ASSESSMENT OF GEO-INFORMATION UTILISATION AT THE TSUNAMI AFFECTED AREAS IN ACEH AND NIAS, INDONESIA

Rizqi Abdulharis (1), D.M. Hakim (2), Ahmad Riqqi (2) and Sisi Zlatanova (3)

(1) MSc Geomatics, Delft University of Technology
The Netherlands
(2) Department of Geodetic Engineering, Bandung Institute of Technology
Indonesia
(3) Section GIS Technology, OTB Research Institute for Housing, Urban and Mobility Studies, Delft University of Technology
The Netherlands

ABSTRACT

On December 26, 2004, up to 30 m high tsunami waves wiped coastline of Aceh and Nias. According to National Development Planning Agency of Republic Indonesia (2005), the death toll has reached 128.515 in 15 municipalities in Aceh and 130 in Nias.

It has been thirteen months after the catastrophe. Unfortunately, the progress of emergency relief process in Aceh and Nias is not as good as it was expected. Many measures have to be taken and one of them is related to the use of geo-information. This paper will assess the disaster management in Indonesia from geo-information point of view. Having identified current obstacles and challenges disaster management sectors faces, this paper suggests an improved utilization of geo-information at post-disaster area.

1. INTRODUCTION

On December 26, 2004, up to 30 metres high tsunami waves wiped coastline of Aceh and Nias, Indonesia, as well as several other South-east Asia countries. It was reported that tsunami waves travelled at an initial speed of 700-800 km/h and reached the shores of Aceh and Nias within 10-15 minutes.

According to National Development Planning Agency of Republic of Indonesia, until April 30, 2005, the death toll has reached 128.515 in 15 municipalities in Aceh and 130 in Nias (2005). At the same moment, it was recorded that 37.083 citizens of 15 municipalities in Aceh were still missing. The estimation of total impact of the catastrophe is IDR 41.4 trillion (approximately equal to € 3.5 billion), which is including damaged assets as much as IDR 27.2 trillion (equal to € 2.3 billion) and losses in the future flow of economy as much as IDR 14.2 trillion (equal to € 1.2 billion).

It has been thirteen months since the catastrophe. The Indonesian government together with inter- and national organisation have been working on the emergency relief, rehabilitation and reconstruction of tsunami affected areas in Aceh and Nias. Unfortunately, the progress of emergency relief process in Aceh and Nias is not as good as it was expected before. This paper will assess the measures taken during the disaster management from the geo-information point of view.

There were numerous activities on tsunami response and relief processes in Aceh and Nias. However, there are still lots of actions to be taken. This paper is going to discuss these issues in five sections. The next section 2 provides a broader introduction on the role of geo-information in disaster management. Section 3 analyses the specifics of geo-information use in the affected areas in Indonesia and summarizes on recognised problems and bottlenecks. Section 4 addresses the future (better) use of geo-information in emergency relief, rehabilitation and reconstruction stages. Finally, Section 5 brings together concluding remarks on the required developments toward ISDI, able to respond to disaster management.

2. THE ROLE OF GEO-INFORMATION IN DISASTER MANAGEMENT

Worldwide the interest in geo-information increases. Almost every month in 2005 there were conferences or activities (Gi4DM, Delft; Bentley Research Seminar, Baltimore; GISplanet, Lisbon; Disaster across Continents, Toronto, etc.) appealing for strengthening the role of geo-information *(Abdulharis et al., 2005)*.

Geo-information (from maps to advanced simulations) has been always used in all the phases of disaster management. In such systems, most of the important data and information necessary are spatially related and therefore a GIS component in such a support system becomes of special relevance. Systems to support decision makers in the phases mitigation, preparedness and recovery are in widely use. For example, GIS based flood simulations. Results of such simulations can be computed and further used to predict the risk and the potentially quantum of damages (mitigation). GIS-based simulation systems are also necessary to develop useful and realistic scenarios to be used in trainings (preparedness). In recovery phase, there is often a high public and political interest to see a situation before and after an emergency and to set priorities for the rebuilding.

According to (*Abdulharis et al.* 2005), there are two general factors that are challenging the use of geo-information in disaster management: the nature of the application and the status of geo-information. Disaster management and especially the crisis response are applications that pose high requirements due to very specific characteristics *(Abdulharis et al., 2005)*:

- Decision have to be taken fast, which requires rapid geo-information technology;
- Many actors are involved (rescue forces, decision makers at different levels, citizens) that must coordinate their activities;
- Decisions are taken under severe time and psychological pressure;
- Usually there is a lot of uncertainty (due to lack of timely information) that creates the need for ad hoc decision making often based on experience and intuition rather than information;
- External pressure (such as that of media) is extremely high, which affects work on all the teams;
- There are no criteria (at the moment) for estimation of the correctness of the taken steps and decision, assessment of the decision making process is done afterwards.

