Collaborative Geospatial Infrastructure: 
A Coordinative Approach in Disaster Management

P. Santosa\textsuperscript{1}, I M. Arsana\textsuperscript{1}, L. Heliani\textsuperscript{1}, Subaryono \textsuperscript{1}, T. Muhammad\textsuperscript{1},
\{purnamabs, madeandi, lheliani, ssubar, triasaditya\}@ugm.ac.id

\textsuperscript{1}Department of Geodesy and Geomatic Engineering
Gadjah Mada University

Abstract

That geospatial data (i.e. maps depicting geo-referenced locations) are important in disaster management might be undeniable. Geospatial information is essentially required for both disaster prevention and preparedness. However, to what extent geospatial information has been effectively utilized remains a question.

Geospatial data may be available but there is usually no coordination in their utilization. Further more, it has been observed in Indonesia that infrastructure of geospatial resources at national and local levels are inaccessible. Consequently, parties concerned with disaster management initiate their own efforts on data collection, access, and dissemination in a sporadic way. In absence of a geospatial infrastructure, responsible agencies lack integrated decision supports to process incoming data and information into sound knowledge for actions.

These phenomena motivate a research toward the development of a collaborative geospatial infrastructure. The philosophy behind this research is how to establish a system that is accessible by parties concerned in disaster management in order to enhance coordination. Being in the early stage, this paper will further elaborate conceptual design of the said research. Design of research will be given including steps, collaborators involved, and the expected outcomes. This research is part of Hi-Link project in Gadjah Mada University, funded by JICA.

Keywords: disaster management, coordination, collaborative geospatial infrastructure

1. Introduction

With regard to geographic location, Indonesia might be unlucky as it is located in the "ring of fire" with many potential sources of natural disasters. An earthquake that shook Yogyakarta and Central Java on 27 may 2007 was an example of one of the most devastating disaster after the Aceh and North Sumatera Tsunami on 26 December 2004. In addition, a report from www.mapreport.com reveals that 10 occurrences of natural disaster have been recorded as per 19 July 2006 in the last six years. Knowing this condition, it is inevitable for Indonesia to seriously search for technologies to deal with natural disasters, both for prevention and post-disaster recovery.
It might be undeniable that geospatial data and technologies are important in disaster management. The California GIS Strategic Plan, for example, states that geographic location matters when it comes to meeting citizen needs. "Geospatial data can be used to strategically situate emergency services resources throughout the state, to track the status of these resources during large or multiple events, and to efficiently dispatch personnel and equipment where they are needed most" (CGISP, 2005). More specifically, geospatial data and technologies can provide significant contributions for disaster management teams in coping with the causes, the people and infrastructure affected from events such as earthquakes, tsunamis, volcanic eruptions, disease outbreaks or spills of hot mud.

From past disaster events, the nation has learned that the lack of coordination and collaboration between the agencies and relief teams could generate some inefficient actions in the field, including delays in aids deliveries, overlapping of health assistances, and failures to pass on the disaster alerts. It has been identified that ineffective utilization of geospatial data is one of the reasons behind this situation.

In fact, Geospatial data may be available but there is usually no coordination in their utilization. Further more, it has been observed in Indonesia that infrastructure of geospatial resources at national and local levels are inaccessible. Consequently, parties concerned with disaster management initiate their own efforts on data collection, access, and dissemination in a sporadic way. In absence of a geospatial infrastructure, responsible agencies lack integrated decision supports to process incoming data and information into sound knowledge for actions.

