Making Sense of Local Spatial Data Infrastructure in Volcanic Disaster Risk Management; A Case Study at Sleman Regency, Indonesia

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Abstract

The Sleman local government conducts a risk management program for the Merapi Volcano to minimize damages and casualties in case of an eruption. This program uses spatial data technologies to enhance decision making and enable coordination of the risk management activities. The current situation is that spatial data are sporadically available, and data integration, sharing and effective use by decision makers within Sleman government agencies is not optimal. This research aimed to design and test an application to support a Local Spatial Data Infrastructure (SDI) for risk management efforts, with a particular emphasis on evacuation planning in case of a Merapi Volcano disaster. One of the essential applications of this local SDI was the design of a geoportal. The design of this portal followed a number of steps. The first step involved a review on the activities needed in managing risks of the Merapi Volcano, and the associated spatial data needed. The next step was to examine the processes, problems, and information flows in evacuation planning. These prerequisites were used as foundation for the development of the application. The initial version of the proposed Geocollaboration Portal was customized in order to facilitate decision makers to coordinate and share updates and information on top of the portal's map when dealing with the evacuation process. This customization consisted of equipping the portal with usable map presentations and interaction tools to support the collaborative decisions in volcanic disaster management. The final step consisted of a user group assessment to evaluate the usability of the application. The evaluation of this assessment showed that the collaborative portal on top of a local SDI could improve the agencies' coordination and decision-making processes in the context of disaster preparedness and mitigation. The result shows the potential use of geocollaboration portals in support of the development of spatially enabled societies.

Keywords: Merapi Volcano, local SDI, risk management, evacuation planning, geoportal.

1. INTRODUCTION

Merapi Volcano, located at subduction zone between the Eurasian and Indo-Australian plates, is a constant threat to its surroundings. The International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) in 1994 has declared Merapi as one of The Decade Volcano due to the fact it has erupted more than 80 times and killed thousands of people. Merapi flanks are also home of dense population in Central Java Province and Special Region of Yogyakarta. Therefore disaster risk management of Merapi Volcano is indispensable to protect the endangered population. Sleman Regency as the nearest region that will affected by Merapi's threat, needs to optimize all data and information available to develop the disaster risk management.

The potential utilization of spatial data technologies for disaster management activities has been addressed both from academic and professional perspectives (see e.g., van Westen and Georgiadou, 2001; Mansor et al., 2004). Currently, local and national agencies in Indonesia already link some spatial data with statistical and social data, to construct hazard identification, preparation and mitigation plans, response actions and also reconstruction programs. However, to conduct a proper Merapi volcanic risk management, the local government of Sleman Regency requires instant spatial data access from various national agencies simultaneously, including the Vulcanological Survey of Indonesia (VSI) and National Coordinating Agency for Survey and Mapping (Bakosurtanal)) in developing a disaster risk map of Merapi Volcano. This access to basic spatial data should typically be accompanied with thematic data, collected by local agencies (such as Housing, Infrastructure and Transportation Agency, Health Agency or Local Planning Agency). The combination of such data helps for example in the determination of the evacuation routes or refuges relocation plan. Accessing data from different stakeholders (including Non-governmental Organizations (NGOs)) at different levels of authority requires, however, coordination.

Unfortunately, in the Indonesian disaster management context the coordination of both stakeholders and data is problematic. Many of the available data are seldomly used, even if they were available, while many of the required data do not exist. One explanation for this situation is that the data are not yet standardized, which by definition makes coordination problematic (Kompas, 2005). If each agency collects the required data with their own specifications and codifications, data sharing and integration of different spatial data produced by agencies cannot be realized. Consequently, the spatial data potential for disaster management is underused.

One advocated solution strategy to improve stakeholder coordination is fostering the establishment of a Spatial Data Infrastructure (SDI), as proposed by Mansourian et al. (2006) and Aditya (2008). Such an SDI would facilitate access and distribution of spatial data among local agencies and could potentially improve utilization of spatial data for developing spatially enabled societies at a local level including in the context of disaster management. A crucial part of such an SDI involves the interface to spatial data and spatial data exchange for all stakeholders before, during and after the disaster. This study encapsulates a full design study. This starts by an exploration of how the design would fit in an overall local SDI strategy. After this general technical specification, follows a context specification based on requirements from a disaster management perspective. Based on the evaluated user requirements we then present the specifications for the actual portal, and the resulting design. We conclude by an evaluation of the design with stakeholders, and a number of general observations how the design could be improved.