Geo-information is scattered in different organizations, systems, formats and applications, and usually is devoted to completely different tasks. It is often discussed that the real barriers for the use of geo-information in disaster management sector are difficulties in making data available, finding the most appropriate data and making systems cooperate *(Zlatanova, 2005)*. The lack of interoperability, due to proprietary standards and developments, delays systems to be connected and updated without massive investments, which are too expensive for many organisations. This results into islands of automation on dedicated tasks, unable to deliver intelligence to multi-user groups.

To which extend geo-information is used is tricky to measure and differs with respect to the different countries. We have selected 11 criteria to estimate the use of geo-information within the different phases in disaster management. These criteria are identified from the researches that illustrated its important roles in disaster management. The first criterion, publicity, is selected based on the nature of disaster management itself, which is to promote awareness of disaster. The second criterion, organisation involved, is based on awareness of the needs of policy and organisation to handle the disaster management *(see Sakulski, 2005).* The third criterion, as well as fourth, fifth, sixth and seventh criteria, is grouped under technical criteria within disaster management. These criteria is summarised from researches conducted by Shi and Zlatanova (2005), van Westen et al. (2005), Love (2005), Ambrosius et al. (2005), Kerle et al. (2005) and Miliarakis et al. (2005). The latter mentioned researches show the importance of simulation, risk analysis, prediction, data collection, visualisation and equipment for disaster management. The ninth and tenth criteria, system performance and rescue team performance, are selected because of the importance of these criteria for evaluation of performance of disaster management system and every component attached to it. As the one of purpose of disaster management is to build awareness and reduce fatality, therefore we include making plan to attack disaster as an important criterion on assessing the use of geo-information within disaster management. See Table 1 and Table 2 for assessment of use of geo-information in Netherlands and Indonesia.

Phases / Use of geo-information	Pro-activeness	Mitigation	Preparedness	Response	Recovery
1. Publicity	X	X	N	X	X
2. Organisations involved	X	X	X	X	X
3. Simulation	X	X	X	N	
4. Risk analysis	X	X		X	X
5. Prediction	X	X		N	
6. Data collection	X	X	N	N	X
7. Visualisation	X	X	X	X	X
8. Equipment			X	X	
9. System performance				N	X
10. Rescue team performance				N	N
11. Making plans to attack a disaster			X	X	

Table. 1: Use of geo-information within disaster management phases in the Netherlands. Notes: X = Implemented, N = Needed (Abdulharis et al., 2005)

Table 1 gives an estimation of the use of geo-information within disaster management phases in the Netherlands, which is comprised from the completed and on-going researches in the Netherlands. From Table 1, it is exposed that the number of systems for technical support in response phase is quite limited. Examples of systems are given in (*Neuvel and Zlatanova, 2006)*. On criterion of visualisation, geo-information experts in Netherlands have been able to generate visualisation of geo-information needed on every phase of disaster management. Table 1 also reveals that in some phases there has been a need on geo-information while geo-information still could not support the implementation within those phases.

Use of geo-information \ Phases	Pro-activeness	Mitigation	Preparedness	Response	Recovery
1. Publicity	N	N	N	X	X
2. Organisations involved	N	N	X	X	X
3. Simulation	N	N	N	N	
4. Risk analysis	N	N		N	X
5. Prediction	N	N		N	
6. Data collection	X	N	N	X	X
7. Visualisation	X	X	X	X	X
8. Equipment			X	N	X
9. System performance				N	X
10. Rescue team performance				N	N
11. Making plans to attack a disaster			X	X	

Table 2: Use of geo-information within disaster management phases in Indonesia.
Notes: X = Implemented, N = Needed

Completely different conclusions can be drawn in the case of Indonesia (Table 2). The use of geo-information is very limited in the first two stages, although many good products have been developed. Real implementations of these procedures almost do not exist. Within the response phase, the needs of utilisation of geo-information almost could not be fulfilled. The only phase that is supported by most of the criteria is recovery phase. However, the visualisation of geo-information within every disaster management phase could hopefully promote awareness on utilising geo-information within disaster management. The following sections concentrate on the use of geo-information during and after the Tsunami.