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2. The Roles of Geospatial Science and Technology in Disaster Management: Hopes and Challenges

Among many disciplines and technologies that can be applied, it has been proven that geomatics can be significantly utilized in disaster management. Many examples of applications have been carried out all around the world and many scientific and popular writings have been published by experts and activists. With regards to Jogjakarta and Central Java Earthquake, one of the most recent researches concerning the use of geomatic technology (i.e. GIS and Remote Sensing) was conducted by the Center for Environmental Remote Sensing (CEReS) in collaboration with the Department of Geodetic and Geomatic Engineering Gadjah Mada University, Bandung Institute of Technology, and the National Institute of Oceanography – India. The research’s aim is to do the inventory of damaged infrastructures in Yogyakarta in the aftermath of the earthquake on 27 May 2006. The research team collected and analyzed ground data, aerial photographs, and satellite images of the disaster prone area. The information collected, during field study, is used to establish the inventory of damaged structures (Sri Sumantyo et al., 2006).
For the same disaster, Arsana et al. (2006) introduced an activity called parcel-based mapping for building damage assessment. This mapping activity utilized parcel map of Land and Building Taxation Office (Pajak Bumi dan Bangunan, PBB) to map and assess condition of six categories of buildings in Purbayan Village, Yogyakarta after the earthquake. The authors claim that the use of parcel map can replace the utilization of Global Positioning System receiver for navigation and positioning.

Banerjee et al. (2003) states geomatics can be utilized for both disaster prevention and preparedness. The last includes disaster relief, rehabilitation and reconstruction. He elaborates that GIS is used to manage the large volume of data needed for the hazard and risk assessment in disaster prevention phase. Meanwhile, in disaster preparedness phase, GIS can be used as a tool for the planning of evacuation routes, design of centers for emergency operations, and integration of satellite data with other relevant data in the establishment of disaster warning systems. In a similar vein, Chiroiu et al. (2001) demonstrates the use of high-resolution satellite imagery for the earthquake damage assessment and confirms that multidisciplinary approach combining remote sensing techniques, spatial analysis and earthquake engineering enable people to quickly estimate physical loss due to natural disasters. The authors further explained that “the information can be integrated into a GIS database and transferred via satellite networks or Internet to the rescue teams deployed on the affected zone”. This information would be then received by the field operators in order to co-ordinate the emergency operations.

Another disaster-based tool used in pre-disaster management is Vulnerability Mapping, which helps in possible mapping of liquefaction prone areas. Successful uses of remote sensing data have been made for damage assessment in the case of the 1995 Kobe, Japan and the 1999 Kocaeli, Turkey earthquakes (Matsuoka et al., 2000 & Estrada et al., 2000 in Banerjee et al., 2003). Other researches utilizing geomatic technology for disaster management were as follow:

- The use of high resolution imagery for the analysis of impact due to the blast of Firework Company in Enschede, the Netherlands on 13 May 2000; and the use of aerial photographs coupled with the application of GIS for damage assessment in the aftermath of Quindio Earthquake on 25 January 1999 in Colombia (van Westen, 2001).
- The use of GIS and Artificial Neural Networks for flood prediction modeling (Santosa, 2005), and River flow prediction and floodplain mapping using GIS and Artificial Neural Networks (Santosa, 2006). These two researches tried to use GIS extensively for modeling flood prediction and to assess the possible areas caused by the flood disaster.
- The Development of a web-based GIS for earthquake information system in Turkey (Dogru et al., 2004).
- The application of GIS for damage and seismic intensity assessment in Lijian, China in 1996 (He, no year)

A web-based GIS is considered as one of geomatic applications that can contribute in disaster management enabling information dissemination.
through internet. Consequently, information could reach more readers in much wider geographical scope within a relatively short period of time.

Regardless of many example showing the roles of geospatial science and technology in disaster management, Goodchild (2005: 227-229) claims that in reality, things are still far from ideal. He has reviewed many Geographic Information and Technology (GI&T) applications worldwide\(^1\) and asserts that during initial response, at least, access to GI&T seems to be confused and ineffectual rather than smooth and efficient.

With regard to coordination, it seems that each party tends to work independently focusing on their own interest. The fact that there are many web-based Geographic Information Systems for Yogyakarta Earthquake produced by different institutions in Yogyakarta is one of evidences that there is lack of coordination in geospatial data management. This is evident since the information displayed by those different application systems usually are obtained from the same sources. It would have been better if there is a system to facilitate coordination among related parties in order to produce an application with better functionality and meet the needs of people more comprehensively. This is the reasons why this research is required.