2. THEORETICAL GROUNDING IN SDI CONCEPTS

SDI as a concept to support coordination is rooted in relatively recent conceptualizations of SDIs. An SDI constitutes of a *set of political, technological, and institutional frameworks to facilitate spatial data availability, access, and utilization* (Nebert, 2004), or the '*metadata, spatial data sets and spatial data services; network services and technologies; agreements on sharing, access and use; and coordination and monitoring mechanisms, processes and procedures* (European Parliament, 2007).

SDIs provide a basis for spatial data discovery, evaluation, and application for all different organization levels (e.g. regional, national, or local level). SDI developments range from local to state/provincial, national, and international regional levels, to a global level (Groot and McLaughin, 2000; Masser, 2005). Most SDI coordination activities were initiated by national mapping agencies (Crompvoets et al., 2004). Originally, the emphasis was on linking large volumes of data at national scales. However, bottom-up SDI coordination activities involved also accommodating the richness of local GIS applications (Yan, 2005; Nedovic-Budic et al., 2004; Muller and von St. Vith, 2009).

2.1 Portals as technical component of SDIs

One of the key elements of SDI coordination is the presence of a geoportal, also known as geospatial portal. It provides access to spatial content together with the metadata. A portal enables users to easily find spatial data which they need. The content of such a portal includes offline data and OGC web services such as Web Map Services (WMS), Web Feature Services (WFS), and Web Coverage Services (WCS). One of the key features of geoportal is the ability to support data exchange and sharing between institutions via the internet (Maguire and Longley, 2005). Therefore redundant data acquisition can be prevented and coordination of efforts in collecting data can be enhanced.

In addition to improving the accessibility of a large variety of geospatial resources, geoportal also facilitate geocollaboration since it can be used in a group of user. Geocollaboration portal enables a single user to interact with other users and exchange spatial information within a group work activities. The data and information provided in such portal are more focused to support discussion and sharing to respond to a particular activity of decision making process, including capability for creating annotations of geospatial features in the maps (Aditya and Kraak, 2009).

In the context of disaster management, previous studies found that SDI strategies can be utilized to reduce time wasted in data collection and to make data integration for the purpose of decision making in flood management more efficient (O'Donnell and Birnbaum, 2005), earthquake response (Mansourian et al. 2006), hazard characterizations and vulnerability assessment (Asante et al., 2006). Utilization of a geoportal for disaster management has been identified for enhancing community preparedness and distributed collaboration among local government agencies (Aditya, 2008) as well as tools for discovery, visualization and access to data related to disaster risk contained by different national organizations (Molina et al., 2008).

2.2 Translating the Merapi Volcanic Risk Management activities into SDI portal requirements

The fact that the Sleman Regency is one of the closest regions to the Merapi Volcano has made the local government painfully aware of the need to develop a risk management strategy urgently. Furthermore, such a strategy should make the most use of the technical possibilities of data management. The activities of Merapi volcanic risk management at Sleman Regency can be classified based on disaster management taxonomy, which classifies disaster management into risk assessment, mitigation, and preparedness.

In terms of risk assessment, the activity of mapping the hazards of the Merapi Volcano has been conducted by VSI as the authorities on monitoring and analyzing Merapi Volcano movement. This national agency had started to compose the map since 1978 based on extensive research and assessment of Merapi's hazards. The most recent hazards map was published in 2002 at scale 1:50,000. The hazards map was based on geomorphology, geology, eruption history, distribution of previous eruption products and additional field studies. The map detailed the types of volcanic hazards in Central Java and the Yogyakarta Special Province. The local government of the Sleman Regency has made use of the hazard map to identify villages and sub-villages prone to volcanic disaster and to employ this as a basis to compile the risk map. Information on hazard area has been used to determine the location of evacuation barracks, or to select which village would be appropriate for capacity improvement programs such as evacuation drill or Search and Rescue (SAR) team training.

The mitigation efforts consist of structural and non-structural mitigation. Structural mitigation refers to any physical construction to reduce or avoid possible impacts of Merapi volcanic hazards. It includes construction of bunkers, evacuation barracks, evacuation roads and development of Early Warning System (EWS). Non-structural mitigation related to other non-physical measures with the aim of modifying the impacts of Merapi volcanic hazards on individuals and the community. Efforts of the non-structural mitigation are formulation of the regulation for Merapi Volcano disaster management, formation of standard operating procedure for emergency response, and establishment of the contingency plan.

One of the key mitigation efforts is the evacuation planning. This refers to the activity of arranging the villagers living in the danger zone in order to locate them to a safer location. In terms of the possible Merapi Volcano disasters, the Sleman Government includes the arrangement of evacuation in the contingency plan. Evacuation planning is organized for villages and sub-villages at Pakem, Cangkringan, and Turi sub-district which have been determined as highest risk area according to the risk map of Merapi Volcano. The planning aims to minimize casualties and to prepare facilities and infrastructures needed in the evacuation process.