3. UTILISATION OF GEO-INFORMATION IN ACEH AND NIAS

Geo-information was widely used in the response stage and is still crucial for rehabilitation of the affected regions. Four months after the tsunami catastrophe, the Indonesian government published a five-year master plan for the rehabilitation and reconstruction of Aceh and Nias. According to National Development Planning Agency, the master plan of tsunami relief is divided into three stages as follows:

1. Emergency response stage (January 2005-March 2005): to rescue the surviving community members and to immediately fulfil their minimum basic needs. This stage is equivalent to response stage of disaster management;
2. Rehabilitation stage (April 2005-December 2006): to enhance public services to an acceptable level as well as to solve the various issues related to the legal aspect through settlement of rights of land and to the psychological aspects through the handling of

disaster victims' trauma. This stage is becoming a part of implementation of recovery stage of disaster management;

3. Reconstruction stage (July 2006-December 2009): to reconstruct areas and communities affected by disaster, either directly or indirectly. This stage could be said as the main part of recovery stage of disaster management.

Basically, utilisation of geo-information in Aceh and Nias within three stages of earthquake- and tsunami-relief in Aceh and Nias could be classified by the geo-information tools that are used. Geo-information tools that have been used and implemented in Aceh and Nias after the December 26 catastrophe are as follows:

1. Remote sensing. Satellite images have been used within activities as follows:
   a. Identification of parcel border and its owner at earthquake- and tsunami-affected areas, by using IKONOS images. This activity is a part of Community Driven Adjudication (CDA) programme, which is still on-going at this moment. This activity is employed at the earthquake and tsunami rehabilitation and reconstruction stage;
   b. Research on monitoring sea level by Radar Altimetry Database System (RADS), which is maintained by Delft University of Technology and NOAA *(see Ambrosius, 2005)*. In the future, his research could be employed within the response stage of disaster management, especially for the next generation of tsunami early warning system;
2. Geographical Information Systems (GIS). GIS technology has always been used by most of organisations that are in charge within earthquake and tsunami relief in Aceh and Nias, whether it is for internal or external use. Some of identified GIS applications are:
   a. GIS vendor ESRI has been working together with Ministry of Health of Republic of Indonesia to develop its information structures and identify strategic facilities and available resources by employing ArcPad *(see Jackson, 2005)*. This kind of GIS application would be very useful if it is employed on the recovery stage;
   b. Mercy Corps is successfully using GIS to analyse, inform and plan its programs throughout tsunami-shattered Aceh Province. Based on its GIS, Mercy Corps has produced 24 kind of thematic maps *(see Burks, Jr., 2005)*. This kind of GIS application is urgently needed on the response stage, as well as on the recovery stage. For example, Mercy Corps' GIS application includes database of tsunami survivors who are still living in the refuge camps, which will be very useful to publish the name of survivors, as well as approximate the number of survivors and death toll of the disaster;
   c. Tomorrow's Hope has employed remote sensing and GIS to build spatial database of Nias *(see Singapore Red Cross, 2006)*;
3. Global Positioning System (GPS). Up to now, GPS has been utilised for capturing information on land deformation caused by earthquake at the earthquake- and tsunami affected areas *(see Vigny, 2005)*. This application will be useful the create the earthquake and tsunami alarm in the future, which is a part of pro-activeness stage of disaster management;
4. Location Based Services (LBS). Geo Research Centre in Postdam, Germany, has established German-Indonesian Tsunami Early Warning System (GITEWS). This system could generate tsunami early warning via internet, e-mail and mobile text message *(see Deustche Welle, 2006)*. Early warning system is one of the most important application on pro-activeness stage of disaster management in order to minimise the fatality;

5. Land administration. During the rehabilitation and reconstruction of land administration in Aceh and Nias, geo-information has become the only means for establishing directives on spatial planning and land policy *(see National Development Planning Agency, 2005)*.

4. Lessons Learned for the Future

It has been thirteen month after the December 26 catastrophe. Geo-information that has been utilised is not only intending to accomplish tasks on emergency relief, as well as rehabilitation and reconstruction stage, but also to prepare the utilisation of geo-information in other stages of disaster management, such as pro-activeness, preparedness and mitigation.

Up to thirteenth month after the December 26 earthquake and tsunami, the utilisation of geo-information is seems to be progressing, from almost nothing at the end of emergency relief stage to almost completely employed at this moment. As it is mentioned at the beginning of this section, some flaws and lack of readiness during the beginning of earthquake and tsunami relief have been paid off. Table 3 portrays some of the implementations but unfortunately only after the Tsumani. Despite the progress, still there is a need for improved utilisation of geo-information in Aceh and Nias in order to achieve better management of disasters and more efficient dealing in the relief phase in the future.

