers, and disseminators need to be fully aware of user requirements when space technology based applications are developed.

It is often assumed that disaster reduction information once acquired would be disseminated to the affected communities and the operational decision makers. A simple mechanism should be designed to ensure that information based on the needs of the users at the various levels is disseminated in a timely manner.

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