Even though the local act of Sleman Regency No. 83/Kep.KDH/A/2006 had described a detailed operation procedure for the evacuation process, in reality, experience from the 2006 eruptions had revealed some common hindrances. The allocation of medical services in evacuation barracks was still inadequate, as many of the evacuees did not receive gas mask to prevent inhaling volcanic ashes. Consequently, some of the inhabitants were confronted with respiratory infections (Kedaulatan Rakyat, 2006). Another issue which emerged was related with the condition of the evacuation roads (Tupai, 2006). Immediate identification of damaged and impassable roads was essential as an input for the local authorities to perform appropriate reparation or maintenance. Moreover, there was a problem regarding livestock of the villagers. Many of the villagers returned to their villages during evacuation phase, because they were worried that their livestock and crops would be vulnerable to theft (Anonymous, 2006). The local government was required to determine places and strategies to relocate these cattle in retrospect.

Preparedness efforts related to raising public awareness regarding the risk of Merapi Volcano were undertaken. The local government conducted workshop or discussion group as one of the methods to make the community understand the Merapi volcanic hazards, and to inform how they should anticipate and prepare for the disaster. Another method was through performing evacuation drills, which involved the community, local government agencies, NGOs and volunteers. This aimed at making people lived through the emergency situation so they would be ready to anticipate the danger. One last essential effort regarding the preparedness is formulation of the Community Emergency Response (CER). This intends to activate community participation in order to develop proper response during emergency situation.

3. METHODOLOGY

This research investigates problems in accessing, sharing and integrating spatial data at local government. Moreover, it looks at the possibility of a local SDI to facilitate data provision and sharing to be used in Merapi volcanic risk management activities, particularly the evacuation planning. For this purpose, interview, questionnaire surveys and field survey were conducted. First primary data collection was done by interviewing officials at local government agencies to gather information about existence of a local SDI at Sleman Regency. In addition, a questionnaire survey to 15 selected institutions was established to identify user requirements. Those two activities are supported by secondary data collection through collecting reports, products and documentations from the local government institutions. Subsequently, a prototype of a geoportal to support the evacuation planning was developed as well as user group assessment to evaluate the prototype.

3.1 User Requirements

The questionnaire responses revealed the requirements of the users, needed to design an application for evacuation planning of Merapi Volcano disaster. These requirements referred to the spatial data for evacuation planning and the geospatial web services required in the application. According to the respondents there were at least six data types needed by the local agencies in the process of making evacuation plan. Table 1 lists these data types.

Table 1: Requirement of spatial data for evacuation planning

Spatial data theme	Attributes	Data provider
Evacuation roads	name, location, length	Dinas P3BA (Local agency for disaster management)
Evacuation barracks	name, location, size, capacity, facility, condition	Dinas P3BA (Local agency for disaster management)
Health facilities	type, name, location	Dinas Kesehatan (Health Agency)
Village administrative map	name, extent, boundary	Bappeda (Planning Agency)
Volcanic hazard map of Merapi Volcano	hazard area, hazard types	BPPTK (Agency for Volcano Research & Technological Development)
Population in the hazard zones	number of population, households, man, women, children, disabled people, pregnant women, elderly	Bappeda (Planning Agency)

From hereon Dinas P3BA, Dinas Kesehatan, and Bappeda will be used to refer to Local agency for disaster management, Health Agency, and Planning Agency in the Sleman Regency. On the topic of geospatial web services, most of the respondents expressed that the prototype should provide a facility where users could discover information. They also indicated to have map visualization possibilities in the prototype. They furthermore believed that using satellite images was easier to understand than vector-based maps. In addition, about 90% expected to have a service which offers the possibility to interact with the map. All of the participants agreed that the spatial data in the prototype should be available via internet and/or intranet.

In addition to the prerequisites resulting from questionnaire surveys, there were additional requirements in terms of information sources and needs during evacuation process. Examining the standard operation procedure of emergency response and analyzing relevant documents (such as the contingency plan and mitigation reports) helped to determine information sharing requirements. The focus was on four local agencies only; those considered the most significant in the evacuation planning. The resulting information needs can be distinguished by three phases i.e. pre, during and post evacuation as described in Table 2.

In the pre-evacuation phase, it is clear that the four agencies require information concerning the alert level from VSI. Information provided by one agency can be used in this case as a basis to perform subsequent actions by another agency. For example, the Dinas P3BA has data about the number of evacuees in evacuation barracks, which they can deploy to the Dinas Kesehatan, who can then determine how much medical equipment and personnel should be delivered.