Phases / Use of geo-information	Pro-activeness	Mitigation	Preparedness	Response	Recovery
Sea level monitoring	T	T			
Deformation monitoring	T	T			
Geological structure modelling		T			
Safe areas analysis		T			
Evacuation routes analysis			T	T	
Early warning system				T	
Refugees data collection				T	X
Fatalities data collection				T	X
Solving land administration disputes					X

Table 3: Utilisation of geo-information in Aceh and Nias.
Notes: X = Implemented, T = Implemented after the Tsunami

Having monitored the utilisation of geo-information at post-disaster area in Aceh and Nias, there are obstacles identified that slowed down the utilisation of geo-information in Aceh and Nias. The first obstacle on utilisation of geo-information identified only few hours after tsunami stroke was the availability and actuality of geo-information. The smallest scale of topographic map of Sumatra Island is 1:50.000. Those maps were outdated as its sources were aerial imagery from year 1970s. Satellite imagery was provided by international organisations shortly after the tsunami, but it could only help in portraying the damages. Indonesian Spatial Data Infrastructure (ISDI) is just starting to be developed, which is to say there were no means to facilitate sharing of geo-information at that moment. However, the initiative of Indonesian Remote Sensing and GIS (RSGIS) Forum on sharing spatial data of Aceh and Nias could at least overcomes the shortage of geo-information needed during earthquake and tsunami relief process in Aceh and Nias *(see Indonesian RSGIS Forum, 2005)*. It has been discussed in many sources that early warning systems could help significantly in reducing damages and saving human life. It is estimated that such systems would also require input from geo-specialists. The early warning systems are expected to become an inter-discipline research since it will include many parameters. Last but not least it was realised that the knowledge on geo-information was insufficient. There should be initiated actions to broaden familiarity to geo-information's roles for each person that is positioned in and/or dedicated to disaster management bodies.

5. CONCLUSIONS AND FURTHER RECOMMENDATION

Based on the analysis of geo-information use in the Tsunami disaster, we recommend several general directions for improvement through al the phases in disaster management.

In order to maximise the role of geo-information on every stage of disaster management, we recommend use of detail and up-to-date topographic map. Since there are still many sources of more detail and up-to-date geo-information, it is recommended to strengthen the foundation of National Spatial Data Infrastructure (NSDI) and include as much as possible the available source of geo-information. A good solution would be establishment of one institution to coordinate utilisation of geo-information before, while and after the disaster happened.

For Indonesia (being in an actively moving area), the deformation monitoring should be a non-stop process, a part of the pro-activeness stage of disaster management. Deformation monitoring not only could provide earthquake and tsunami alarm, but also provide alarm for other variation of disaster such as landslide and volcanic eruption.

Within the mitigation stage, much more research should be performed on the geological structure of the continents and effects of humankind activities to the nature. In advance identification of possible-to-happen disaster will off course help to minimise the fatality caused by disaster itself.

In preparedness stage requires more attention with respect to providing information of the safest area for salvation of diverse disaster. It is also recommended as well to create calculation of evacuation route to safe area of diverse disaster, either outdoor or indoor, and publish the information by the most understandable way.

During the response stage advanced new technologies should be employed for al different actors, i.e. citizens, rescue units in the affected areas, decision-makers, politicians, etc. The most appealing example of systems are early warning systems and LBS applications for different purposes, for example, to monitor number and name of refugees at the identified place or physical fatalities. Having updated information system in hand, the accurate information on the helps needed could be published as soon as possible after the disaster happened.

A special attention has to be paid on the land administration. In this respect, development of guidelines is urgently needed for handling land administration matters during recovery stage.

REFERENCES

Abdulharis, R., D.M. Hakim, A. Riqqi, and S. Zlatanova (2005): Geo-information as Disaster Management Tools in Aceh and Nias, Indonesia: a post-disaster area, Presented at Workshop of Tools for Emergencies and Disaster Management of 19th Conference EnviroInfo 2005, Brno, Czech Republic, Sept. 7-9, in: http://www.wsis.ethz.ch/8abdulharispaper.pdf.

Ambrosius, B., S. Scharroo, C. Vigny, E. Schrama, W. Simon (2005): The 26 December 2004 Sumatra Earthquake and Tsunami Seen by Satellite Altimeters and GPS, Presented in 1st International Symposium on Geo-information for Disaster Management, Delft, 21-23 Mar. 2005.

Deustche Welle (2005): Indonesia Imports German Tsunami Warning Model, in: http://www.dw-world.de/dw/article/0,2144,1475511,00.html (Accessed 24 Jan. 2006).

Burks, Jr., R.O (2005): Plotting a Better Future, in: http://www.mercycorps.org/countries/indonesia/1006(Accessed 24 Jan. 2006).