3. **Research Plan**

It has to be admitted that this research in currently in an early stage; hence not many can be revealed in this paper concerning research results. It is a part of Hi-Link Program of Gadjah Mada University funded by Japan International Cooperation Agency (JICA). This research considers two fundamental problems that hinder effective coordinated work with geospatial information in disaster management activities for post-earthquake recovery and disaster preparedness.

First: Through geospatial infrastructure, various geospatial resources, comprising of geosensors in the field, geospatial databases, satellite images, statistics information, and maps managed by various agencies, can be functioned as useful decision supports to help agencies and relief teams in responding to a disaster. Unfortunately, such infrastructures at national and local levels are inaccessible or missing. As a result, in support of disaster responses planned, the agency and relief teams initiate their own efforts on data collection, access, and dissemination in sporadic way. As such, it is difficult to ensure that the disaster responses performed by those agencies and teams can be coordinated properly. Further, in absence of a geospatial infrastructure, responsible agencies lack integrated decision supports to process incoming data and information into sound knowledge for actions (e.g. processing information on tsunami warning into effective and efficient emergency actions).

Second: Most of geographic information systems are designed for personal work. Hence, to facilitate coordination and information access in response to a disaster, the organization and visualization of various geospatial resources for

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\(^1\) See for example
decision supports, ranging from large screen displays in a coordination center to PDAs for field personnel, are not yet solved.

To address those problems in an integrated way, and do so in the context of disaster management, therefore:

a. A cognitive systems engineering, in particular a scenario-based method is applied to gaining a deep understanding of group work and community awareness with geospatial information and technology in the context of disaster management.

b. The knowledge obtained is used to develop a novel approach in organizing location information, sensor measurements, thematic and statistic information distributed across the region into a local geospatial infrastructure.

c. The research will also be focused to develop a map-mediated decision-support system on top of the local geospatial infrastructure. The system will have an ability to synthesize reports, statistics, and real-time earth phenomena (e.g. location, coordinates, geosensor measurements) on top of thematic maps. The system can be seen as a Virtual Coordination Center and is aimed at facilitating coordination, information access, and knowledge exchanges between the agency collaborators and the local community in the context of disaster management in the Jogjakarta region.

d. The simulation of the collaborative use of that Virtual Coordination Center in a specific disaster scenario will also be evaluated. This simulation, aimed at improving coordination and cooperation between agencies and the local community in disaster management, will involve the agency collaborators and the local community (including non governmental organizations).

To achieve the above objective, collaboration is essentially required among competent parties. This research is planned to be conducted in collaboration with Local Information Agency, Jogjakarta Province Office; Local Meteorological & Geophysics Agency, Jogjakarta Province Office; and PT. Almega Sejahtera (industry collaborator). These collaborators are expected to provide data/information and assisting hardware for the research.

4. Expected Results

The expected final results of this research is a Web based GIS to facilitate coordination among groups involved in the disaster management activities. It is also purposed to help disaster preparedness tasks and response actions to disaster. For this purpose, spatial and non spatial database would be built in the system necessary to develop geospatial infrastructure. The use of built geospatial infrastructure would be useful and valuable means to facilitate disaster management activities among groups of people.

5. Concluding Remarks

As previously mentioned, this research is currently in an early stage. No specific result can be provided in this paper. Its presentation in PUDSEA conference is also aimed at obtaining input and suggestion to give better direction
of this research. It has to be noted that geospatial science and technologies are undoubtedly essential in disaster management. Unfortunately, it has also been indicative that the utilization of geospatial technology and product faces difficulties. This, consequently, result in lack of coordination among parties with interest to the availability of those data/technology. These are reasons on top of which the idea of this research was built.

6. References
CGISP (2005), California GIS Strategic Plan, accessed on 7 November 2006 at 7 pm from http://gio.ca.gov/docs/GTC_W_05_Ellison_GIS_Plan.pdf