Table 2: Information needs in evacuation process

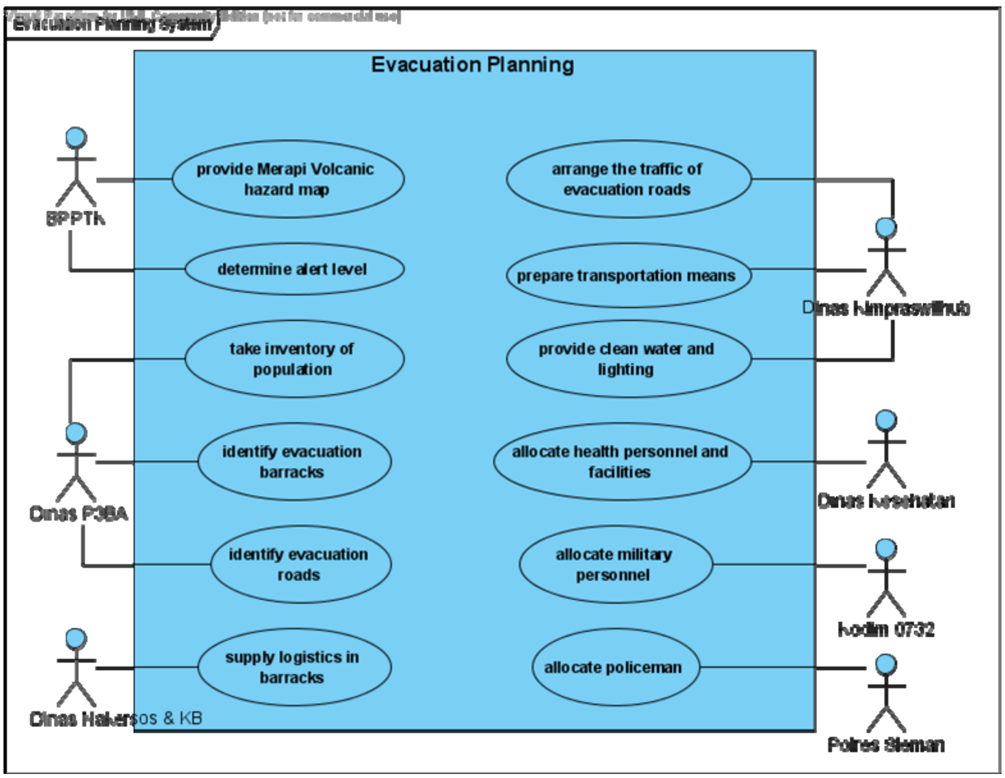
Institution	Pre-Evacuation	During Evacuation	Post-Evacuation
Dinas P3BA	- hazard zones - notification of alert level from VSI - susceptible population - village map - evacuation roads condition - available resources in the village - available facilities in evacuation barracks	- number of people evacuated in barracks - number of injured people	- damaged area/villages - number of missing people
Dinas Kimpraswilhub	- notification of alert level from VSI - evacuation roads condition - alternative routes - susceptible population number - available transportation means - location of evacuation barracks	- traffic flow of the vehicles - supply of the water	- damaged roads affected by the eruptions and cost estimation - available transportation means to return the evacuees
Dinas Kesehatan	- notification of alert level from VSI - susceptible population number - location of evacuation barracks - condition of health facilities and infrastructure - available medical team (doctors, nurses, midwife)	- number of people evacuated in barracks - number of injured people - supply of medicines	- number of injured people who need more treatment
Dinas Nakersos & KB	- notification of alert level from VSI - susceptible population number - location of evacuation barracks - potential location of public kitchen	- number of people evacuated in barracks - logistics supply (food, blanket, mattress, etc)	- logistics remains in the warehouse

3.2 Design of The Prototype

The requirements were represented in a visual model using Unified Modeling Language (UML). UML helps to achieve an effective communication between system developers and the users. There are two types of UML diagrams used in designing an application for evacuation planning i.e. use case diagram and sequence diagram.

A use case diagram enables the system designer to discover the requirements of the target system from the user's perspective (Tsang et al., 2005). Therefore the data collected during the fieldwork supported the creation of a use case diagram. This diagram describes which actors are involved and which actors have which roles in evacuation planning. The use case diagram in Figure 1 identifies seven institutions with significant functions. This model was used as the basis to determine the users who will operate the prototype.