Indonesian Remote Sensing and Geographic Information Forum (2005): Workshop-2 of RSGIS Forum Initiative, 15 Feb. 2005, Jakarta, http://www.rsgisforum.net/cgi-bin/index.cgi?action=viewnews&id=128

Jackson, R. (2005): GIS proves invaluable in Boxing Day Tsunami Clean Up, in: http://www.computerworld.co.nz/news.nsf/ NL/98802D11D1EB99E4CC256FB500304638 (Accessed 24 Jan. 2006).

Kerle, N., R. Stekelenburg, F. Heuvel and B. Gorte (2005): Near-Real time Post-Disaster Damage Assessment with Airborne Oblique Video Data, Presented in 1st International Symposium on Geo-information for Disaster Management, Delft, 21-23 Mar. 2005.

Love, T.B. (2005): The Use of GIS Technologies within the NOAA Climate Prediction Center's FEWS-NET Program, Presented in 1st International Symposium on Geo-information for Disaster Management, Delft, 21-23 Mar. 2005.

Miliarakis, A., H. Al-Raweshidy and M. Stratakis (2005): LoBi-X: Location-Based, Bi-Directional, Information Exchange, over Wireless Networks, Presented in 1st International Symposium on Geo-information for Disaster Management, Delft, 21-23 Mar. 2005.

National Development Agency of Republic of Indonesia (2005): The Master Plan of Rehabilitation and Reconstruction of Aceh and Nias, Indonesia, Jakarta.

Neuvel, J. and S. Zlatanova (2006). The thin line between risk prevention and disaster response, accepted for UDMS, Aalborg, Denmark, 12 p.

Sakulski, D. (2005): Geo-information as an Integral Component of the National Disaster Hazard and Vulnerability "ATLAS", Presented in 1st International Symposium on Geo-information for Disaster Management, Delft, 21-23 Mar. 2005.

Shi, P. and S. Zlatanova (2005):Evacuation Route Calculation of Inner Buildings, Presented in 1st International Symposium on Geo-information for Disaster Management, Delft, 21-23 Mar. 2005.

Singapore Red Cross (2006): Tidal Waves Asia Fund: List of Tsunami Approved Projects, in: http://www.redcross.org.sg/tsunamirelief_projects_m.htm (Accessed 24 Jan. 2006).

Van Westen, C.J., B.K. Piya and J. Guragain (2005): Geo-information for Urban Risk Assessment in Developing Countries: the SLARIM Project, Presented in 1st International Symposium on Geo-information for Disaster Management, Delft, 21-23 Mar. 2005.

Vigny, C., Simons, W.J.F., S. Abu, R. Bamphenyu, C. Satirapod, N. Choosakul, C. Subarya, A. Socquet, K. Omar, H.Z. Abidin, B.A.C. Ambrosius (2005): Insight into the 2004 Sumatra-Andaman Earthquake from GPS Measurements in South-East Asia, Nature, 436, 14 July 2005, pp. 201-6.

Zlatanova, S (2005): Crisis design, Geospatial Today, May-June 2005, 4(1), pp. 30-36.

CVs of Authors

Rizqi Abdulharis is an MSc candidate on Geo-information Engineering and Land Management at Delft University of Technology, the Netherlands.

D.M. Hakim is an associate-professor at Department of Geodetic Engineering, Bandung Institute of Technology (Institut Teknologi Bandung/ITB).

Akhmad Riqqi is a lecturer and a PhD candidate at Department Geodetic Engineering, Bandung Institute of Technology (Institut Teknologi Bandung/ITB).

Sisi Zlatanova is an assistant-professor at the OTB Research Institute for Housing, Urban and Mobility Study at Delft University of Technology, the Netherlands.

Co-ordinates

Rizqi Abdulharis
MSc Geomatics
Delft University of Technology
Korvezeestraat 405
2628 DT Delft
The Netherlands
E-mail address : kiki_gis@yahoo.com
Website : www.geomatics.tudelft.nl

Dr.Ir. D.M. Hakim and MT Ir. Ahmad Riqqi
Department of Geodetic Engineering
Bandung Institute of Technology
Jl. Ganesha 10
40132, Bandung
Indonesia
E-mail address : dmhakim@gd.itb.ac.id
riqqi@gd.itb.ac.id

Dr.Dipl.-Eng, Sisi Zlatanova
Section GISt, OTB
Delft University of Technology
Jaffalaan 9
2628 BX Delft
The Netherlands
Telephone number : +31 15 2782714
Fax number : +31 15 278 2746
E-mail address : s.zlatanova@otb.tudelft.nl
Website : www.gdmc.nl