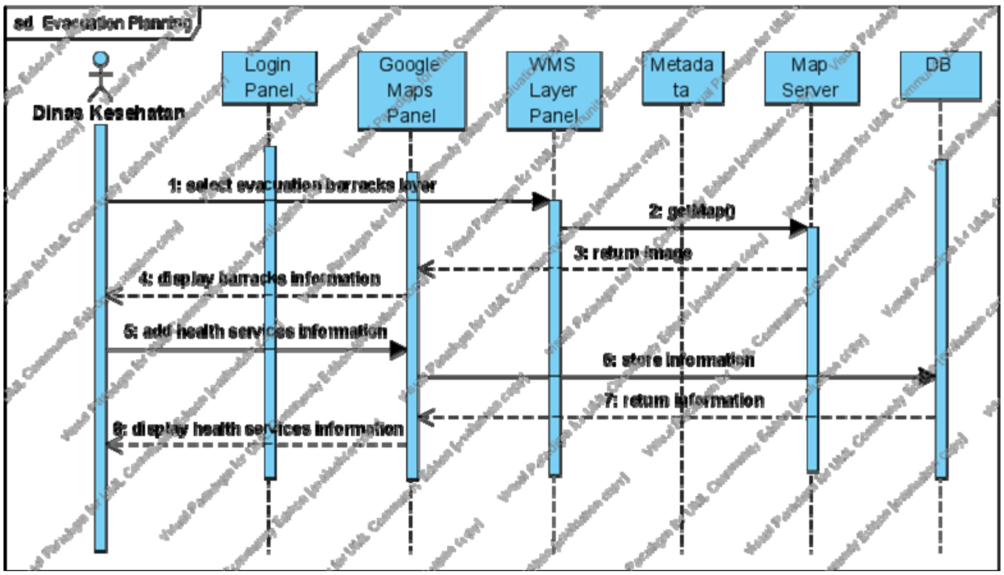
Figure 1: Use case diagram of the evacuation planning system



Secondly, a UML sequence diagram is created to show the interaction of messages between objects in the prototype. This diagram has two dimensions: the vertical dimension and the horizontal dimension, respectively representing the passage of time and the objects involved in the interaction. The sequence diagram represents six main objects, namely: Login Panel, Google Maps Panel, WMS Layer Panel, Metadata, MapServer and Database. In the beginning, a user has to login before to start utilizing the system and to access the map presentations. The purpose of login is to manage the access rights on the maps, in such a way that only recognized users may obtain access. Consequently, unauthorized users will not be able to add invalid information on the maps. After a user has successfully entered the system, the Google Maps Panel displays a satellite image of the Sleman Regency. Then, the user can select any available thematic map – in this case: any map which may be required for evacuation planning (supported by its metadata information). The prototype facilitates a user to add any information to the selected map. This include appending new points, lines, and polygons within the *Google Maps*, and attaching relevant and significant additional attribute information on those objects. The information inserted by the user is saved in the database, thus enabling other users to view it.

An example of a detailed sequence diagram for evacuation planning is presented in Figure 2. Based on the use case diagram, the Dinas Kesehatan has responsibility in the allocation of health personnel and facilities. This task can be achieved by making use of the prototype. First, Dinas Kesehatan had to know recent situation at evacuation barracks in order to determine appropriate health services. The information can be found in the WMS Layer Panel provided in the prototype. Subsequently, after recognizing this information, allocation of the health personnel and facilities can be deployed by using add annotation facilities in the maps presentation.

Figure 2: Sequence diagram of the allocation of health services



3.3 Geospatial Web Services Development

One of the user requirements is to provide a portrayal service in the prototype. The collection of data required for evaluation planning preceded the creation of the services in the prototype. The prototype only used data from the *Kecamatan* Pakem, Turi and Cangkringan, since the evacuation planning prioritized these sub-districts. OGC WMS and OGC KML (formerly Keyhole Markup Language) were used to accommodate this prerequisite.

MapServer was the software tool used to implement the WMS instances. WMS was created for the sub-districts boundary theme. The initial preparation of the spatial data used *ArcGIS*. Then followed the creation of a Mapfile (which is a text file required by the *MapServer)*. The Mapfile described the relationships between the objects. Additionally, it points the *MapServer* to where data are located, and it defines how things are to be drawn.

The purpose of implementing OGC KML is to display the spatial data in the Google Maps Panel thus it can be cascaded synchronously. The KML were created for five themes: Merapi volcanic hazard zones, village administrative, evacuation barracks, evacuation roads, and health facilities. Population theme was attached to the village administrative map so each village would have attributes regarding distribution of the inhabitants. In order to generate KML files for these data, the author utilized *Export to KML Extension version 2.5*, which is an extension developed for *ArcMap 9.x*. The extension allows ArcMap users to export any point, polyline, or polygon dataset in KML format. The KML data format was selected since it offers flexibility to be exchanged and displayed instantly on top of web map interface.

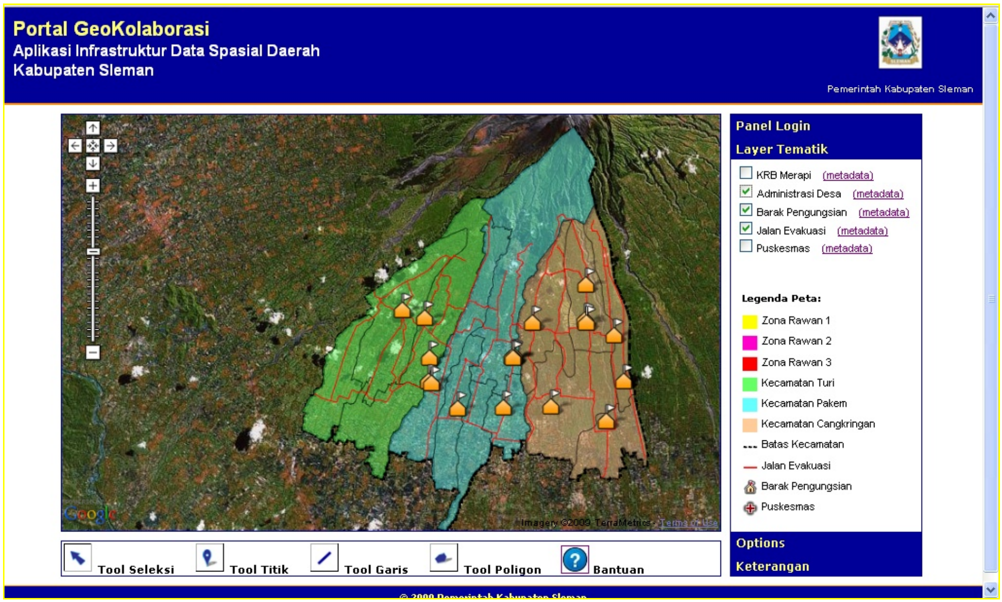
3.4 Customization of The GeoCollaboration Portal

The GeoCollaboration Portal is an application of a local SDI developed that aims to support decision makers investigate, analyze and provide alternative solutions when dealing with disaster management at Yogyakarta Province (Aditya 2008). It facilitates data sharing through availability of enhanced map interface where various WMS layers can be cascaded synchronously. It provides synchronous annotation which can be used to share information among local agencies. GeoCollaboration Portal was built using PHP programming and improved with MySQL database in the server side while the map presentation was developed using *Google Maps API.* Synchronous communication via a portal is seen in this project as a possible innovation to improve the quality of coordination and communication among the agencies.

In this research several customizations to the Portal were made. With the aim to make the Portal prototype for a local SDI implementation, it supports the evacuation planning conducted by Sleman Regency government. The foremost adjustment regarded the data layer. All the created geospatial web services were integrated in the prototype. A total six spatial resources are available: the Sub-district boundary, the Merapi volcanic hazard zones, the village administrative boundaries, the evacuation barracks, the evacuation roads, and the Centre for Community Health (*Puskesmas)*.

In addition to the data layer adjustment, a new map legend for all data layers was a first enhancement to the prototype. The legend can help users to understand which features are available in the layer. A second enhancement was the generation of metadata for each data layer. The metadata consist of information regarding the spatial data and created based on the FGDC's metadata standard. With these metadata, users were able to view for example, description of the spatial data and also its contact information. Another enhancement was creation of a help file in the prototype. This help file provides the user with a guideline in how to utilize specific elements of the prototype. An adjustment was also made in the user list of the prototype. From the use case diagram in the design phase, one can determine which user can operate the prototype. There are four local agencies considered as the users i.e. Dinas P3BA, Dinas Kimpraswilhub, Dinas Kesehatan and Dinas Nakersos (agency for human resources and social). Interface of the prototype is presented in Figure 3.

Figure 3: Interface of the customized prototype



3.5 Evaluation of The Prototype

The purpose of conducting an assessment test for the prototype of a local SDI application is to determine effectiveness, satisfaction and accessibility of the application. In addition, the assessment also aims to determine usefulness of the prototype in supporting evacuation planning activities for Merapi Volcano disaster. The testing also included a group discussion in order to elaborate user expectation and opinions concerning issues of local SDI related with the application. Usability data was collected using observation and questionnaire method while the group discussion was conducted in a structured way with predefined questions. Participants of the evaluation are 3 (three) persons that are representatives from local agencies involved in evacuation planning of Merapi Volcano Disaster, specifically Dinas P3BA and Dinas Kesehatan. Bappeda which has significant role in the implementation of local SDI was also present.

The evaluation consisted of utilization of the application based on specific scenario regarding evacuation planning. The scenario used for test assessment was based on disaster event of pyroclastic flows which is predicted to flow down to the south slope towards Gendol, Kuning, Boyong and Bedog River. This pyroclastic flow affects seven villages i.e. Wonokerto and Girikerto in Turi sub-district; Hargobinangun and Purwobinangun in Pakem sub-district; Glagaharjo, Kepuharjo, and Umbulharjo in Cangkringan sub-district (Dinas P3BA, 2009).

From this scenario several tasks were generated for Dinas P3BA and Dinas Kesehatan in accordance to their roles in evacuation planning. Dinas P3BA has tasks to specify evacuation barracks that will be used and to provide information about numbers of the evacuee. In this regard, Dinas P3BA has to share their findings through the portal synchronously. Meanwhile, Dinas Kesehatan has roles to identify location of the health facilities and to supply information regarding health services which will be designated to the evacuation barracks. Dinas Kesehatan should also update their findings through the portal. Tasks for Bappeda were established based on its role as leading institution in the implementation of local SDI at Sleman Regency.

That scenario was then implemented as a collaboration session involving participants from representative agencies. The participants execute the tasks according to their specified roles. During the execution of the tasks, video and audio recorders were utilized to observe participants activities when interacting with the prototype. After the test session, the questionnaire response was measured using likert scales which represent participant's levels of agreement to a statement regarding usability issues (i.e. effectiveness, satisfaction and usefulness). Some useful comments were put forward by the participants as they carried out the tasks that were given to them during the session. These comments were noticed as one of significant input – beside the remarks collected from the group discussion, for further development of the prototype.

4. RESULTS AND DISCUSSIONS

4.1 Existing Local SDI at Sleman Regency

At national level, SDI coordination has been arranged through the Presidential Act No. 85/2007. The importance of local SDI implementation has been recognized by the Sleman Government. However, the effectiveness of the local SDI at the Sleman Regency is still rather limited, and only a few initiatives have been conducted to change this. Interviews with officials from Bappeda revealed that SDI development initiatives started in 2008 by information awareness activities onthe advantages of a having a local SDI. In the following year, this program was enhanced by formulating a local regulation draft, which would act as a foundation to implement a local SDI strategy for the Sleman Government. Currently, this draft regulation is however still under discussion, although the expectation is that it will be a formal declaration in the course of 2010. Apart from this formalization strategy, the local government also began to prepare single-base maps of entire Sleman Regency, and planned to establish a project for creating metadata of all spatial data.

The currently available spatial data in the Sleman Regency come from different local agencies. Table 3 provides an overview of these data. It shows that most of the spatial data are provided by Bappeda and derived from the topographic maps (1:25,000). This might be insufficient for programs that need more detail information such as urban planning or land system in sub-districts level. The Local Land Agency (BPPD) has started to utilize larger scale information from Ikonos image in 2005 and has produced administrative boundary and land parcel maps with scale of 1:5,000.

Table 3: Spatial data available at Sleman Government Agencies

Theme	Contents	Provider	Scale	Format	Latest update
Administrative boundary	village, sub-district	Bappeda	1:25,000	ArcGIS *shp*	2006
	village, sub-district	BPPD	1:5,000	ArcGIS *shp*	2006
Environment	slope, geological, soil, forest resource, mine and mineral resource, geomorphologic, soil water reserve	Bappeda	1:25,000	ArcGIS *shp*	2005
Land	landuse	Bappeda	1:25,000	ArcGIS *shp*	2007
	parcels	BPPD	1:5,000	ArcGIS *shp*	2005
	land amplification	Dinas P3BA	1:50,000	ArcGIS *shp*	2008

Transportation	road network, transportation system	Bappeda	1:25,000	ArcGIS *shp*	2006
	road network	Dinas Kimpraswilhub	1:25,000	AutoCAD	2005
Hydrology	river, irrigation system	Bappeda	1:25,000	ArcGIS *shp*	2007
Utilities	electricity network, telecommunication	Bappeda	1:25,000	ArcGIS *shp*	2005
Facilities	health facility	Dinas Kesehatan	--	ArcGIS *shp*	2005
	education facility, worship places, commerce facility	Bappeda	1:25,000	ArcGIS *shp*	2007
Population	density	Bappeda	1:25,000	ArcGIS *shp*	2005
Economics	gross regional domestic product, fishery production, rice production, industry, rice field distribution, crops plant	Bappeda	1:25,000	ArcGIS *shp*	2005
Natural Hazards	Merapi volcanic risk, landslide, drought, cyclone	Dinas P3BA	1:50,000	ArcGIS *shp*	2004

Table 3 also shows that there are several redundant data sets. For example, the road network data is provided by Bappeda and also by the Dinas Kimpraswilhub. Although both of the data contain in the same scale and content, the format and feature catalogue is different. Bappeda distinguishes road into five classes (national, collector, local, other, and footstep road) whilst Dinas Kimpraswilhub uses three classes (national, provincial and regency road).

Meanwhile, from survey activities it can be concluded that all the institutions involved in Merapi volcanic risk management have spatial data whether in digital or hardcopy format. However, only 27% of the spatial data contain metadata. This indicates that not all institutions are aware about the importance or have the capacity to maintain metadata. The spatial data are generally used in problem analysis, as visualization instruments in meetings, and as (geo-)reference tools for field surveys. In terms of spatial data access and sharing, most of the respondents (68%) experienced that accessing spatial data from other institutions is not difficult. There are two main methods to know which spatial data are available at institutions, firstly by searching in the catalog and secondly by asking directly to official. Giving the digital maps in CD/DVD is the most common method of data sharing compared to providing the print out maps and online maps. However there are some problems experienced when they integrating the data such as different scale/resolution, different format and inconsistent features of the spatial data.

4.2 Evaluation Results

From the observation data it was recorded that all of three participants completed their tasks successfully and they were able to access the prototype using different internet browser. On the subject of usefulness, participants voice their agreement on the usefulness of the prototype to be implemented in the Regency. All users agreed that the spatial data available in the prototype were required to support the activities of evacuation planning. They were satisfied with the information embedded in the thematic maps, as they could easily find a number of population data, through clicking on a village in the village administration layer. They were also pleased with the prototype’s capability to create synchronous annotation on maps since they utilized this facility in order to finish the tasks. It was proven that by using this function, a user could generate and share recent information in term of evacuation process, such as number of evacuees or location of damaged roads. From the evaluation session, it can be concluded that coordination and communication among the participants in response to the evacuation scenario can be facilitated well using the geocollaboration portal. Thus it can be concluded that the geocollaboration portal facilitate the group to effectively complete the evacuation scenario. This finding shows an example how to deliver SDI advantages for a specific need urgently required by a local government.

The users found the prototype was effective in exploring and in interacting with the map layers. Moreover, in terms of prototype's feature in spatial data provision required for evacuation planning, all participants were able to find those data which provided by different local agencies. Response from the questionnaire illustrated their satisfaction with the user interface and content of the prototype. Most users were pleased with the available metadata, since it enabled them to locate the information, which they themselves considered valuable. One limitation was however that the metadata elements were only available in English, and not in Bahasa Indonesia. This was considered a significant requirement for the improvement of the prototype.

Generally, the participants understood the advantage for the existence of a functioning local SDI to support the evacuation planning. By testing the portal prototype, they were able to see the advantage of having the technical facility of coordinated data sharing among stakeholders. In order to enhance the implementation of the local SDI, they insisted improving several aspects, such as increasing the availability and quality of the spatial data, establishing local regulations on data availability and standards for interoperability, the development and maintenance of metadata, and the further reinforcement of skills.

5. CONCLUSIONS

Risk management is indispensable for the protection and reduction negative impacts of any Merapi Volcano disasters. The Sleman Government has been executing hazards identification, risk assessment, mitigation measures and preparedness actions. It is found that in performing these activities spatial data are crucial for the local government. There are a couple of important findings related to the risk management activities. First, the risk management required cooperation and coordination among different local agencies. Even though the Bupati Act clearly stated roles of each agency, in its implementation some overlapping functions were occurred. Second, although the local government has produced a standard operating procedure for evacuation process, some general obstacles were identified in the field. It includes insufficient medical services, identification of damaged evacuation roads and livestock dilemma of the villagers. A local SDI could be introduced to overcome such problems.

The study found that in order to support the risk management, local SDI has to be able to provide related spatial resources, access to the data, metadata information, and web services which enables interactions with spatial resources. These functionalities are basis for development of the prototype. It is found that geoportal can be exploited to provide spatial data resources, metadata layer and interactive map presentation. Meanwhile, geospatial web services represented by WMS and KML files were generated to supply the spatial data to the geoportal. From this research it is found that users of the prototype have in the same agreement concerning the advantage of a local SDI to support the evacuation planning. Further from the evaluation session done, it can be concluded that coordination and communication between agencies involved in evacuation planning can be facilitated well by the geocollaboration portal developed. From this work, it becomes very clear that a customized geocollaboration portal for a local SDI can support the development of spatially enabled societies at a local level.

However, some suggestions were also recorded for the next prototype development particularly on spatial data quality, standard of feature cataloguing and metadata development. Regarding development of the prototype, an interesting next step will be to enable spatial analysis on top of the map presentation in order to more effectively support evacuation planning and other disaster management related efforts. It will require implementation of other geospatial web services such as OGC WFS, WCS, WPS and integration with the geodatabase of the dataset. Those suggestions bring more focused requirements to improve the design and implementation of a geocollaboration portal of local SDI in order to support tailor-made and customized local needs.

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